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Campus Telecommunications Systems: Managing Change

Association of College and University Telecommunications Administrators

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ACUTA
Association of College and University
Telecommunications Administrators

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Introduction

The purpose of this book is to provide a broadbased understanding of the rapidly changing environment of campus telecommunications. The anticipated audience for this material is the non-technical university administrator who may not have direct responsibility for telecommunications, but has a need to understand the general environment in which his telecommunications manager functions and the basic concepts of the technology.

Five topic areas were selected that best cover the preponderance of issues. No attempt has been made to associate or closely coordinate materials from one chapter's subject to that of any other. Each chapter generally stands alone. In total, however, the five chapters address the topics and issues that most often generate inquiries from university administrators outside the telecommunications department.

The first chapter, **The Changing Telecommunications Environment**, chronicles the industry's history of monopolistic legacies and traditions up to the present environment in which managers of today's campus telecommunication resources must do business.

Chapter two, **Telecommunications Technology and the College Campus**, establishes an understanding of the basic technology and illustrates the converging of voice, video, and data technologies. The transport of voice, video, and data signals constitutes the discipline of today's telecommunications.

The third chapter, **Student Services**, provides examples of possible resource-sharing opportunities. The sharing of technical resources, costs, and revenues has become an area of major interest on college campuses. This chapter perhaps illustrates one area where opportunity is limited only by one's lack of entrepreneurial creativity.

Chapter four, **Financing Telecommunications**, also provides a jumping off point for creativity. Telecommunications systems and their associated infrastructure represent significant strategic capital investments. This chapter outlines possible support mechanisms for establishing and maintaining these investments.

Because the purchase and/or installation of major telecommunications systems and infrastructure occurs infrequently, the use of outside expertise is often desirable if not a necessity. Chapter five, **Selecting a Consultant**, establishes general parameters for when to solicit the skills of a qualified telecommunications consultant, what skills should be solicited, how to evaluate those skills, and how to get the best from a consultant after you've selected one.

Again, the intent of these five chapters is to provide a sampling of topics and examine those issues and items of most interest and relevancy to a university administrator with no telecommunications background. As the reader develops insight from this material and questions arise, the best first stop is the telecommunications manager at your own institution.

Chapter 1

The Changing Telecommunications Environment

Telecommunications services have changed dramatically during the past decade. Ten years ago, local telephone companies dominated the marketplace, and service offerings to colleges and universities were largely dependent upon what their local telephone company had to offer, with relatively few other choices. The principal responsibilities of the official in charge of the campus telephone system was to order services from the phone company, see that services were billed properly, and pay the monthly telephone bill. Now some colleges and universities completely run their own telecommunications systems, some still rely solely on Bell and other Local Exchange Carriers, while others are somewhere in between. Telecommunications has evolved from a utility-oriented function to a broadly-encompassing information resource department that requires professional management.

According to the Commerce Department's *U.S. Industrial Outlook 1993*, the U.S. telecommunications services market (excluding equipment) is expected to realize 1993 revenues of around $184 billion—93% for domestic services, the remainder international. In 1989, the figure was $149 billion, demonstrating about 25% revenue growth over the past five years. Long distance toll revenues will account for around $73 billion (40% of the 1993 total). In 1993, data communication services rev-

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For this book, minor revisions were made by **Marvin J. Peck,** Coordinator Analyst, Emory University, Atlanta, Georgia.

enues are expected to grow by 19% over the previous year, while cellular mobile telephone service revenues will increase 31% and satellite service revenues will increase 27%. The 1990s are positioned for explosive growth in telecommunications services.

Who are the customers? More than 88 million U.S. households and 30 million businesses presently use an estimated 143 million telephone access lines, about 49 lines per hundred population (Sweden uses 66 lines per 100, Canada 53, Japan 42, and the United Kingdom 41). They are served by 22 local Bell Operating Companies (BOCs), GTE, Sprint (United Telecom), Southern New England Telephone Company (SNET), and around 1,300 local independent telephone companies. Long distance service is provided by AT&T, MCI, Sprint, WilTel, LDDS Metromedia, Cable & Wireless, Advanced Telecommunications (ATC), Allnet, and over 400 smaller carriers.

The physical U.S. telecom plant comprises vast mileage of aerial wire, 3.5 million miles of cable, 4.5 million miles of optical fiber, and 57,000 miles of microwave radio relay systems. There are over 15,000 central telephone offices. Total cumulative investment in the U.S. telecom plant is about $320 billion.

Substantial changes in the delivery of telephone and related telecom services have taken place since the 1984 divestiture of American Telephone and Telegraph, along with the beginnings of deregulation in several sectors of the telephone industry. Telephone users used to think that only the telephone company could supply reliable equipment and services, with the result that there was often a fear to look elsewhere. However, colleges and universities no longer need to allow that fear to restrict their choices. Competition has also improved attitudes in delivery of services, particularly among some of the former monopoly companies. To better understand the ramifications of what has occurred, a brief outline of AT&T history is in order.

AT&T: A Brief History

Alexander Graham Bell was credited with inventing the telephone in 1876. With two partners, Gardiner Hubbard and Thomas Sanders, who had financed Bell's experiments, they devised the formula that would become the basic philosophy of the Bell System for the next century: "Equipment could only be leased, not bought."

Early in 1878 one of Western Union's biggest customers replaced its telegraph equipment with the Bell Company's telephones. Western Union promptly offered to purchase Bell for $1,000,000. When the offer was refused by the Bell Company, Western Union attempted to drive Bell out of business by purchasing the manufacturing rights to telephone equipment. This resulted in Western Union's formation of the American Speaking Telephone Company, and the start of what became known as the "Telephone War."

The same year Bell bought control of Western Electric. In so doing the company forged a unique business arrangement that would continue for over a century: Bell would buy all of its equipment from Western Electric; in return, Western Electric agreed to sell all of its equipment to Bell at cost.

■ One System, One Policy, Universal Service

In 1880, the company name changed to the American Bell Telephone Company, and adopted the well-known "one system, one policy, universal service." Bell was now on its way to becoming the largest corporation in the country. The basic framework was maintained up to divestiture in 1984: vertically-integrated supply, a network of licensees owned substantially by Bell, heavy emphasis on research and development, and strong supervision of the entire system by the parent corporation. In 1897 Bell reorganized again, becoming the American Telephone and Telegraph Company. Up to this time, Bell had been involved in over 600 lawsuits, and had won them all.

Eventually, the Bell Company evolved into an organization with five basic components:

- American Telephone and Telegraph
- The 22 operating companies (BOCs)
- Western Electric
- Bell Laboratories
- AT&T Long Lines

From the beginning all the way to the 1984 divestiture, AT&T applied standardization, deciding for every operating company in the entire Bell System what financial policies would be adopted, what services would be instituted, and what practices would be followed.

■ Toward Monopoly

By 1913 AT&T had secretly gained controlling stock in Western Union. And it also refused to connect independent companies to its long distance network. Responding to protests from a group of independent companies, the Department of Justice advised AT&T that certain planned acquisitions of independent companies were clearly in violation of the Sherman Antitrust Act. At the same time, the Interstate Commerce Commission began an investigation to determine whether AT&T was attempting to monopolize communications in the United States. Public sentiment was that Bell was too big and powerful, and forces were gathering to change this.

Bell could see the pressure mounting quickly, and agreed to the following (known as the Kingsbury Commitment):

1. Dispose of all its Western Union stock.
2. Acquire no more independent telephone companies without the approval of the Interstate Commerce Commission.
3. Allow other telephone companies to attach to the Bell System toll network.

■ Further Investigations

The Communications Act of 1934 created the Federal Communications Commission (FCC), which replaced the Interstate Commerce Commission as the federal agency with jurisdiction over the nation's telephones. Thus began the first of four investigations by the government into the corporate affairs of the Bell System. The major objective was to separate Bell and Western Electric, but the attempt failed. In 1949 the government began an in-depth study of the Bell-Western Electric relationship; the government found no evidence of wrongdoing.

In 1956 Congress investigated the Bell-Western Electric arrangement and ruled that Bell had the right to decide who should receive licenses on AT&T patents. In addition, Congress ruled that non-Bell suppliers did not have the right to buy equipment from Western Electric unless the Bell System permitted them to do so. Bell was now free to set its own pricing policies.

Until 1968 the Kingsbury Commitment and the Communications Act of 1934 upheld the principle that the public interest was better served by a system of regulated telephone monopoly than by open competition. Up to this time, tariff regulations flatly stated that use of any non-Bell equipment was essentially illegal and was cause for Bell to deny service.

■ Challenges to Monopoly: Carterfone and MCI

In the mid-1960s Thomas Carter invented a small device, the Carterfone, that enabled truckers to interconnect a private two-way radio with the telephone system via a base station. Bell claimed this was illegal, but in 1968 the FCC ruled that the device could be connected to the telephone lines without threat of disconnection by Bell. Reluctantly, Bell agreed that foreign equipment could be attached to its network as long as the equipment was technically compatible and protective devices were installed between the equipment and the phone company lines.

The Carterfone decision of 1968 was only the beginning; other obstacles to competition began to fall. Jack Goeken, founder of Microwave Communications Inc. (which later became MCI), realized that one could transmit long distance calls via microwave at far less cost than the Bell System was charging to transmit with coaxial cable. To prove his theory, in the mid-1960s he began offering microwave toll calls between Chicago and St. Louis. This was the first attempt to compete with Bell in the long distance market in over 60 years.

When McGowan asked the FCC to approve service on this route, Bell asked the FCC to freeze out MCI. This attempt failed, and in 1971 the FCC's "specialized common carrier" decision ruled that anyone could offer long distance service.

With this decision in hand, McGowan quickly set out to build a coast-to-coast network.The only practical solution was to connect customers to the network via the local telephone exchange, allowing customers to use their regular telephones. Bell countered by initiating a strategy to thwart MCI's entry into the long distance market, using legal, technical, and financial means.

This adversity prompted MCI to file an antitrust suit in 1975, charging Bell with anti-competitive practices such as planning to bypass the FCC and file toll tariffs, cutting off service to the entire MCI network, forcing MCI customers to use a 12-digit access code, denying access to Bell System operators, etc. In 1980, MCI won a record antitrust judgment against Bell, with a $1.8 billion award for triple damages. However, AT&T appealed, and the case continued. In 1985, a federal court awarded MCI $113 million for Bell's anti-competitive behavior.

Divestiture

By 1974, even with the handicap of the Carterfone decision, the Bell System supplied about 80 percent of the phone service in the U.S. The Justice Department felt this was too large a share and on November 20, 1974, filed a suit to attempt again to sever the Bell-Western Electric relationship. The suit was aimed not only at AT&T's size or market share but also at its behavior.

The most lucrative aspect of the old Bell System was its relationship with Western Electric. By permitting the operating companies to buy equipment only from Western, AT&T had a monopoly. AT&T could shift its huge profits away from the regulated parts of the corporation, toward the nonregulated manufacturing arm. Research costs for developing and building equipment could be added to the local and long distance rate base.

A lengthy Justice Department investigation begun in 1974 determined that Bell was using the captive relationships among its manufacturing, Long Lines, and local telephone divisions to preclude competition. It was also determined that Bell's interference with competition was causing technological stagnation. The 1974 suit was aimed at severing Western Electric from Bell and forcing Long Lines to deal with the local companies on a more arms-length basis.

In 1981, after many delays and 18 months of hearings, the trial actually began. The case could have dragged on for years. However, AT&T realized that, while it was fighting antitrust actions and divestiture in court, the data communications market and the telecommunications revolution were quickly bypassing the company. As a regulated monopoly, AT&T was prevented from entering the computer market where it wanted to compete freely.

On January 8, 1982, AT&T reached a settlement with the Justice Department. Judge Harold Greene carefully reviewed and modified the agreement and in August 1983 finally approved the divestiture agreement, also known as the Modification of Final Judgment (MFJ). AT&T retained its long distance telephone services, although rival companies such as MCI could also compete in this newly deregulated market. AT&T kept its telecom products manufacturing capabilities (competing in an open market) and its research arm, Bell Labs. AT&T

was free to enter previously-prohibited electronics business ventures, such as computers and information services, although it was excluded from involvement in electronic publishing over its own lines for several years, as a concession to the newspaper industry. Finally, it would divest its telephone operating companies.

The 22 Bell Operating Companies (BOCs), continuing operation as regulated businesses, were reorganized into seven Bell Regional Holding Companies (RHCs; sometimes referred to as RBOCs): Ameritech, Bell Atlantic, BellSouth, NYNEX, Pacific Telesis (called PacTel), Southwestern Bell, and US West. The BOCs continued to provide local telephone service, including cellular phone, but long distance services were limited to their local access and transport areas (LATAs); the continental U.S. was divided into 161 metro area LATAs.

The BOCs were allowed to provide, but not manufacture, customer premises equipment (CPE). They were no longer required to purchase equipment from Western Electric, but could select freely among vendors in the open market. They were awarded the right to issue Yellow Pages (revenues were supposed to help subsidize local telephone rates, thereby supporting "universal service").

The BOCs were banned from providing information services (e.g., electronic publishing) and inter-LATA long distance service (reserved to AT&T and other long distance carriers), but were not barred from nonregulated activities. Some Bell Labs staff were transferred to a new research organization for the BOCs, called Bellcore. Finally, the BOCs were granted use of the Bell name and logo (although AT&T's Bell Labs retained that privilege as well).

[NOTE: For a detailed, comprehensive treatment of the divestiture, see Temin, Peter, with Louis Galambos. *The Fall of the Bell System; A Study in Prices and Politics*. Cambridge, England, Cambridge University Press, 1987. 378p.]

Implications of Divestiture

Divestiture has brought choice to users in both local and long distance services, equipment, and all other aspects of telecommunications services which were previously unavailable. In order to address such a rich variety of choice, it has become imperative for higher education institutions to employ knowledgeable telecommunications managers who can create up-to-date telecommunications systems which will bring new capabilities to their users while controlling costs. Following are examples of changes which ensued, and of which telecommunications managers must be aware.

The long distance telephone services market changed dramatically following divestiture. While AT&T remained in the market as the dominant long distance carrier, with tariffs subject to FCC approval, competitive long distance carriers, also known as other common carriers (OCCs), or specialized common carriers (SCCs), are not subject to rate regulation. New OCCs were quick to jump into the market. To put things in perspective, in 1984 (the year of divestiture), AT&T's toll revenues were $35 billion, about 90% of the total U.S. long distance market. In contrast, by 1992 U.S. long distance carriers generated toll revenues of $58 billion (projected to grow to $80 billion by 1997), and AT&T's market share had dropped to 63% of the total. The top three U.S. carriers combined, AT&T, MCI, and Sprint, had nearly 90% of the entire long distance market, the remainder being shared by over 400 smaller carriers.

In a regulated market, rates are based on the telephone company's average cost of serving customers. In a competitive market, rates are based on what the traffic will bear, above actual costs. As the basis of phone pricing changes from average to actual costs, those customers who seem assured of benefiting the most will be large users with heavy long distance traffic. The move to a "price cap" plan (state public service commissions and the FCC set price *ceilings* on rates), rather than rate base regulation, has eliminated the incentive for long distance carriers to inflate their rate bases with excessive capital spending and cost structures. Instead, profits are now directly related to productivity gains. One consequence of this has been scaling back carrier staff, replacing "live" operators with computerized voice response systems. One result of this post-divestiture change is that direct distance dial rates for interstate calls have dropped (as of 1992) between 40% and 45% since the Bell divestiture and the advent of long distance competition.

Post-divestiture competition has led to a proliferation of new services which are addressing high growth rates. These include 800 and 900 calling, WATS, private lines, data communications, integrated services digital network (ISDN), and video-conferencing. The technological foundation for the next generation of long distance will be digital switching and optical fiber networks. The BOCs plan to have more than 60 million ISDN-capable access lines in service by the end of 1994.

Colleges and universities now have choices. They can negotiate with carriers for the best rates, and can use multiple carriers for least cost routing and for preventing total loss of long distance services. Careful selection of vendors has ignited student long distance resale programs as a potential revenue source: Students share institutional long distance capabilities and benefit from cost savings.

With all the benefits of choice has come the threat of fraud, which includes activities such as over-priced operator-assisted calls; unauthorized calling card calls; and unauthorized entry to long distance networks in order to generate "free" calls. The campus telecommunications manager must be vigilant to such schemes, as they presently exist or expand in the future.

Centrex and PBX

Centrex switching was designed to provide low-cost telephone services for medium- to large-scale customers, by providing dial service and eliminating the use of operators to process calls through use of features such as direct inward dialing, direct outward dialing, and station-to-station dialing. Centrex service originates in the telephone company central office rather than in an on-site system such as a PBX network, which essentially creates a private network for large corporate users.

Centrex customers were among those who felt the financial burden of access charges. While PBX customers are only billed for access charges on their trunk lines, Centrex is billed for each main line in service. Since Centrex is the only product local telephone companies can sell following divestiture, those companies have a clear interest in preserving this offering. New PBX technologies, coupled with post-divestiture access charges, resulted in a loss of Centrex users in the early to mid-1980s. In addition, several strong international telecom manufacturers entered the PBX market to compete against AT&T.

However, since then some BOCs have enhanced their Centrex offerings, and, in order to maintain their customer base, file tariffs with their respective public service commissions to have the access charges reduced or absorbed entirely. Shipments of PBX systems surged in the 1970s to the early 1980s, then levelled off, due in part to the strength of the Centrex market as well as the failure of PBXs to compete in data communications markets. The pros and cons of Centrex vs. PBX remain a local issue for any institution addressing switching/service alternatives.

Other Considerations

New, specialized telephone services, available since divestiture, have been gaining use on college and university campuses, benefiting faculty, staff, and students. *Voice processing* may be viewed under two categories: *Voice messaging* is people-to-people communications, with applications such as mailbox, message delivery, telephone answering, and caller routing. *Voice response* is people-to-computer communications, with applications such as information collection and dissemination, and transaction processing. These and other types of new technologies are discussed in Chapter 2.

Some telephone customers, feeling that the rates for both access and toll charges are too costly, have built their own networks in order to bypass local exchange facilities. Private bypass networks are established by using microwave, fiber optics, satellite, radio, infrared, laser, or cable TV lines. When large toll users bypass exchange facilities, they may leave a large amount of fixed exchange costs to be borne by the remaining users of the network. As the user base shrinks, rates paid by the remaining users may rise so that an acceptable grade of service can be maintained. The BOCs estimate that they lose some $3 billion in annual revenues to bypass.

ISDN

ISDN is an all-digital transmission system designed to carry voice, data, and image signals, and may be the emerging structure for the next step in global network telecommunications. ISDN requires the installation of public-switched transmission facilities to accommodate a changing mix of services which are now based on the use of digital technologies. Advantages include offering better services, features, and cost advantages, as well as offering services to small businesses and residential users formerly reserved to large business/government. Although voice services are still dominant, the greatest growth for the 1990s will be nonvoice services, including data, video, facsimile, images, and graphics.

Capabilities include the use of digital loops from central offices to user premises, multichannel facilities, user-accessible control channels, plus circuit-switched, packet-switched, and nonswitched connections. Examples of customer premises equipment (CPE) that can be connected to ISDN include ISDN terminals, digital telephones, and personal computers with ISDN adapter boards. Factors influencing the growth of ISDN markets include implementation of standards, availability of feature-rich services, an innovative regulatory environment, and wide-scale development of ISDN chip technology (VLSI chips).

Other Government Actions

Under the Operator Services Act of 1990, the FCC required "aggregators" capable of selectively offering 10-XXX access to do so by March 1992. The FCC included colleges and universities which sell phone service to students in the aggregator classification. Costs of conversion (potentially quite expensive) would be borne by the colleges and universities, not the carrier. In 1992, ACUTA, ACE, and NACUBO filed a petition requesting that the FCC exempt colleges and universities from the aggregator classification with respect to telephones located in campus dormitory rooms, arguing that colleges and universities are not in the same business as commercial hotels/motels. The petition was denied in early 1993, with further action pending.

The Americans With Disabilities Act (ADA), signed July 1990, mandates that "reasonable modifications" be made to "communications barriers" to enable people with disabilities to receive services or participate in programs provided by public institutions. Compliance requires public telephone access, with requirements such as adequate space and mounting height, lack of obstacles to phone or coin slot, stipulated phone cord length, compatibility with hearing aids, volume control, touch-tone service (where available), installation of text telephones (TTs; formerly called TDDs), and provision of emergency services such as 911. Other considerations for services to the disabled include electronic Yellow Pages, text-to-voice conversion, and voice recognition applications.

Bell Regional Holding Companies Initiatives

In recent years the Bell Regional Holding Companies (RHCs) have pushed forward with new initiatives to gain capabilities from which they were excluded by divestiture. First, they want to be able to manufacture telecom equipment, and compete in a potentially lucrative marketplace. In June 1991, a Senate bill enabled the RHCs to enter this arena, which has three specific market segments:

- Consumer electronics equipment, such as telephones and fax machines. The U.S. has the largest trade deficit in this segment, which is dominated by Far East manufacturers. Among the emerging technologies involved is personal communication services (PCS), which both transmits and receives via radio transmission, using pocket-sized wireless telephones, hand-held organizers, and two-way paging devices. They operate independently of public switched telephone system.

- Networking equipment that attaches telephones to central phone company equipment switches. This market has exploded since divestiture, with hundreds of companies involved.
- Large-scale central switching equipment. Fewer than ten companies worldwide are active in this segment, with AT&T being the only U. S. participant. Due to high start-up costs, the RHCs have eyed joint ventures with foreign manufacturers, although regulators favor domestic-only provisions for RHC ventures.

Second, the RHCs want to offer information services such as data programming, electronic publishing, and video programming. This would involve the integration of voice, data, and image technologies, such as telephones, televisions, videocassette recorders, radios, and answering machines, and would also impact information sources such newspapers and other publishers. A July 1991 court decision (by Judge Harold Greene) allowed the RHCs to enter the information services market, and in July 1992 the FCC ruled that telephone lines could be used to carry television programming (although the RHCs would not be allowed to *produce* programming). Predictably, the cable television (CATV) industry did not greet this decision with enthusiasm.

The ramifications of these decisions are mind-boggling. They would allow the RHCs to enter the CATV marketplace, carrying movie channels, shopping services, electronic Yellow Pages, and interactive educational programs, as well as offering billing and collection service for video programmers. Such entry could stimulate both RHCs and CATV operators to install fiber optic cabling in order to offer more services, with improved transmission capabilities. Such an upgrade might require a decade of time and an estimated $400 billion investment. In turn, the resulting fiber optic networks will vastly improve the telecom infrastructure, just as the installed copper wire network provided huge improvements in telecom services over the past 100 years. The delivery of enhanced information services to homes and businesses would be well on its way.

Local Fiber Optic Networks

In September 1992, the FCC issued a landmark ruling allowing companies that operate fiber optic telephone networks to compete with local telephone companies in providing local distance services. This ruling effectively dismantles the monopoly of the RHCs and other local telephone companies, and is intended to force them to lower prices and improve service. Among the fiber network companies who benefit from the ruling are competitive access providers (CAPs) such as Metropolitan Fiber Systems, Teleport Communications Group, and Intermedia Communications, who presently serve most major U.S. cities. Advantages accruing to CAPs are that they serve high density areas, they have no mandate to subsidize rural and residential services, and they are free of the regulatory restraints incumbent on local telephone companies. These competitive edges allow CAPs to offer network services at sharply reduced rates.

Chapter 2

Telecommunications Technology and the Campus

Technology in the telecommunications industry changes at a rapid pace—it is even changing as these words are put to paper. While this chapter will neither make the reader a technical expert nor advocate one technology over another, it will provide some insight into telecommunications technology and the issues that surround it.

In the telecommunications industry, technology alone does not drive change. It is one element of a complex equation that involves economics, standards, and regulation. The telecommunications industry, particularly in local exchange and interstate markets, is still a highly regulated industry. What can be done, who it can be done by, and for what price are often under the control of regulatory agencies. The telecommunications industry is also highly competitive. Its services and products can be viewed as standards-based commodities, with each vendor bringing comparable products to the market and attempting to differentiate themselves by price or service. While decisions regarding technology should not be made without looking at all the issues—regulation, standards, and competition, this chapter will address only standards and their affect on technology.

This chapter was written by **John S. Meickle,** Director, Telecom Planning & Technology, Yale University.

Standards

Standards are, very simply, an agreed upon way of doing something. And, as one pundit said, "The nice thing about standards is that there are so many of them."

Why have standards? Standards should be beneficial to all involved with the product: the manufacturer, the service supplier, and, most importantly, the purchaser of the standards-based equipment. Standards ensure that the product will perform in a predictable manner, that software companies can write software to interact with it, and that an end user can purchase this equipment from multiple manufacturers.

Why should the end user choose standards-based products? Cost is an obvious consideration, both in purchase price and ongoing maintenance and support. Standards have the potential for creating commodity markets for equipment, which generally means more competition and better prices. When using standards-based products and services, it is often easier to find trained staff or alternate suppliers of support.

Why would an end user not want to purchase a system based on standards? In some business scenarios there may be a telecommunications technology that permits new functions to be performed or that somehow helps create a new product or service that dramatically differentiates that company from its competition. Colleges may choose to bypass standards-based technology if they have some service need that can't be met, see a strategic value in fielding proprietary systems, or are in some form of strategic relationship or development partnership with a vendor of proprietary products.

While standards are a vast improvement over each manufacturer doing his own thing, they are not a panacea. Most standards have a certain amount of engineering "wiggle room" in them, so interoperability between two manufacturer's devices may not be as complete as you may have hoped. Also, some vendors may claim standards compliance, yet their product may only partially comply. As with buying anything, it's *caveat emptor.*

Digitization

Digitization is the ability to put a signal such as a voice or television image into a binary format, a string of zeros and ones that can be manipulated, stored, or transported and then reconstructed into the original signal. Digitization creates a common method for dealing with diverse forms of signals and information. The common method permits the signals to be treated as a commodity and handled in a standard fashion. That yields efficiency. It also breaks down pre-existing barriers between voice, data, video, and other forms of information so that new products, services, and applications can be developed.

All human-to-human communications begin and end with an analog interface—the speaker and microphone of a telephone handset, a CRT for video. Digital communications is not a replacement for analog communications; rather, it is an adjunct technology that makes it "better, faster, cheaper."

■ Digital Information in an Analog World

Computers inherently use digital, or binary, information. By design, they process and store information that has been coded into a format that consists of zeros and ones. The key concept is coded. Numbers from a decimal system, a voice, a television image are changed into patterns of ones and zeros according to a set of rules called an encoding scheme. Just as Morse Code was used in telegraphs to change alphabet characters to long or short pulses, there are encoding systems for various characters of signals. ASCII (American Standard Code for Information Interchange) code is used to change alphanumeric characters into binary patterns, PCM (Pulse Code Modulation) is a code used to make telephone signals digital, and H.261 is one technique for making a video signal digital. Audio Compact Disks use another technique. There are lots of techniques for converting signals to digital and for converting them back to their original state. The common denominator is that all these signals can be made digital. The signals can then be processed, transported, or stored in a digital fashion. But there hasn't always been a way to transport them digitally.

In the 1950s and 1960s computers were an important but scarce resource to burgeoning business and academic functions. Being scarce, they were centralized, and information had to be brought to them. They were also expensive, and it was an economic necessity to make full use of them around the clock. Systems to use them called "time sharing systems" were developed. This lead to the ability to have multiple printers, keyboards, or other data input or output devices accessing the computer at the same time. As time sharing evolved, the need to have remote data input and output devices developed. The quandry was how to distribute this digital (or binary) information over communications systems such as the telephone network or radio frequencies that were analog.

The solution is a familiar device, a modem. Modem stands for MOdulate/DEModulate. Modems modulate, or change, an audio signal of a known frequency (a carrier frequency) according to a defined set of rules. When a modem receives a binary *one* from the computer, it changes the frequency one way. When it receives a binary *zero*, it changes the frequency another way. The modem receiving the analog signal on the other end "knows" the rules—that one type of frequency change means *one* and another type means *zero*—and it demodulates the signal accordingly. Its output is binary and it passes it along to the terminal or printer. Each binary element—the one or zero—is known as a *bit*. Early modems functioned at speeds of 300 or 1,200 bits per second (bps). Bps is commonly used as shorthand for defining the speed or capacity of a connection or a network.

Data communications has come a long way since these early days, but it has taken innovations in the technology and engineering of networks to reach the level of performance we see today.

■ Creating Digital Networks

Parallel development began on the network front and, like computers, was driven by economic necessity. As the national telephone network began to grow, there were needs for more and more circuits to connect central offices to each other and to connect the central offices to customers. This became a burden on the *outside plant,* the copper cables that carry the signals and the poles and ducts that support those cables. Telephone companies began to look for ways to multiplex signals. This is a key concept for most modern communications technologies.

Multiplexing is a technique for making a circuit carry multiple signals at the same time without having the signals interfere with each other. It permits the maximum use of a transmission facility. For telephone companies this translated to having a copper cable with "X" many pairs of signal wire in it carry many times "X" number of signals. This permitted the telcos to avoid installing larger and larger cables, digging more duct banks, and placing more poles. The technology was driven by cost avoidance.

Pulse Code Modulation (PCM) is a technique used to convert audio information, such as a voice, into a digital code. It works in a fashion not unlike a movie, which is a series of still photographs that are taken at fixed intervals. When the photographs are projected, the mind is "fooled" into seeing continuous motion. PCM works in just the same fashion. Using electronic hardware, a "snapshot" (or sample) of the audio signal that is the voice is taken, and that sample is converted to a code consisting of eight bits (or binary numbers). The voice, which is a continuous stream of sound, is sampled 8,000 times per second. Therefore, one second's worth of voice is the equivalent of 64,000 bits (8 bits times 8,000 times a second). The voice, which is now in a digital format, can be transmitted, stored, processed, or mixed with other binary signals. When converted back to audio, the hardware takes the bits in 8-bit groups and recreates the original snapshots. Like a movie, the snapshots are played in sequence, and the mind hears what appears to be continuous speech.

Once technology had been developed for making voice digital, there needed to be a way of multiplexing and transporting that digital information. Time Division Multiplexing (TDM) was the technique developed. TDM is best visualized as a train. Flat car number 1 holds eight bits from voice conversation number 1. In flat car number 2 are the 8 bits from conversation number two; likewise for conversation numbers 3, 4, 5, etc. When all the input conversations have been searched, it starts again with the next 8 bits from conversation number one. At the distant end, the eight-bit "freight" is taken off, separated from the other input conversations, and sent off to be converted back to analog. The transmission speed of the circuit (or the train in the example) is always in 64 kilobit increments, each increment representing one voice channel.

What PCM does is convert voice or information from analog to digital and back again. Voice telephony now entered the realm of binary, the internal language of computers. What TDM does is permit conversations or data streams to be interleaved and carried on a faster medium. For the telephone companies in the 1960s that meant they could carry 24 conversations on facilities that would previously only support two conversations. For telephone companies in the 1990s it means that tens of thousands of simultaneous voice or data connections can be carried over a single pair of fiber optic strands.

Cable and Wiring

Wire and cabling will probably represent one of the larger investments that a college or university will make to enable advanced telecommunications-based services available to its staff, faculty, and students. That being the case, it's an area that should be given thought, attention, and research and should be approached in an organized and planned way by an institution. Following are some brief comments on the various forms of transmission media available.

■ Access Systems

Any renovation or construction project should include provisions for sufficient outlets; appropriate wire and cable (including fiber); defined routes for cable to travel such as conduit, cable trays, or other systems; and adequately sized telecommunications closets and riser systems. All too often these fundamental items are forgotten by architects or are considered low priority items that can be cut in case of budget problems.

■ Copper Wiring

In spite of all the press about the wonders of fiber optic (and it indeed is wondrous), copper remains the workhorse of building distribution systems. And, to paraphrase Mark Twain, reports of its death are greatly exaggerated. Engineers keep finding ways to 'push the envelope' on its ability to support higher and higher bit-per-second (bps) rates. There are now low cost station distribution wires available that will support data rates over 100 mega (million) bits per second.

Not all copper wiring is created equal, and for what many people would consider a mundane topic, there is an amazing amount of diversity in design and performance. Each configuration of wire, its insulation, and design affect the speed and strength of the signal it can carry. Like many areas in technology, it comes down to a cost/performance evaluation. Unshielded, twisted-pair cabling has become the defacto industry standard for voice and data. Following is information on the varieties of unshielded, twisted pair cabling available.

The Twisted Pair "Levels" System

Level	Description	Application
One	Voice	Minimal for analog voice, 20 kilobit data
Two	ISDN/Low Speed Data	Up to 1 Megahertz. Useful for digital voice & ISDN, AppleTalk, etc.

Three	LAN/Medium Speed Data	Supports up to 16 megabit data
Four	Extended Distance/ Medium Speed	To 20 megahertz
Five	High Speed LAN	To 100 megahertz. Can support Copper Distributed Data Interface, a 100 megabit/second technology.

■ Fiber Optics

Fiber optics is considered one of the "wonder technologies" of the 1980s and 1990s. Implementation of fiber optics in the backbone networks of the long distance carriers has simplified their networks, speeded the transition to all digital transmission, lowered maintenance costs, dramatically increased capacity, and made transmission largely immune to induced noise and disruption. The end result for users has been improved quality, more rapid implementation of services, and lower cost.

Fiber is a hair-fine strand of glass. It is actually composed of multiple layers of glass, and it is the size and chemical composition of those layers which determine the optical performance of the cable. Like copper cable, there are varieties of optical cable and common uses for each. There are two primary layers in optical cable, the cladding or outer layer, and the core. The core consists of ultra pure silicon or other chemical compounds and it becomes the path that light is reflected down. The cladding layer performs two functions: It standardizes the outside diameter of the fiber and, more importantly, acts as a mirror.

Multimode fiber has a larger inner core than singlemode fiber, typically 62.5 microns in diameter. Light is shot in at one end, and reflects off the surface between the core and the cladding layer. Because of the relatively large diameter, light scatters and bounces off the walls of the core at different angles.

Singlemode fiber's core is much narrower, typically 9 microns or less. It works on the same principle as multimode, but because it is much narrower, the angle at which the light can bounce off the core's wall is much shallower, yielding a much straighter path for all the light.

Generally, multimode is used for lower speed applications, if 600 megabits or less can really be classified as low speed. Typically, multimode is used for campus distribution systems and for distribution in buildings, primarily for data communications. Singlemode fiber is used, at the present time, primarily in the telephone and cable company market, where long distances are common and where the speeds used are extremely high. Singlemode fiber is appropriate for where the bandwidth needed is in the gigabit (billion bits per second) range or where analog video is being transmitted.

Which fiber cable should you use? The answer isn't simply to use one or the other; you may want to use both. For most current data and voice applications, multimode is fine and it will be useful into the far future. However, if you plan to field video in the short term, singlemode will be necessary. With premise data rates going up an order of magnitude every couple of years, it becomes easy to envision data networks requiring data ranges in the billions of bits per second, singlemode fiber placed now may become a "buried asset" that will enable that future.

■ Planning and Management

A quality cabling plant, well organized and documented, will enable all telecommunications-based systems and applications. A poorly installed or managed plant will be a constant hindrance. Consider the following in the design of your telecommunications distribution system:

- **Access**

Get plugged into the building construction and renovation process at your institution. That is the time—during construction—to install or improve the telecommunications infrastructure of a building. Remember, wire may have a long life, but a good access system works as long as the building stands. Make sure you have sufficient space in the design for telecommunications closets, risers of sufficient size, and distribution support systems that can be used by craftspeople without disrupting an office. Help your architectural and construction peers help you by having written standards and requirements.

- **Build One System, Not Many**

  The tendency has been over the years for the telephone professionals to install one type of wire and have their own closets; the data professionals want different wire and separate closets; the video and security folks want something completely different. While it takes cooperation, patience, and understanding, look to develop a common wiring system that serves the institution as a whole.

- **Think Ahead**

  Don't wire just what's needed or put in just the quantity that is needed. Again, wire and fiber have a long life and applications and uses tend to grow over time.

- **Structure**

  Install an organized wiring system. Write down your standards for how you want wire and cable installed so that each telephone closet is laid out in the same fashion instead of each one looking different. Plan the layout to anticipate growth.

- **Document Your Cable System**

  Whether or not your telecommunications unit charges back for connections, it's an investment worth making to implement a "cable management system." There are a variety of turnkey packages available. Beside the obvious ability to restore service quickly in case of fire or vandalism, there are advantages such as knowing when to plan for—and being able to budget for—the expansion of cable facilities. It is also information that is useful in diagnosing and speeding up repairs.

Voice Networks

The most comprehensive telecommunications application (and often the most overlooked—till something goes wrong!) fielded at colleges and universities is voice service. Due to its long history, the general familiarity of form and function, and the industry's reliability, telephone service is often taken for granted. It's assumed to be easy, that it manages itself, and—scariest assumption of all—that "the phone company does it all." While the focus of this section is voice networking, it should be kept in mind that many of the technologies described are used in data communications, particularly for wide area communications.

Pulse Code Modulation (PCM) and Time Division Multiplexing (TDM) have been mentioned earlier in the chapter as the bedrock upon which the current generation of digital communications equipment is based. Those technologies permit the digital encoding of voice and its multiplexing and transport. Three additional technologies are switching, signaling, and transmission.

■ Switching

Switching is the technology of getting a call to its proper location. Cord boards were the first true implementation, followed by electro-mechanical switching. Electro-mechanical switching was invented by an undertaker named Strowager who was convinced that the local operators were directing calls for burials to his local competitor (the first recorded example of using telecommunications for competitive advantage!). After Strowager switching came reed-and-relay switching and crossbar switching. All created an electrical path over which analog signals were carried.

While early telephone systems did indeed have a matrix of wires or relays to perform the cross-connect function, today's telephone systems perform the same function using digital technologies. The primary technology used for voice and circuit switched telephony today is TDM switching. The TDM switch, or matrix, is the heart of each telephone switching system, whether it is a key telephone system, a PBX, or a Central Office switch.

The switching matrix is now an addressable multiplexer. The common control software instructs the matrix to constantly deliver eight-bit PCM "packages" from one address to another. The address could be a telephone number, a port location on the switch, or a specific trunk. During the course of the call, the address may be changed. Changing the address destination where the stream of packets gets delivered to is the switching function.

■ Signaling

A telephone call, be it long distance or local, needs to traverse a number of switches in order to get to its final destination. For example, a call might originate in a local telephone system (PBX) belonging to a university on the East Coast. That's one switch. The call then goes through its local telephone company, perhaps an additional two switches. The call is then given to a long distance carrier who might route it through three or four switches of their own before it is handed off to the local telephone company on the West Coast. There the call travels through two more switches until it reaches the PBX of the called college. The end PBX is one more switch.

In the example above, the call goes through approximately 10 switching matrices. How do the switches along the way "know" how to route the call? The technology used is called signaling. The information that is passed along tells how to route the call. In voice networks there are two forms of signaling:

- **Inband Signaling**

The term *inband signaling* is derived from the fact that signals, which set up how a call should be switched, ride in the same talk path that the conversation will ride in once the call is connected. Using the East Coast to West Coast call example, the caller dials the destination digits to originate the call. The PBX's software analyzes the digits and instructs the matrix to route a connection to a trunk going to the local telephone company. The PBX sends a signal out over the trunk to "wake up" the telephone company Central Office. It's the modern equivalent of turning the crank on your phone. The Central Office sends an electrical signal back and the PBX forwards the digits that were dialed originally by the user. The software of the Central Office then analyzes the numbers and selects a trunk going to another switch. The process is repeated over and over again until a path (or circuit) is created across the country and through the West Coast PBX and the phone rings on the desk. The signaling travels in and creates the path of the call.

- **Out-of-Band Signaling**

In the past several years, as telephone switches have begun to look more and more like computers, the nature and capabilities of network signaling have changed. Long distance carriers and local telephone companies are now implementing a different form of network signaling called Signaling System 7. It is called *out-of-band signaling* because the signaling instructions for setting up and routing a call are not part of the circuit that is used to carry the voice. The instructions travel on an entirely different network called a "packet switched network." More on packet switching later.

There are some distinct advantages to breaking out signaling from the actual transaction of setting up a call. A simple example is calling a busy station. In the East Coast to West Coast example, the call would extend from switch to switch, arriving on the West Coast only to return a busy signal. That effort, which can't be charged for because it wasn't a completed call, costs the long distance carrier money to process and ties up trunk circuits between network switches—trunk circuits that could be used to process billable calls.

The inherent capabilities of Signaling System 7 are not limited to call connection alone. It's a technology that has had, and will have, tremendous impact on the services available to end users of voice services such as colleges and universities.

• ISDN Signaling

Out-of-Band signaling is not limited to telephone company and long distance carriers alone. There are implementations of it that will be used as part of ISDN (Integrated Services Digital Network). ISDN is conceived as a way of making the "loop" (or connection between the central office and the user) digital. While ISDN will be discussed in greater detail in the Data section of this chapter, there is bandwidth set aside in the ISDN link for call set-up information. It is used to link the user's telephone set, personal computer, or telephone system to the central office or PBX and to exchange instructions on how to process the call, give the status of the call, and provide other information.

■ Transmission Standards

How is the information that makes up the call carried from one place to another?

While there are many techniques for multiplexing, the one most commonly used for voice telephony networks is based on TDM and uses what's called the North American Digital Hierarchy or "T" hierarchy. The following table shows the rate and capacity of digital links:

Designation	Speed	Consists of	# of Voice Channels
DS0	64 kBits/sec	one 'voice' channel	1
DS1 (T-1)	1.544 mBits/sec	24 DS0 or voice channels	24
DS2 (T-2)	6.18 mBits/sec	4 DS1 or 96 DS0	96
DS3 (T-3)	44.736 mBit/sec	7 DS2 or 28 DS1 or 672 DS0	672
DS4	139.264 mBit/sec	3 DS3 or 84 DS1 or 2016 DS0	2016
Non-Standard	405–432 mBit/sec	9 DS3 or 252 DS1 or 6048 DS0	6048
Non-Standard	565 megabits/sec	12 DS3 or 336 DS1 or 8064 DS0	8064

The North American Digital Hierarchy, while extremely useful, has some limitations. It is *asynchronous,* which means that each DS0 or voice channel contains its own timing (or framing) information. The *standard* is standard only to the DS3 or 45 megabit level. That means to go from one network to another or from one manufacturer's transmission equipment to equipment made by another manufacturer, the signals must be de-multiplexed to DS1 or DS3 levels. The standard is also only standard in North America and a few other places in the world. A similar, but non-compatible, hierarchy system is used in Europe and is known as the "E" digital hierarchy.

The lack of interoperability leads to added complexity in a network and added costs. Additional equipment must be added to shift connections from one system to another. The complexity and lack of interoperability between different vendors' systems also makes network management and network diagnostics harder to perform. To overcome these shortcomings, a new digital hierarchy is being created called SONET, for Synchronous Optical NETwork.

Like the North American Digital Hierarchy, the SONET hierarchy has steps of multiplexing, shown below:

Designation	Speed
OC-1	51.840 mBits/sec
OC-3	155.52 mBits/sec
OC-9	466.56 mBits/sec
OC-12	622.08 mBits/sec
OC-18	933.12 mBits/sec
OC-24	1.244 gBits/sec
OC-36	1.866 gBits/sec
OC-48	2.488 gBits/sec

and so on up to 13 Gigabits per second.

n Transmission Systems

• Cable

Cable systems provide a physical connection between transmission locations, such as between campus buildings or between the campus and the telco. There are numerous installation options for cable systems, such as aerial, direct buried, trenched, or underground conduit. Aerial cable is not usually considered an enhancement to a campus landscape, and is susceptible to weather damage and the occasional vandalistic shotgun blast. The bane of buried cable is the errant backhoe, and underground conduit systems are very expensive. Each installation has its advantages and disadvantages, and their appropriate use is dictated by factors such as cost, availability of right-of-way, aesthetics, terrain, physical security, etc. The two main cable types are:

Copper This cable is used with "T-carrier" multiplex systems which operate at the DS-1 (or T-1) hierarchy rate, equivalent to 24 voice channels. Each T-1 connection uses 2 pairs of wires, one pair to transmit and one to receive; hence a T-1 cable with 25 wire pairs can carry 12 T-1 connections. T-1 cables typically have a metal shield physically dividing the wire pairs into two groups. One group holds all the transmit pairs, the other holds the receive pairs. This shield prevents the digital signals in a transmit pair from electrically "leaking" into a receive pair and causing interference. T-1 signals lose power as they travel through copper wire, and repeaters must be spliced into the cable at approximate one-mile intervals.

Fiber Optic This cable is used with large capacity multiplex systems, with transmission rates ranging from a single DS3 (equivalent to 672 voice channels) up to hundreds of DS3s. Each fiber multiplex system requires one fiber pair: one to transmit and one to receive. Typical fiber cables have from 4 to 50 fiber pairs. Like T-1 systems, fiber optic signals lose power over distance. In multimode fiber, the average range is three miles; for singlemode fiber, ranges of up to 50 miles are possible before an optical repeater becomes necessary. Fiber cable requires extra care during installation, mainly that it not be excessively pulled or bent. Proper splicing of fiber cable is critical and more complex than for copper cable. The ends of the fiber strands must be exactly aligned and held fast or a substantial (potentially disabling) amount of signal power will be lost.

- **Line of Sight**

Line of sight systems connect two or more points without copper or fiber connectivity. Where line of sight is not directly available, it is possible to engineer the system to be reflected or repeated. The two key technologies are:

Digital Microwave A point-to-point telecommunications medium, used by carriers where right of way is too expensive to acquire or outside plant is too expensive to construct. Point-to-point distances can be up to 20 miles without a repeater and greater if a repeater system is used. It is used primarily in the end-user market as a cost effective alternative to telco tariffed offering and as a form of network back-up. Almost all digital microwave conforms to the DS hierarchy (although some are now being released with SONET format).

It should be noted that digital radios and other forms of free air transmission can be susceptible to extreme weather conditions. Heavy snow or rain can attenuate the radio (or optical) signal and strong wind can shift the dishes. The end result is an increase in line transmission errors or complete loss of service.

Free Air Lasers These are the optical equivalent of digital microwave systems, using a laser instead of a microwave beam. The chief difference is that lasers do not require licensing, as microwave does, nor do they require frequency or path research.

The distance between end points is much shorter for free air laser than for digital microwave, typically in the two- to four-mile range. Units can be mounted outside or inside behind a window. Outside, the unit should be mounted in a window that has an overhang to prevent water from dripping down in its path (and thereby redirecting the laser in another direction) and care should be taken to coordinate window washing with scheduled system downtime. You don't want the window washers shutting down your system, nor do you want to expose them to potentially injurious laser light.

Infrared An optical cousin to the free air laser, these systems are more limited in capability but are substantially less expensive. Infrared transmission capacity is only a few DS1s, and the operating distance between sites is measured in yards, not miles. These systems are ideal for temporary service, disaster recovery, or reaching buildings inaccessible by cable, such as a right-of-way denial across a city street.

- **Satellite**

A satellite, at 22,300 miles above the Equator, orbits the earth at the same speed that the earth rotates. To the observer from earth the satellite appears to be stationary above the earth, hence the name "Geo-synchronous."

A communications satellite in geo-synchronous orbit acts as an active "mirror" to bounce signals off. The satellite receives a signal from a transmitter on earth, regenerates it, and rebroadcasts the signal. The rebroadcast signal is then received by other satellite dishes. ESPN distributes its video programming to cable TV providers using this service. Educational seminars—on a one-point-to-multipoint basis—are also conducted in this fashion.

For the business user not in the media industry, the most common type of geo-synchronous satellite network is called VSAT, meaning Very Small Aperture Terminal. It derives its name from the fact that it uses a smaller diameter dish, typically three to six feet, than other forms of satellite telecommunications. The smaller dish is a result of a trade off of higher power and narrower end-user bandwidth.

■ Voice Network Summary

Using the technologies described above, voice networks can be created. Whether it is the network of a long distance carrier, a local telephone carrier, or the telecommunications department of a college or university, the same basic technologies are used. It is regulation, business objectives, and economics that functionally separate telcos from carriers and end users.

Voice Services

■ Long Distance

The networks consist of switching devices, called tandem switches, connected to transmission equipment—either microwave or fiber. Each network forms a web of interconnected switches that route calls or connections between them. Calls are picked up on one end of the network and delivered to the other. While the equipment used is developed and marketed specifically for carriers, the basic technology has been described in other parts of this chapter.

The chief way that carriers differentiate themselves from their competition is by price and/or service. To that end, the billing systems of a carrier are often used to create product differences. Examples of this are MCI's "Friends and Family" and Sprint's "The Most" which take a commodity and package it to appeal to a certain market. There are also technology-based ways that vendors are "customizing" their networks. The key tool in this effort is Signaling System Seven (SS7).

The most common current use of the capabilities SS7 enables is what are called Virtual Networks. Using a Virtual Network, a business user can embed in the carrier's network custom information or use rules that apply only to that business. A company using a Virtual Net can have a custom dialing plan for national or world-wide application so it appears that every distributed site is on the same telephone system. The net can be programmed to ask for authorization codes or programmed to restrict calling to certain numbers or area codes. Custom billing arrangement can be created. Virtual Networks are marketed by a number of different names: AT&T calls theirs Software Defined Network or SDN, MCI calls their product VNet, and Sprint refers to theirs as VPN or Virtual Private Network.

■ Local Exchange

Local Exchange Service has typically been the domain of a monopoly service provider, the telephone company. They, like carriers, use a complement of switches and transmission facilities to create a web of connections within a region or a state. They are the traditional providers of "last mile" connections, the wire that brings service right to your campus.

While there are many similarities between a local telephone company and a long distance carrier in a technology sense, there are many differences in their operational and regulatory environments. Because telephone companies have a very high local presence—they serve 95% or more of residences and businesses in their service area—there is a very high capital investment and operational expense associated with outside plant (cables, telephone poles, duct systems) and a relatively heavy load of requests for service changes, etc. Long distance, in comparison, is a relatively "hands off" kind of business that builds upon the aggregation of customer demand that a telephone company provides.

Due to changes in perception of the role of technology, a newly found zeal for being "competitive," and awareness of the profound effect telecommunications can have on the economy of a state or region, state legislatures and PUCs have been attempting to come to grips with new regulations that will promote telecommunications infrastructure modernization and competition. The local exchange market is about to see some of the upheaval that long distance carriers experienced in the last decade.

Competitors for the last mile include cable TV companies who have been aggressively installing fiber to improve and expand video service and Competitive Access Providers (CAPs) who have been installing fiber optic rings to serve large business customers in urban areas. This competitive drive has received some backing at the FCC with recent initiatives requiring telcos to permit their competitors to "co-locate" equipment in telco central offices and to permit them to offer dedicated and switched telephone service. Congress is also considering legislation that will substantially change the local telecommunications environment.

These regulatory and financial issues will determine, to a large degree, what services are available and their price. If local operating companies survive relatively intact and as competitive providers, some of the services that they hope to provide your organization include:

- **Advanced Intelligent Network**

  AIN is an overhaul of all the internal order processing and service provisioning systems that exist in a telephone company and integration of those systems to a SS7-based switching network. The goal is to create a highly automated telephone company that will respond to requests for service virtually instantaneously.

- **Video**

  To do the massive overhaul envisioned requires revenue. And video services are pictured as a great source of revenue. The operative phrase is "video on demand," where films or TV shows would be stored and retrieved at the viewer's discretion, not the scheduling of a network.

- **Information Services**

  The federal courts, a major change agent in telecommunications policy, have overturned previous bans on the telephone companies providing information services. This reversal has yet to produce an abundance of new services or resources. However, telcos view educational institutions as both a resource and a customer for these services.

The Private Branch Exchange, or PBX

■ PBX Generics

The PBX is one of the most common devices used by colleges and universities to supply telephone service to its users. The PBX is, generically speaking, a "black box" that connects one telephone to another. There are many designs, or architectures, that different manufacturers have used when creating telephone systems. Those differences are often highlighted by manufacturers to make their product unique. The bottom line is that a PBX is basically a commodity device for placing telephone calls that should be evaluated on its price, capabilities, maintainability, and the vendor's commitment to preserving the investment that you are about to make in their product.

PBXs consist of a number of distinct elements, no matter what their architecture. Following is a description of those key components and their function:

- **Common Control**

Common control consists of the processors, or CPUs, memory, the stored program, and specialized devices that define the capabilities and behavior of the telephone system. Processor structure may be a single central processor that controls the entire system or it may be a multi-processor or distributed architecture system. Common control devices include components called *registers* that collect dialed digits, *senders* which store and output dialing digits, *codecs* which convert analog signals to digital and vice versa, and other equipment necessary for the processing of telephone calls.

In general, the common control hardware (and software, to the degree possible) should be redundant both to prevent system outages by the loss of a component and to facilitate maintenance and upgrading. Redundant capabilities vary by vendor. Some systems incorporate it, some don't, and some permit redundancy to be selected based on perceived risk. Generally, redundancy adds to both the cost and the reliability. Determining whether to add redundancy or not is a risk/price evaluation that the purchaser needs to make.

- **PBX Software Features**

The common control software, in addition to providing call set-up instructions, contains a wealth of features that affect both the behavior of the system and how your users will use the system. PBX features and capability are subjects worth an entire book and something that many consultants make very nice livings from. Reviewing and understanding features and capabilities—as well as their interactions—is time well spent during an evaluation.

- **Matrix**

Matrix is another name for the PCM/TDM switching fabric common to all current architecture switching equipment, be it for the network carrier's switch or the PBX on your campus.

There are two key architectural differences in PBXs that relate to the matrix. One design is called "blocking" architecture where there are more stations and trunks on the system than there are talkpaths in the matrix. The design assumption is that not all telephones and trunks will be used at the same time, so the matrix is looked at as a resource that can be shared. Telephones and trunks contend for access to the matrix. If no matrix is available to complete a call, that call can be blocked from being processed.

The size of the matrix in the system that you purchase is based upon assumptions of the amount of traffic that your campus has. Operationally it is also necessary to "traffic balance" the telephone system to make sure that the appropriate number of high and low usage telephone stations contend for a set percentage of the switching matrix.

The second design is called "non-blocking." As the name implies, the matrix is sized so that every line and trunk has access to the matrix without contending for it. This design is especially useful for switches that handle high traffic, such as ACD applications, or that carry large numbers of switched data connections.

- **Station-side Equipment**

Telephone sets, the most visible part of a telephone system, provide a number of functions. Their visibility and functionality make them a key factor in the selection of a telephone system. Not all telephones work exactly the same, and it's worth the time, from a user-acceptance standpoint, to thoroughly evaluate the telephones that can be supported by the telephone system that you select. What the users see, feel, dial, and experience during the installation of your system will dramatically affect how they perceive the system and how they will accept the system.

• **Trunk-side Equipment**

Trunks are the facilities that connect your telephone system to the outside world.

■ Additional Capabilities of Modern PBXs

• **Switch-to-Host Integration**

A switch-to-host computer connection is a generic name for an interface between a PBX and an outboard computer. The outboard computer could be a host computer, a personal computer, a LAN, or any form of processor in between. The interface allows applications and data that are resident on the outboard computer to modify the internal processing of a call in progress.

Using this capability, it is possible for programmers to customize the behavior of the PBX to support specific business situations. For a college or university this might include an on-campus E-911 service that queries a database for room number, occupant name, and other pertinent information, or an inbound calling system for the Admissions Office that automatically brings up the applying student's records and status from a database based upon the calling number of the inbound call.

• **ISDN Interfaces**

Integrated Services Digital Network is a digital telecommunications link for voice and circuit switched data. In addition to passing voice and data in clear 64-kilobit channels, it provides call processing information, in a digital fashion, between the PBX and a network or between the PBX and a station terminal, be it an ISDN digital telephone or a computer with an ISDN board installed.

When considering ISDN capability, be sure it complies with "ISDN National X," with X being the most current release. National 1 is the current release with National 2 to be released soon. National 3 is scheduled to follow that by a year.

• **Integrated Data Communications**

ISDN is one way of providing data services using a PBX. Vendors have a variety of ways in addition to ISDN for shipping data through a PBX. Some use circuit switching, some packet switching, some use outboard processors or networks, and some are proposing using ATM switches.

- **Bandwidth On Demand**

Bandwidth on Demand is a technology that is related to data switching and ISDN. It is the ability to change the bandwidth of connections, in 64-kilobit increments, on a call-by-call basis. It requires software capable of configuring these connections and a switching matrix adapted for the function.

- **Remotable Equipment**

Some PBX architectures have the ability to place equipment outside the PBX using fiber or other transmission. The equipment could be a single line card, a shelf of line cards, or a stack or more of equipment. The equipment is placed closer to clusters of users. The trade off may be cost avoidance for construction of outside plant or a need to serve a site that can't be readily reached with a cable plant.

- **Wireless Stations**

Most major PBX vendors are talking about adding "adjunct" boxes or switches on their PBX that will provide a modest number of "wireless" stations. The implementations are preliminary at this point and will be until the FCC determines which frequencies are available and wireless telephone standards are adopted in the U.S. This topic will be discussed in greater depth in the "PCS" section of this chapter.

■ The PBX of the Future

Is there a PBX in your future? There may not be. Or the PBX of today may evolve into a "bandwidth controller" that does everything. No one is sure, least of all the PBX manufacturers themselves. Following are some directions currently discussed for the PBX market:

- **PBX as Local Area Network**

In this proposed model, the PBX will become a highly distributed set of boxes, all interconnected with high bandwidth fiber. The boxes, or more correctly hubs, will reside in local telecommunications closets, and they will provide voice, data, video, and image transport through a common set of local wires. There will be integrated management across all functions, and the PBX will manage all local and wide area communications. This is the model put forward by most PBX vendors.

- **Local Area Network as PBX**

With this feature, as proposed by manufacturers of local area networking equipment, the PBX becomes a "voice server" attached to an ATM LAN. LAN hubs (instead of remote PBX shelves) reside in closets and serve voice, data, video, and image applications through a common set of wires. Does this architecture description sound redundant? The key difference is who—what companies—will "own" the turf. Will predominantly voice vendors become the vendor of choice for all data needs? Will hub and router vendors be your choice for voice? The answer will probably be a compromise.

- **The LAN-controlled PBX**

Both Microsoft, through its "Microsoft at Work" program, and Novell in conjunction with AT&T are proposing a set of commands or Applications Program Interfaces (APIs) that will permit the PC on a desk top, through applications, to monitor and control the telephone serving that desk. The APIs, which also extend to voice mail, fax, and other office equipment, will permit the user to create and use automated directories, control voice mail, have a "screen pop" of who is calling before the phone rings, etc.

- **PBX as Bandwidth Controller**

One vision for the PBX is that it will become the gateway between the services on site and the rest of the world. It will have high speed SONET or MAN (Metropolitan Area Network) interface to the outside world and will function as a protocol converter between communications techniques used on the premise and those used outside. In this scenario, the PBX's matrix is most probably an ATM switch.

■ Purchasing a PBX

- **Commodity**

Remember that voice switching services are basically a commodity. Buy on price, service, and support—not on name alone. And shop around. In these days of tight institutional budgets, competition is a wonderful thing.

- **Understand What You Are Buying**

Don't rely on a consultant alone to make your choice for you. Be sure your staff understands the vehicle that you are selecting and why you are buying it. It's often said that "The Devil is in the details" and, to extend the metaphor, the devil you know is better than the devil you don't know.

- **Take a Broader Perspective**

Look at your institution as a whole and leverage the opportunity to install a PBX, and especially a wiring plant if you are doing that too, as an opportunity to improve the telecommunications infrastructure for the entire institution. Think longer term and think about the other applications like data, video, building management and control, etc.

- **Buy What You Need**

Your vendor may suggest options, but *you* must determine what you need. You may want to think about buying a system that is capable of performing XYZ function. Buy it, but if you don't need function XYZ immediately, don't buy it now. Cards and equipment that are purchased and sit idle get outdated quickly. Newer versions of the card are issued, applications change, or you might never really need to do XYZ. Better to develop a capital plan and bring that function on-line when needed.

- **Plan for Growth**

Don't size your duct plant, your cable plant, your switchroom, or your PBX for what you need at day one. Think ahead. The more fixed the asset, like duct runs, the more you need to think in terms of decades instead of years. Be sure your switch is expandable and make sure the vendor isn't selling you a product that they are going to decommission in a couple of years.

- **Think About Your Users**

It's both easy and fun to focus on the technology. But it's the people that count and it's your users who will make or break your installation. Sweat the details on what the user sees, what feature set they will need, what the feature access codes are like, how the phones work, how the user is trained. The list can go on and on. The better you cover points like this, the more successful your cutover will be. A telephone system will almost always "function" by just pulling it out of the box and plugging it in. Implementation problems usually stem from human failure in planning, logistics, or project coordination.

Centrex

Centrex is a telephone-company owned and operated "PBX" that is typically provided to an institutional or business customer on a lease basis. While technically a central office switch and not a PBX, the system provides PBX functionality including DID service, 4- or 5-digit intercom dialing, support of electronic key sets, attendant capabilities, etc. In most cases the equipment is located in a telephone company central office and delivered to the customer's premise over telco outside plant.

One of the aggressively promoted features of telco provided Centrexes is ISDN, the functional equivalent of "data through the switch." Other promoted features are reliability, no need to budget for technical upgrades, and no need to staff up because the maintenance and support are "outsourced."

The degree to which the user chooses to become involved with a Centrex is up to the user and the telco. It is possible to have a remote maintenance terminal that will permit changes to station functionality in near real-time. Some telcos permit changes to the outbound network routing tables or to other system functions. The systems can, and do, support outboard devices like voice mail, integrated voice response, and other telephony based applications.

The choice between a Centrex and a PBX comes down to issues of money and institutional preference. An institution must weigh the facts of staffing and management requirements for a PBX vs. those for a Centrex (even if the telephone function is "outsourced" to the telephone company, there will still be a need for college and university staff and management). Each institution has its own philosophies and approaches toward management and technology. They will also influence the decision.

Choosing a Centrex

Choosing may not be the correct term since there will not, for a while anyway, be competitive Centrex offerings from which to choose. Typically there is one telephone company and they will be offering one flavor of Centrex. That being the case, here are some things to keep in mind:

- **Create Competition**

  Centrex isn't a competitive offering. Make sure you test your Centrex offer against the economics of installing your own PBX. In spite of Centrex being a tariffed offering, the telephone company will be much more flexible if they believe that there is a strong possibility that you may indeed install a PBX from a competitor.

- **Negotiate Hard**

  Don't take the first offer that is presented to you. You may not even want to take the third or fourth offer. Evaluate hard and negotiate harder.

- **Think About Growth**

  Do your best to anticipate growth (it's a lot tougher than it sounds), and do what you can to compensate for it in the contract, especially if you are negotiating a multi-year contract.

- **Think About Your Whole Institution**

  Keep the big picture in mind, especially when negotiating the contract. Beyond ISDN, how can data be best served?

Should you roll in an SMDS implementation? A fiber ring? A Metropolitan Area Network? Do your data or video organizations need to get to distributed locations that the Centrex will easily reach but that their networks won't? Think beyond dialtone—think infrastructure.

- **Think About Your Phone Company**

In getting ready for negotiations, think about what your telco, as a whole institution, is trying to achieve. Are they looking to get into the video market? Information services? Work-at-home support? Hospital and medical networking? Select an area or two and think about writing in a joint implementation project that is beneficial to your institution and to them.

- **Think About Your Users**

Same advice as for a PBX but with one additional warning. There can sometimes be a warm, fuzzy feeling that "the phone company will do everything for us." Certainly they will bring in lots of well trained, professional individuals, but the goals of your institution and requirements of your staff need to be championed and promoted. It is very easy for telco staff to get involved in the mechanics of putting the system in and inadvertently miss the fine points that will make the install both an immediate and long term success.

Whether you choose to install a PBX or a Centrex, you need to remember that you are doing more than taking care of voice service. You have an opportunity to enable the future. If you make the right choices and negotiate the right deals now, you will position your college or university to cost effectively implement other telecommunications applications and services in the future.

Enhanced Communications Services

■ Paging

One of the first, and still most widely used, wireless services was radio paging. With changes in chip and display technologies, pagers have shrunk from over a pound in weight to an ounce or less. While the weight has gone down, their functionality has gone up. Initially, pagers were tone only, giving no indication of who called. The recipient had to call back to a message desk to see who had called. That was followed by voice, which while conveying more information, did so in a squawk not unlike a parrot in pain. Current beepers have evolved into display units showing either the call-back number of the individual paging them or full, scrollable text message. It is safe to assume that further developments will occur as allied technologies progress. It's easy to imagine fax- or video-capable pagers.

■ Voice Processing

Voice Processing is a hybrid technology that combines elements of voice telephony and information processing. Simply, it is using voice systems to convey or collect computer based information. It should be noted that the services mentioned below are artificial separations, and often products provide functionality for two or more classifications. Following are some voice processing applications:

• **Voice Mail**

The most common, and perhaps most hated, voice processing application is voice mail. Who hasn't called a company and been put in "voice mail jail" or felt that a service provider might just be hiding behind voice mail. The effect of poor implementation and use noted, voice mail (or v-mail) is merely a store-and-forward technology. Simply, a voice is digitized, compressed, and stored on a disk, and then retrieved, expanded, and played back upon request. That's the science of it. The art of it is in its effective use. Training users how to use it well, tailoring its implementation to promote, not hinder, the work of a department, and continuous refinements are the hard part. Key voice mail services are:

Voice Mailboxes The most common usage, essentially a centralized telephone answering machine. While perceived this way, voice mail is actually more. It provides confidential message storage in group settings, it typically has the ability to answer directly to the mailboxes of callers if they have a mailbox on the same system, and it provides message storage and forwarding functions.

Mail Messaging Using voice mail and pre-programmed distribution lists, it is possible to create a single message that is sent to many individuals' mailboxes.

Mail Notification Using either interfaces to a PBX or Centrex or by dialing into a paging system, it is possible to notify users that they have received a message. Using paging, the systems can usually outdial a specific numeric code for digital beepers to indicate a mail message.

Automated Attendant After voice mail, the second most common function is automated attendant, whereby the caller is asked to respond to statements with touchtone keystrokes: "For marketing, press 1; for sales, press 2..." The system then interacts with the PBX or Centrex and routes the call to the selected department.

Announcements Simply, providing information such as hours, holiday schedules, snow day information, or directions. This function can be made interactive, and perhaps more valuable, by utilizing automated attendant functions.

■ Integrated Voice Response

IVR is the abbreviation for Integrated Voice Response which is interfacing a computer application with a device that will translate spoken requests or touchtone key entry into computer commands that interact with the application. Going from the host to the user, the IVR device or function will annunciate the text or numeric information provided by the computer for the user.

Typical uses for a college or university might be account balances on a student credit card, status of applications or loans, or grade information. As with all voice-related applications, success depends on good design and execution of the IVR interface.

The IVR interfaces are relatively straight forward. The key issue is having the correct information available in a database in a form that can be accessed. If the information cannot be readily accessed or is not accurate, IVR, as a technology, is useless.

■ Fax Mail

Like voice mail, fax store-and-forward consists of a digitized and compressed representation of an original analog fax modem signal. Upon request, just as with voice mail, the digitized record can be recalled, decompressed, and converted back to an analog signal. That signal is then sent out over phone lines to another fax machine. The record can be retrieved by individuals to be sent to a specified fax machine, or the fax machine can be instructed to repetitively send it out to many distributed fax machines.

The key use for fax mail is distributing written documentation on request. The inbound fax is received by the fax mail service and put into an individual's mailbox. The user can then retrieve the message by directing the system to dial and output the message to a local fax machine. Using fax-to-text conversion software and voice synthesis hardware and software, it will be possible in the future to instruct the machine to "read" the fax message to the user over the phone.

■ Switched Video Teleconferencing

Switched Video Teleconferencing is somewhat the darling technology of the early '90s. It has seen fairly rapid growth in the number of units on the market. While not a new technology, it hit its stride once an international standard for intercommunications became available. That standard is called CCITT H.261 and it describes how a video image is compressed and transmitted at various speeds. The speeds are increments of 64 kilobits per second from 128 kilobits to a full T-1 at 1.544 megabits per second. It's the logical equivalent of the Group III fax standard that promoted the ability of different manufacturers' fax machines to communicate with each other.

H.261, or "P Times 64" as it's often called, is not the only method of digitizing and compressing a video signal. There are many techniques, most of them proprietary. In many cases the proprietary techniques, or algorithms as they are known, produce superior video images to the H.261 standard. The drawback of the proprietary algorithms is that one manufacturers' equipment can only "talk" to equipment made by that manufacturer. In fact, sometimes they can only communicate with devices made by the same manufacturer if they are at the same revision level of the encoding algorithm.

The future of video seems promising. Computer manufacturers are rapidly integrating video capabilities into desktop machines. The cable and telephone companies are working on allied technologies that will spill over and ultimately improve the product. The computer and networking operating system companies such as Microsoft and Novell are integrating hooks for video into their products.

■ Cellular and Personal Communications Systems

Cellular radio works by breaking up a geographic region into a series of smaller radii or "cells," each served by a radio and antenna system. Each of these local transmitters is networked back to the equivalent of a Central Office. There is also a command and control network, akin to SS7 signaling.

As a vehicle moves across a region, the user's cellular telephone negotiates with the local transmitters. As the vehicle approaches the edge of a cell, the command and control network simultaneously transfers the call from the transmitter in one cell to the transmitter in the adjacent cell and instructs the user's telephone to shift to a preassigned frequency in the next cell. Very little interruption occurs as the call is transferred.

The present cellular radio system in the United States is analog. While its architecture is a vast improvement over older technology, it is being phased out. It will be replaced by digital cellular. The digital cellular will also be complemented by a service known as Personal Communications Services (PCS), which essentially means a wireless telephone or data device that is tied to a building or a campus. Both technologies will work in a similar fashion.

The architecture of cells and the technique for handoff will remain essentially the same for digital cellular and PCS. For digital cellular it will be a regional service with transmitters located every few miles; for PCS the transmitters will cover a floor of a building or a small section of a campus. Digital cellular will be connected to a regional network which in turn will be connected to the public switched network, just as analog cellular is now. PCS or wireless telephones will be connected to a PBX or special PBX-like device on a customer premise.

Data Networks

■ Dedicated Circuits

A dedicated circuit is what appears to be a point-to-point connection: Terminal "A" is plugged directly into host computer "B" as if there were a direct cable. Typically, there isn't a dedicated piece of wire connecting the two locations, but a dedicated circuit gives the appearance of being a cable. Information isn't shared by multiple terminals or hosts and the connection is always there. There are no procedures for "dialing" the call, selecting who you want to connect to, or determining the speed at which you wish to communicate. The circuit is yours; it's dedicated.

Dedicated circuits, when implemented in a wide area, share the same transmission infrastructure as is used for the voice network. Digital information can share the same path as digitized 64 kilobit/second voice traffic. The transmission equipment cannot tell the difference between voice bits and data bits. However, there are some differences.

Since the equipment can't tell the difference, you should be able to send your data at 64 kilobits, right? Not quite. As mentioned earlier in the chapter, the predominant transmission equipment installed in the network is "asynchronous," meaning that timing is independent by connection. In order to ensure timing from end to end, which means that the digital code can be properly decoded by the receiving end, transmission equipment uses an organizational technique called framing. These bits, which provide timing, in-band call signaling, and organization, steal 8,000 bits of every 64,000 bits. The signaling technique is called "bit robbing" and it yields a transmission speed of 56,000 bits per second. The loss of 8,000 bits per second, which would be the loss of 1,000 characters per second, would be disastrous for data communications. It isn't disastrous for voice as the mind compensates for the missing information.

■ Circuit Switched Data

The model for circuit switched data is switched voice service. A machine, instead of a human, "dials" or outpulses a digital sequence that is a request for a connection, and it includes the destination "telephone number." As with voice calling, the switches between recognize the numbers and route the call accordingly. On the receiving end, a machine answers and the connection is made. And, like voice calling, there is a toll for long distance (and in some cases, local) calls. Circuit switched technology can be implemented within a Private Branch exchange, within the area served by a telephone company, or nationwide or internationally through a carrier. Below are the key types of circuit switched data:

- **Data Through The Switch**

The primary type of data through a PBX is switched data. Using base voice switching technology, "data telephones" can make connections between themselves just as voice telephones can. A data station can then, on an as needed basis, connect to any computer that is attached to the PBX. A user may need to work in the morning on an administrative application that is resident on a mainframe, so he "dials" into that. In the afternoon he needs to get to an academic application on a mini-computer, so he "hangs-up" from the mainframe and dials the mini-computer.

- **Switched 56 Service**

If you extend the internal model of a PBX to a telco or carrier's network, the first model of circuit switching was Switched 56 Service. It was a pre-cursor to standards. You could call from one data station to another as long as all stations were on the same network. AT&T users could call AT&T users, Sprint users could call Sprint users, etc.

- **Integrated Services Digital Network**

ISDN was first envisioned as a way of automating the creation of dedicated circuits and then as a way of creating switched digital connections, on demand, on the model of the Public Switched Voice Network. In this model, connections would be set up and torn down on a one-by-one basis by intelligent machines instead of by people dialing: a data call to a stock broker, a subsequent call to the bank, a third call to the office. These are all terminal-to-host type connections. What the model didn't envision was peer-to-peer processing, where multiple computers need to communicate to perform functions. The two types of ISDN interfaces are:

Basic Rate Interface A BRI link is a 144-kilobit-per-second digital link that consists of two 64-kilobit Bearer or "B" channels (total 128 kilobits) and a 16-kilobit signaling or "D" channel. The data link protocol of the "D" channel is X.25, with the signaling protocol called Q.932. The data link, besides being used for call set-up and Automatic Number Identification, can also be used for other forms of packet data transport.

Primary Rate Interface PRI, the "big brother" of BRI, is a method of connecting end-user devices such as PBXs to other PBXs, to local telco offices, and to carriers. It is based on the T-1 transmission standard of 1.544 megabits, which is the equivalent of 24 multiplexed channels of 64 kilobits each.

Using inband signaling, a T-1 connection provides 24 simultaneous connections. When a T-1 is provisioned as Primary Rate, it provides 23 digital circuits of 64 kilobits each and one 64-kilobit circuit for signaling and information transport. The terminology for the digital circuits is "B" for Bearer and "D" for the signaling link. The datalink protocol on the "D" channel is X.25 and the signaling itself is defined by a CCITT standards known as Q.931.

■ Packet Switching

You will note that with switched and dedicated circuits there is a potentially large amount of bandwidth, 64 kilobits or 8,000 characters per second, reserved for a single connection that may be used for keyboard entry or typing. The output from typing is only a dozen or so characters per second. It's not technically efficient use of bandwidth. Packet switching is both a switching technique, in that it routes connections, and a multiplexing technique in that it lets many data devices share a modest amount of bandwidth as opposed to each having dedicated bandwidth assigned as in circuit switching.

Conceptually, packet switching is taking a set of data to be transmitted, breaking it into smaller units, "enclosing" the units into digital envelopes that contain address and routing information. Those "envelopes" or packets are then sent over a network with the packets of information from other communicating devices. The individual packets share a common circuit or are multiplexed. Using the unfortunate analogy of the Post Office, the packets get sorted, or switched, by the addresses on them and are then routed on a different circuit. In a large network they may be sorted and rerouted numerous times.

At the destination end, the packets are separated from packets belonging to other communicating devices. The packets are checked for errors, stripped of their envelopes, returned to their original sequence, and presented to the computer they were destined for. The process is repeated in reverse when the computer wishes to communicate back to the device that sent it the message.

The packet switching technique described above is called X.25. It is one of many protocols that use packets as a basis for organization and routing. Other techniques will be discussed in the LAN section of this chapter. X.25 is useful for transaction-type networks, because it can accommodate small packets and because of its error correction capabilities.

While packet technologies to date have been very logical and cost effective for data, the contention for bandwidth, the error correction, and lack of assured timing have made packet technologies unusable for voice and video connections. Sound quality becomes choppy, much like the effect of a poor quality speaker phone, or the image may break up. However, that may all change with technologies such as ATM.

■ Asynchronous Transfer Mode (ATM)

ATM is a packet-based switching technology that is just leaving the labs and making its appearance in trial applications by carriers, telcos, and providers of premise equipment. Its packet is a 53-byte "cell" or "fast packet" that contains routing information. ATM routing and cell handling generally follow the model explained above for X.25, but do not contain the high degree of error checking that X.25 has because ATM was developed assuming "reliable" fiberoptic transport system.

ATM is viewed by some as a "grand unification" technology. Its 53-byte cell could become the next PCM as voice, data, video, and image devices become adapted to output digitized information in that format. The concept is that ATM will be able to overcome the technical shortcomings that keep digital voice structured differently from data. The speed of switching, the error free optical transport, and a common format will allow all packets to be treated equally. The concept is that the small, consistently sized cells are "granular" and can be readily intermixed. That means that in multiplexing together packets from voice and video, which require a consistent delivery time, those packets can be given regular access to the bandwidth. Data, which is typically much less sensitive to delay, can be fit between the regularly scheduled voice and video packets. The concept is that voice will not be choppy because it will not be interrupted or delayed by data nor will data languish inefficiently in pipelines designed to meet voice bandwidth requirements.

■ Local Area Networks (LANs)

As the name describes, LANs provide data communications (for the present time, anyway) in a local area such as a work group, the floor of a building, or within a campus. The origin of LAN technologies can be thought of as an extension of the backplane of a computer. Computers communicate with peripherals over shared copper circuits known as a "buss." In most LANs it's as if that buss were stretched out across the office and connected to other computers in the office. They deal with each other, over a single circuit, as if they were peripherals of each other. The analogy from telephony is having several individuals share a party line. Following are descriptions of the major LAN technologies:

- **Token Ring**

Token ring's name is a dead giveaway as to how it functions. Every device on the network is "daisy chained" to the next device on the network until all devices are reached and a ring is formed. A special data packet known as a token is passed from one device to the next—the logical equivalent of passing the baton in a relay race. If you have the baton, you run; if you don't, you wait. If a PC is in possession of the token, it may broadcast a message packet. When it is finished broadcasting its message, the PC regenerates the token and sends it along to the next PC. That PC may choose to broadcast or not. If it doesn't, it regenerates the token for the next device. Round and round the token goes, in a very structured and predictable pattern. Typically, token ring communicates at 4 or 16 megabits per second.

- **Ethernet**

Ethernet is another buss-based technology that uses packets as its methodology for transferring data. Unlike token ring which uses the token system to regulate access to the buss, Ethernet uses a protocol called Carrier Sense Multiple Access with Collision Detect (CSMA/CD).

CSMA/CD is best thought of as being in a room with a number of people. When one person is talking, everyone listens (that's the Carrier Sense Multiple Access part). If two or more people start to talk at once, everyone stops for a moment and the most dominant person starts talking first. For computers on an Ethernet, it's pretty similar. All attached devices can receive any message broadcast, but only act if the packet is addressed to them. Essentially they are in listen mode. If they need to broadcast a packet, they may—as long as no other device is broadcasting a packet. If two devices start to broadcast at the same time, the data packets sent are scrambled and it appears to be a collision. Both broadcasting devices stop shipping their message and then wait a random amount of time to attempt to broadcast again (that's the Collision Detect part of the name). Most Ethernets are clocked at 10 megabits per second, but standards are being developed that could move it up to 20 or 100 megabits per second.

- **Fiber Distributed Data Interface (FDDI)**

Another buss technology, this one based on optical fiber instead of copper. FDDI is a transmission technology with a 100-megabits-per-second bandwidth available to be shared by all the devices attached to it, just as ethernet and token ring share their common bandwidth among all attached devices. The technique used to coordinate and control access to FDDI's ample bandwidth is a token passing scheme similar to the one used in token ring.

• ATM as a Local Area Network

While described above as a switching technique, ATM will also have a role within the premise as a transport medium for voice, data, and digital video. ATM will most likely be transported using SONET transmission. That will give it a scalable bandwidth, added to in 50+ megabit hunks, that ethernet, token ring, and FDDI will not have. ATM is today being used to deliver 52 and 155 megabit dedicated bandwidth to individual workstations over existing copper wiring. The network bandwidth can then be further scaled upwards by using fiber to the wiring closet.

At the present time, however, standards are not fully developed. Vendors do, indeed, have products available but they are limited function devices supporting data only. Protocols, or agreed methods for doing things, have yet to be completely defined for internetworking data, voice, and video.

■ Wireless LANs

Much press coverage is given to the topic of wireless communications in general and wireless data networks in particular. The key applications for wireless are to provide data connection for mobile users and in locations where traditional wire installation is too difficult or expensive. There are also some intra-premise mobility issues, especially for staff whose job entails moving or for workplaces such as warehouses, parking lots, or athletic facilities. Following are some of the key wireless technologies currently in place:

• Packet Radio

Packet radio communications is one of the oldest forms of wireless data. A constant carrier frequency is used, and shared by, multiple transmitters. Commercial packet radio systems are in production. Ardis, a company co-owned by IBM and Motorola, is one service provider and RAM Mobile Data is another.

• Infrared LANs

Using the same technology principles that are used for packet radio, infrared can be used within the small confines of an open office area or a classroom. Inherently the technology is less expensive, using commodity Light Emitting Diodes (LEDs) and receivers that are used in consumer electronic devices. At this point there are no standards developed for this communications protocol. However, such a standard will be critical if manufacturers are to successfully sell wireless devices such as Personal Digital Assistants.

■ Circuit Switched Wireless Data Communications

This differs from packet only in that a dedicated channel is used for wireless communications instead of a common channel with uniquely addressed packets. The overall use concepts remain the same, allowing people to reach or generate data no matter where they are.

Circuit switched wireless data will be built upon digital cellular or, within a premise or campus, Personal Communications Services (wireless telephone service). Instead of voice, a data connection can be created, probably at 32 kilobits.

Data Internetworks

■ Internetworking of LANs

Internetworking is the connection of individual networks with other networks, both within a premise and between one's premise and the outside world. This is a massive subject, critical for the success of telecommunications for colleges and universities. This section will cover only the high points of internetworking. What should be remembered is that internetworking is often across unlike systems—different operating systems, different manufacturers. What is needed is a common set of standards that will enable common transactions to be performed. Two key items are:

- **Address Conventions**

One of the key items of networking is the standardization of addresses. Without consistent structure of addresses and without safeguards to prevent addresses being assigned multiple times, messaging would be possible only across smaller, private systems. Network addresses are presently issued by an organization affiliated with the National Science Foundation.

- **Protocols**

Protocols, or the rules of how transactions are performed, are also key to reliable interexchange of information. If you can send a message to a different machine but it cannot be understood or acted upon, you may have a connection but you don't have communications. Protocols enable communications.

During the 1970s there were initiatives, primarily by the Defense Advanced Research Project Administration (DARPA) and research universities, to create common machine-to-network and machine-to-machine interfaces. The result was the protocol called TCP/IP or Transaction Control Program/ Inter-Processor. TCP/IP provides some of the following functionality:

TelNet Host to terminal communications

FTP File Transfer Protocol, the ability to retrieve a file from another machine.

SMTP Simple Mail Transfer Protocol, standards for mail exchange between disparate systems.

A wide range of interoperability functions can be built based on these and other protocols. Interoperability is an important capability whether it takes place within a local area network or across a continent.

■ Wide Area Networks (WANs)

Wide Area Networking is the term used to describe transporting data information from one premise to a distant location. Local Area Networking techniques, because of their origin as "extended computer backplanes" hit the wall after a few thousand feet. Within a large premise or in a campus environment, these techniques are overcome by segmenting the network and using devices such as repeaters, bridges, or routers to regenerate signals or limit their propagation.

When leaving the property for which you control the right of way, the choice of digital transmission technologies shrinks rapidly. For wide area telecommunications, the only game in town is the DS hierarchy. The name of the game then becomes "How to get the most data transmitted for the least amount of money." The options for the user include structuring a dedicated network for the institution or using data network services provided by a carrier or telco.

■ Private Internetworking

For private internetworking, a school evaluates its data traffic (and perhaps its voice traffic as well) between sites and makes a determination that there is sufficient traffic to effectively use the bandwidth available in a leased dedicated circuit. The circuit could be a 56 kilobit line, a T-1 circuit, or a T-3 circuit. The key point is that to make it cost effective the line should be used as much as possible, around the clock, to get the most out of the fixed rental that is paid to the telco or carrier every month for that service. While there are many techniques for connecting multiple sites, some dictated by the data equipment or vendor support, following are two key technologies:

- **Multiplexing**

Multiplexing, as mentioned earlier, is a technique for having many devices share a limited bandwidth. Using the assumption that not all devices will need to communicate at the same time, "intelligent multiplexers" were created to parse out access time to the bandwidth on an as-needed basis. Manufacturers such as Network Equipment Technologies (NET), Ascom Timeplex, and General Datacom all make high end muxes that can integrate voice and data traffic and ship it over dedicated, point-to-point circuits.

• **Internetworking**

Limited to LAN-to-LAN application, internetworking is done by having a bridge or router with a DS transmission interface connect to a leased line. The leased line terminates in a second bridge or router at the distant end.

■ Public Network Offerings

Private networking has a number of potential risks associated with it. As an institution grows or needs to communicate with additional sites, the ongoing cost of monthly rental for circuits to link the sites can become staggering. Ensuring that the capacity of the network is effectively used and that the network is in good working order can be a management problem. Lack of bandwidth at peak hours can have a ripple effect on productivity right through the school. Each of the services below can be described as "bandwidth on demand," whereby the user can send as little or as much data as needed on a moment-by-moment basis. The user orders a fixed-price-per-month connection to the carrier's network and is then charged on a utilization basis for transactions across that network. The billing is typically per 1,000 packets (kilopacket). Due to the bursty traffic nature of LANs, traffic monitoring and cost analysis may be more difficult than circuit switched voice and data services. Historical trend analysis of bills may be the best approach but it does introduce delays into the decision process.

As an alternative to building a private net on its own, a school may wish to consider using a networking service provided by a telco or carrier; however, kilopacket traffic charges should be monitored and cost studies performed to ensure that private services are not more cost effective. A hybrid public/private net may be a cost effective alternative for some corporations.

• **X.25**

X.25 is readily available as a protocol supported by front end processors, routers, and other data communications devices. While suitable for transaction processing and line-by-line interactive sessions, there are performance limitations for full screen sessions.

- **Frame Relay**

Frame relay is a slimmed down version of X.25. The X.25 protocol stack has many layers of error correction and packet integrity checks. Frame relay removes some of those layers because the inherent reliability and low error rates of today's digital networks make them less necessary. Fewer layers of software equals less processing of the packets which means faster throughput. Typically, frame relay is described as a T-1 (1.544 megabit) service. As with X.25, frame relay requires the setting up of virtual circuits, which means that the network manager must define what endpoints they will connect to and determine the preferred speed of that connection.

- **Switched Multimegabit Data Service**

SMDS uses the same 53-byte cell structure that is the foundation of ATM. It differs from frame relay in a number of distinct ways. It is a "connection-less" protocol which makes it more like an Ethernet or token ring than the circuit oriented X.25 or frame relay. It is designed to support applications requiring a constant flow of data as well as bursty LAN-to-LAN data. This becomes critical for digital video or real time voice applications. Lastly, in its design SMDS is scalable up to the gigabit range.

- **Asynchronous Transfer Mode**

The ATM structure will again make itself known through other services, most notably broadband ISDN. If digital HDTV develops, if telcos are allowed into the cable TV business, if the country builds a fiber-to-everywhere network, there will be incredible cross-pollination between residential markets and business markets, especially in the manufacturing and transmission areas. That could drive the cost of equipment and connect time down and make broadband ISDN a viable service for business.

- **The Internet**

The Internet is an international collection of networks. It has grown by word of mouth, each net that is added enhancing the value of the whole. In the United States the highest tier of the Internet is a DS-3 (45 megabits/second) network connecting a number of supercomputer and research centers. The network is run by the National Science Foundation (NSF), a not-for-profit network, and it has strict rules regarding the transport of commercial or profit-making companies' traffic.

The next tier in the nationwide network consists of the regional carriers who are quasi-commercial organizations who serve both nonprofit institutions such as colleges and universities as well as profit-making companies. The traffic of the for-profit companies is shunted off instead of being transferred to the NSF network. The regional carriers, in theory at least, serve a physical territory. While this was true during the inception of domestic Internet services, due to the increased popularity of the Internet there has been a dramatic increase in the past three years of the number of connections. As a result the regional carriers are competing with each other and with established commercial carriers such as Sprint and MCI for market share.

While connectivity is the key element of telecommunications, one should not forget the real purpose of the connectivity: Information. The Internet is a wealth of information. If you have not taken the opportunity to "browse" it, you should. There are also several books published on it available from your library or local book seller.

Video

As an interactive, telecommunications-based service, video is in its infancy. Most video today is transported on dedicated, high bandwidth networks using satellite channels and coaxial networks. The great majority of video is transported as an analog signal. Following is a brief discussion of where the industry is and where it might be going:

■ Analog Video

The broadcast video market is evenly split between traditional radio-based broadcasting service and CATV service which serves a dedicated market by delivering the video signal on copper and fiber cabling. In both cases a carrier frequency is modified by analog video input and then transported to the end user, either by cable or by radio waves.

■ Digital Video

Driven by the same technological currents that are driving all telecommunications related technologies—Digital Signal Processor DSP, microprocessor, multimedia, regulations, standards—video is about to undergo dramatic changes, not necessarily in content, but in production and delivery methods.

When thinking about digital video production, one needs only to look at the totally digitally created dinosaurs in the movie Jurassic Park or the special effects of Terminator II to realize the power and capability of digital tools. On a transport basis, the carrying of digital video presents some challenges as awesome as Jurassic Park's tyrannosaurus. Digital video will devour bandwidth.

Due to research work for both teleconferencing and for high definition video, new compression algorithms have been developed that can produce quality video programming at much lower transmission speeds. With compression, a high definition video signal will fit in a standard broadcast channel that presently carries regular video. Standard, or NTSC, TV signals, will be compressed so that up to 10 channels could then be carried in the bandwidth reserved for a single non-compressed NTSC channel. While there is no official standard for NTSC digital compression yet, the leading candidate is called MPEG II which was created as a standard by a consortium known as the Motion Picture Experts Group from which the standard draws its name.

How can you prepare for digital video? At this point, the best short term strategy is to attempt to keep current on video and follow the trends. If you are going to be putting in fiber, it would probably be wise to put in some single-mode as well as multimode. If you are going to be installing an analog CATV system, make sure you understand your vendors' technical development plans. If you are buying your system from a "turnkey" supplier of video systems, make sure the contractor knows the migration plan for the equipment that they will be providing and that your long-term interests are being considered.

Chapter 3

Student Services

Providing student services on a university campus presents a delightfully symbiotic relationship between the need to serve a primary component of the campus community and the need to raise funds to serve that component.

Student services generally fall into two categories. *Residence services* enhance the student living experience and often generate revenue. *Administrative services* enhance and improve the administrative and educational interaction between the students and the university.

When student telecommunications services are being discussed, residence services most commonly come to mind. These have traditionally included the provision of dialtone to student rooms and the resale of long distance service, but increasingly they include data services, video services, and a variety of others. Residence services are valuable to the university because they can generate substantial outside funds as they make student residence halls a more attractive housing option.

Administrative services such as touchtone access to registration or financial information enhance the student experience by increasing the access to information, reducing the time spent standing in line, and enhancing communication between students, faculty, and administration. They can also increase faculty–staff efficiency.

Chapter 3, Student Services, was written by **David Barta,** Telecommunications Manager, University of Oregon.

Residence Services

■ Options

A variety of services is offered to dormitory residents on campuses across the nation today:

• **Telephone**

For decades universities have been providing some sort of telephone services, whether it be payphones or hall phones in residence wings. This level of service required a minimal university financial commitment and supplied the basic security and outcalling services but little more. Many universities have replaced this smattering of services with the provision of at least one dialtone to every student room and have layered a wide array of other telephone services upon that. These services include voicemail, an assortment of calling features such as call waiting and three-way conference calling, and the highly lucrative resale of long distance service.

• **Fax**

As facsimile services have become a ubiquitous business tool and have begun appearing in more and more homes, students are needing increasing access to fax facilities. Universities can place faxes in centrally located areas and send faxes on a cash or credit basis. They can also contract with vendors who can provide the same service with credit- or debit-card operated machines. As facsimile machines are more commonly attached to university data networks, fax transmission and reception can also be provided from there.

• **Directory Assistance**

CD ROM telephone directory databases can be purchased to enable the campus operators to provide directory assistance service to the campus. This service is traditionally a fee-per-call service provided by the telephone companies. It can be supplied to students free or for an added charge. Making the data base accessible through the network permits queries to be performed without adding clerical staff.

• **0+ Calling**

Most universities contract with one carrier to be the primary carrier of 0+ calling services, receiving a commission in return. Providing students with telephones in their rooms will substantially increase the use of this service and the corresponding commissions.

Recent decisions by Congress and the Federal Communications Commission (FCC) have designated hotels, hospitals, and universities which allow residence hall telephones access to off-campus operator assistance as aggregators. Aggregators are immediately required to provide access to 0+ carriers in addition to the institution's designated carrier via 800 and 950 numbers. They are also required to post notices on or near telephones providing specific 0+ access information to students and eventually to provide 1-0-xxx-0 dialed access. The proscribed time period depends on the cost of changing the installed telephone system to accommodate this requirement.

- **TDD**

The Americans with Disabilities Act has mandated equal access to facilities for persons with disabilities. This may take many forms, but particularly it requires some provision of TDD services or translation services to students, faculty, and other users of the university who have hearing impairments.

- **Cable TV**

A significant percentage of the current generation of dormitory residents has been raised in an environment which included cable TV. They have come to expect that if cable TV is not provided as part of their student housing, it will at least be available. While universities are still debating whether entertainment television should be provided to people who are at the university to study, the debate is more and more frequently being decided on the side of giving the students the responsibility of managing their own time. One reason for this decision has been the fact that a high percentage of residence hall students already bring their own television sets and receive network programming.

The provision of cable TV service provides not only a revenue opportunity, but also unique educational opportunities. As part of their arrangements with cable providers or in systems they have installed themselves, universities have generally made some number of channels available for local university programming. The programming can take the form of bulletin boards of upcoming events, athletic events, classes being broadcast for distance learning, news shows produced by students, or special events and lectures.

Cable television providers in markets nearing saturation see residence hall students as a market which they can serve with low overhead and low installation cost. Frequently, they are willing to make deals which seem too good to be true. In exchange for an agreement to buy a block of service and provide it to students, cable television providers will often agree to entirely rewire dormitories including the installation of data wire, telephone wire, additional cable TV wire, front end equipment allowing university access to channels, and access from the university to local public access channels. They will provide all of this and give the university a low bulk-rate per drop for the entertainment service.

- **Data Network Access**

Most universities now support some sort of backbone data network. These networks provide access to academic computers, student administrative and financial information, library information and services, semi-public bulletin boards and information sources such as Internet Usenet newsgroups or Gopher servers, public domain software libraries, network faxes and printers, campus-wide electronic mail, and Internet or bitnet access. As networks become increasingly common in workplaces, as the campus network gains in administrative and academic utility and use, as the Internet grows, the experience of operating in a networked environment becomes more important to students and more sought after by them.

Traditionally, universities have provided network access through modem pools or networked computer labs. However, as demand has grown, the cost and size of modem pools have become unwieldy, and computer labs have become increasingly crowded. Direct network access from dorm rooms offers one better way of providing service to on-campus students. Provision of network access to the off-campus student community will continue to be tied to modem pools and on-campus computer labs until ISDN-BRI is available and reasonably priced in more states or the cable TV or telephone companies offer some other high-speed alternative.

- **Calling Cards**

Calling cards are a traditional telephone related service not dependent on residence hall dialtone. Many large and small common carriers can provide calling card service including billing, carrying the traffic, and even marketing. The university is generally paid a commission. The advantage of calling cards is that it puts the university in a position to gain some revenue on sales of long distance service to off-campus students with very little direct risk. The dangers for a university already providing long distance from residence halls are the confusion competing marketing efforts can create for residence hall students and the danger that the common carrier will eat into the higher margin residence hall business.

- **Credit Cards**

Credit cards can be a close cousin to calling cards. Just as many common carriers are now offering universal cards providing not only long distance service but credit as well, universities can also provide a version of the same thing. University universal cards can be used as ID cards or calling cards and for security door locks, library book checkout, and the purchase of foodstuffs and supplies. They can be configured as credit cards and tied into the university accounts receivable system or work on a prepaid basis. This type of card bridges the gap between telephony services and administrative services and requires careful campus-wide coordination.

■ Administrative Issues

- **Billing Systems**

Having a captive audience for a valuable service is great, but you have to be able to bill for it. Most universities already have some sort of billing system in place. Adding student long distance service will dramatically increase the number of call records to be processed. This will increase the need for buffer memory, data storage, input time and processing speed or processing time, or both. Billing systems may also need to accommodate different rates for students and faculty/staff and different types of monthly charges.

The telecommunications department must determine whether it will be loading the student telecommunications charges into the university's student accounts receivable system or handling accounts receivable itself. This will determine whether the billing system will have to accommodate an interface with the accounts receivable system. Either way, the billing system may need to download student addresses from the university student information system.

• **Staffing**

The addition of students to the billing system will significantly increase the workload of the staff responsible for running the system. Student phones, cable TV, or data networking also take staff time for marketing the services, enrolling the customers, logging trouble reports, and answering questions.

The support needs of data network services in particular can be especially daunting. Any university department with a local area network and campus backbone network connectivity knows how much time and energy can be spent making computers communicate properly with each other over the network. Like faculty/staff, students come to college with varying degrees of computer skill. Unlike faculty/staff, they may show up for school with an even wider array of computers they may want to attach to the network. Telecommunications will need to standardize on certain sets of communications hardware and software. Furthermore, there will need to be limits on what computer hardware will be supported on the network and that limit will need to be publicized to future residents of student housing well before they arrive.

• **Accounting**

Telecommunications departments are variously viewed as cost centers or profit centers in both the public and private sectors. The provision of student residence services can fit either model but it tends to fit better in the profit center model, particularly if long distance service is being resold. Earning this outside revenue may require a telecom department to operate as a self-funding entity or to give up central funding proportionate to the new net revenue. This may be particularly true for publicly funded institutions which have accounting structures and operational limits mandated by state laws.

Whether mandated by state law or not, accounting structures must be created to differentiate student revenue and expenses from academic/staff revenue and expenses. This information is necessary for an understanding of the cross subsidy between student long distance income and student dialtone, other student services, and academic/staff services. Recognition of this subsidy is important because long distance revenues can vary widely depending upon shifts in residence hall occupancy, student body demographics, and competition in the long distance market.

Taxes are another reason for carefully accounting for student services revenues. Depending on the tax status of the university, student residence hall service revenue may be taxable. This is even true of public institutions where these revenues may be subject to Unrelated Business Income Tax (UBIT), depending on how directly the services tie to the university mission.

Administrative Student Services

Administrative student services go hand-in-hand with residence services. Residence services give students access to telephones and the data network. That access can then be used to make administration and communication of registration, financial, and academic information easier for the students and more efficient for the University. Using the public telephone network and university modem pools, similar access can be provided to students residing off campus.

- **Interactive Voice Response**

The most commonly used telecommunications tool for providing enhanced administrative services is the interactive voice response system. Placed as the interface between the administrative computing system and the telephone facilities, the whole system is commonly called touchtone registration.

In addition to registering students for classes, interactive voice response systems can give students access to their financial account information and allow them to make payments using credit cards. Application for financial aid can also be accomplished through interactive voice response systems.

- **Online Access**

Interactive voice response has caught on as a telecommunication technology to help automate administration of students because all students have access to telephones, whether they are on campus or not. Online access from the campus network or directly into administrative computers has the potential to supplement or supplant interactive voice response as network access becomes easier and more widely available. Already schools are experimenting with using computer labs or kiosks for online registration and whole course catalogs are available on network fileservers to be reviewed by anyone with direct network access or a telephone and a modem.

Campus network access can also be used to post class assignments and collect papers or tests. Networks and bulletin boards are even used for class discussion, particularly in distance learning applications.

- **Voicemail/Bulletin Boards**

Voicemail systems and their voice bulletin boards can be used to enhance and increase communications between students and faculty-administrators while reducing the support staff needed to perform this function. Information lists such as student employment openings, corporate recruiting visits, available housing opportunities, menus, events, gym or library hours, and class schedule changes or assignments are easily posted on bulletin boards. Frequently asked questions such as, "How do I get a transcript?" or "How do I apply for admission?" can also be posted on bulletin boards.

Strategic Partnerships and Issues

The successful provision of both student residence and administrative telecommunications services requires a partnership between the telecommunications department and any of several other departments. They must work together to resolve a variety of issues which determine how the services will be provided.

■ Residence Services

The most significant partnership in the provision of residence services is that between Telecommunications and the Housing Departments. As long as the student service is being provided, Housing and Telecommunications will have an ongoing partnership with both financial and administrative components.

In particular the two departments will need to agree on whether dialtone, cable TV, or data network access is provided as part of the student rent paid to Housing or if it is to be paid separately to Telecommunications. If Housing agrees to provide the service in every room and pay for it out of student rent, the cost to Housing, per room, will need to be negotiated, including whether the charge will be applied to vacant rooms during the summer. If students are enrolled for the services individually, Housing may still have an interest in what rates are charged and even in splitting the revenue.

Housing and Telecommunications will also need to agree on whether Housing, Telecommunications, or the students themselves will provide such terminal equipment as telephones, network access cards, or cable TV adapters. It further needs to be determined who will provide troubleshooting and who will pay for damage to telephones, jacks, network equipment, etc.

Besides Housing, Telecommunications will have several other significant partners in the provision of student services. They may be departments such as Accounts Receivable, Administrative Computing, Data Network (if it is different from Telecommunications), Physical Plant, or General Accounting, or the cable TV provider or local telco in Centrex environments.

The relationships between the Network department, cable TV provider, Telecommunications department, and Physical Plant become particularly acute in an environment where more than one service is being provided. These departments must reach agreement on issues of cable control, troubleshooting, and installation responsibility.

The relationship with the University's Business Office can be particularly valuable in the provision of services when Telecommunications is charging directly for services, whether they be regular monthly charges or long distance charges. Ideally, the charges will be fed into the University's accounts receivable system, appearing on the students' bills with their other charges and subject to the same collection procedures as other student charges.

Questions to be resolved with the Business Office will revolve around how information from telephone billing systems is fed into the accounts receivable system, how Business Affairs will be compensated for the extra load placed upon them by the billing and collection of telecommunications services charges, and how call detail information will be made available to students. Typically an arrangement with the university's Accounts Receivable and Collections departments will help limit uncollectible debt to 1% or less.

Despite the low uncollectible rate and general student honesty and credit worthiness, one relationship which will eventually come into play will be that with the Student Conduct department. The theft and use of a long distance authorization code, or the destruction of a telephone, network interface, or other telecommunications hardware should be treated like the destruction or theft of any other University property.

If the telecommunications department chooses to run its billing system on the campus administrative computing facility, several issues must be resolved. What are the costs associated with the service, and what is the priority of telecommunications applications vis a vis other University jobs in terms of both programming and CPU time, and ability to access realtime information? For example, if long distance information is processed as a batch job only once a month, it is impossible to serve and quickly bill short term residents of student housing such as summer conferences or even short summer sessions.

The Local Exchange Carrier (LEC) is a partner with the Telecommunications department in the provision of many services. However, they may be an opponent when the University decides it will provide its own dialtone and long distance services to residents of student housing. The assumption of monopoly status by the University for the provision of telecommunications services in University-owned student housing has generally been accepted nationwide. However, the LEC has often been making substantial revenue by providing the service and will not always give it up without a fight. Before Telecommunications commits funds to enable the provision of telecommunications services to student housing, it should seek an opinion from the state public utility regulating authority to be sure it will win any challenge from the LEC.

■ Administrative Services

The strategic partners in the provision of administrative services will generally be the Registrar, Business Affairs, Financial Aid, and the LEC. The Telecommunications department can play a central role in the provision of administrative services, but it is typically a technical adviser and provider of telephone access to interactive voice response systems providing touchtone registration.

Technical and Administrative Considerations

A variety of technical and financial issues must be addressed before student residence and administrative services are activated. Some of the hardware questions such as dorm cabling and network or telephone switch capacity must be addressed if it will even be possible to provide the services. Other issues such as billing, accounting implications, and staffing questions will be critical if ongoing service and financial pitfalls are to be avoided.

■ Cable

Unless they were built in the last 10 years, most residence halls were wired to accommodate a maximum of one dialtone per room. This dialtone was provided by the local telephone company so the dorms were connected to the local telco's system, not the university's system. There were no provisions for data networks or cable TV.

With divestiture, the inside-building wire became the property of the university. With some minor riser cable improvements, it may be capable of providing limited but ubiquitous telephone service so long as the university has or installs infrastructure to connect the residence halls to the PBX switchroom. This is not a concern in a Centrex environment.

Any services beyond telephony services will usually require enhanced cable to the rooms as well as enhanced data network or cable TV connectivity to the buildings. Installing the wire for multiple services will generally also require larger cable ducts, better wire closets, and multiple outlet jacks to accommodate the variety of connectors. As mentioned earlier, cable TV companies are sometimes willing to install TV cable, enhance the duct and closet structure, and pull university-provided voice and data cable in exchange for an agreement to purchase a block of cable TV programming.

■ Hardware

Whether it's PBX or data network gear, the hardware providing the service onto the residence hall cable must be able to handle the load. For the telephony services, this will mean having sufficient PBX ports and voicemail system capacity.

Providing student residence data network services will substantially increase the load on the campus backbone network. This may mean reconfiguring parts of the network or moving to a network protocol with more capacity. The various file servers, e-mail servers, faxes, printers, etc. may all see increased use and may require enhanced capacity.

Cable TV is generally a new service, so the main issue is generally cable. However, location of the cable TV network headend should be carefully considered to make it easiest to allow access to it by those who will be responsible for controlling it. Careful location will also make it less costly to connect the headend to facilities which will originate university programming or to classroom facilities, should the university choose to expand use of the system beyond entertainment TV.

■ Outside Network Connectivity

Student residence service usage normally dovetails nicely with faculty/staff usage. The students use the facilities most heavily in the evenings and weekends at times when faculty/staff usage is low. However, consideration of student impact on trunking or internet gateways is still important. It is not unusual for the busiest daily telephone network hour to be consistently in the late evening so trunking capacity will need to be sufficient to serve that peak, rather than the normal daily faculty/staff peaks in the mid-morning or afternoon. That includes trunks to the local telephone company as well as private networks and any bypass facilities to long distance carriers.

If the university is receiving measured local telephone service, student telephone service may cause cost increases significantly greater than those associated with just adding trunks. In such areas, the increased cost may determine whether the provision of phones in the residence halls can be cost effective or if it should carry a fee like long distance service.

The increased use of long distance facilities is good news because it signals a revenue-producing service taking place. Additionally, the overall increase in university long distance consumption will generally enable the university to receive a larger bulk-rate discount from the long distance carrier.

Administrative Services

■ Technical Issues

Administrative services can consume telecommunications network resources in a bursty and peaked manner. An improperly designed and scheduled touchtone registration system can inundate a university's telephone system and even shut down a LEC office. True stories of such disasters are legend in university telecommunications circles, but careful attention to system design can prevent them.

The key element to safe system design is retaining call flow control. One way to maintain call flow control is to use the capabilities of many PBXs.

There is a tendency to try to play it safe by segregating touchtone registration traffic from the rest of the university's traffic—bringing the calls in on lines going around the PBX or maintaining separate trunk groups. This approach, however, gives up some of the control of the traffic. It may lessen the potential impact on other incoming university calling, but it leaves the university network open to blockage caused by peaked use of residence hall students calling out to get back in to the touchtone system.

Attaching the touchtone system to the PBX eliminates the need for on-campus students to use outgoing trunks to access the system. Additionally, it allows the call routing, queuing, and Automatic Call Distribution (ACD) PBX features to limit the touchtone system impact on the campus network and enhance the call processing capability of the system.

Mingling touchtone registration system traffic with the rest of the university's traffic also takes full advantage of the economies of scale and reduces the number of new trunks needed to serve this application.

A second key element of a successful touchtone registration system implementation is administrative throttling of student calling. Administrators must calculate the number and length of calls to expect and factor in the number of ports in the system. This should include some understanding of the peaked nature of calling volume as course drop-add or registration deadlines near. All this information is used to calculate the length of time it will take to register all the students and to formulate a schedule to spread the call volume as evenly as possible. This schedule must then be communicated to the students and enforced.

The third key element of controlling call volume is coordination with the LEC. The LEC wants to limit adverse impact on the local network as much as you do. They will cooperate by flagging telephone numbers to watch for call volumes exceeding agreed-upon limits. If those limits are exceeded, they will put an agreed-upon choke program into affect which will limit the number of calls they will attempt to connect.

Although touchtone registration is the most common way of providing administrative student services, access to student information and registration records can also be provided by residence hall interactive cable TV systems or data network access. The same issue of throttling student use applies to these methods as well. The danger of a poorly designed schedule, however, is not shutting down the university or the town, but merely providing poor service to students.

■ Administrative Issues

Because the telecommunications department will often function like a vendor providing components of student administrative services, cost to the department ultimately charged with financial responsibility for the system will be a significant issue. Touchtone registration will use lines off the PBX and also queuing and ACD features which require extra telecommunications department time to design and administer. The new network load may require additional trunks and associated PBX hardware. This telecommunications application will probably be the only one like it on campus, so it will necessitate individual and careful pricing.

Access to telecommunications management devices by personnel outside the telecommunications department is another administrative issue impacting touchtone registration. Typically the system parameters controlling ACD operation and call routing are controlled by the PBX or adjunct computers and are accessed only by personnel from the telecommunications department. A large application such as touchtone registration may warrant passing limited access to this control to the department directly administering it. This can usually be done by creating security passwords and accounts with limited capabilities. Before it is implemented, however, there should be adequate training and clear understanding of what changes the administrator will make.

Chapter 4

Financing a New Telecommunications System

Business and finance officials and telecommunications managers at both public and independent institutions should know what options they have when the time comes to finance a new telecommunications system. This chapter will summarize the financing options available to higher education administrators, whose goal is clearly to ensure that the system is financed at the lowest possible cost to the institution.

Public Institutions

In most institutions, the telecommunications manager has responsibility for the quality of communications on campus and is usually the most informed campus official with regard to the effects of structural changes in the telecommuni-

Chapter 4, Financing a New Telephone System, was written for *Campus Telephone Systems* by **William B. Dougherty**, E. F. Hutton & Co., Inc., and **John W. Sleasman**, Case Western Reserve University. It has been revised to Financing a New Telecommunications System for this book by **David Barta**, Telecommunications Manager, University of Oregon.

cations industry on the university. Involvement with a telecommunications consultant will help the manager to become aware of some of the financing options available. From the beginning the telecommunications manager should work closely with financial staff so that the limits of what the institution can afford are clear. Such teamwork should be established before the system is bid. (If there is no agreement on how to pay for the acquisition, it may be wasteful to hire a consultant and spend the time to create the RFP. The finance officer of the institution should be the author, or at least co-author, of the financing section of the RFP.) If a telecommunications consultant is hired, he or she usually incorporates vendor financing proposals in the request for proposals. Once responses are received from vendors, the manager and the finance officer should catalog what their options are and which option will enable the institution to obtain the lowest price for the equipment. It must be pointed out, however, that overriding political considerations sometimes prevent choosing the option that offers the lowest price.

Cataloging the Options

Though it is not possible here to outline specifically all the options available to all public institutions, the following list provides an overview.

• **Appropriations**

A lump-sum, line-item appropriation by the state legislature for the amount needed to fund an institution's telecommunications system might be the least complex option. For two reasons, however, most legislative bodies are unlikely to do this. First, because of the decline in federal support and the increasing demands for local assistance, most states are not in good enough financial condition to be able to commit to a major new capital expenditure. Second, and more importantly, there is already a budgeted stream of revenues for existing equipment, usually for an operating (nonownership) lease. For most legislatures the existence of a previously budgeted line item in an operating budget is sufficient justification to deny requests for the same item in the capital budget.

- **Excess cash**

A few institutions find they have sufficient excess cash to finance a new system, but this is, of course, not the case with most.

- **Debt financing**

A third method is some form of debt financing. The debt can be issued directly by the university and secured by the pledge of student fees and tuition, or it can be issued by a state building authority and secured by annual appropriations of the state legislature. In many states, particularly in the East, this may be a viable alternative. However, especially in the West, states such as Colorado do not have statutory authority to issue bonds for other than "auxiliary" enterprises. Dormitories, student center, and recreation facilities at such institutions are most often financed through a student fee assessed solely for the purpose of retiring the bonds. These institutions do not have the legal authority to issue bonds for the purpose of acquiring "academic" equipment, such as a telecommunications system.

In other states, such as Michigan, state law allows institutions to issue bonds for academic purposes without prior legislative approval, and tuition is pledged for repayment of the bonds. While this might seem a less complex option, universities in states permitting these transactions may find that students do not accept the use of tuition-backed bonds to finance the equipment or that administrators are unwilling to utilize the debt capacity for needs other than "brick and mortar" projects.

In many other states, the ability of a university to issue its tuition-supported bonds is subject to prior approval by the legislature. Given today's high federal deficits and associated political peril, most legislatures are wary of approving new debt financing for any project.

It is important for the telecommunications manager to understand the institution's debt options and the political environment. The mechanics of the transaction are more likely to be the responsibility of the finance officer.

- **Vendor financing**

Most telecommunications consultants recommend that each vendor be asked to submit separate financing and equipment bids when responding to the university's RFP. Vendor responses in the financing area tend to consist of introducing the university to third parties specializing in lease financing. Only the very well-capitalized and profitable telecommunications suppliers are capable of internally financing a university's system. Indeed, suppliers offering this form of financing usually reserve the right to sell their leases to third parties. In the most popular form of vendor financing, the vendor introduces the university to a commercial bank, leasing company, or investment bank that actually provides the financing. Usually, the financing is not limited to the equipment being offered by the vendor. Generally, it is in the best interests of the university to separate the equipment selection decision from the financing decision.

- **Lease-purchase financing**

Universities have long used lease-purchase financing to acquire various capital equipment items. (Lease financing is third-party financing. It is also frequently called an installment sale.) Such leases, when properly structured, are not considered a debt of the university or state; they bear tax-exempt interest rates; and they are typically repaid within three to five years. Title to the leased items passes directly to the university upon the final lease payment. Generally, these leases are nonrated, are relatively small in size ($5,000–$10,000), and are sold on a private-placement basis to sophisticated individual investors and financial institutions. Some leases have been for much greater amounts—in the $2.5 million to $6 million range.

(The par amount of leases being privately placed has been increasing, in terms of the dollar amount referenced. Analysis has to be undertaken by the university to determine whether private placement can compete with the certificate structure in terms of interest cost.)

Lease-purchase financing offers advantages that are consistent with a university's financing needs. The following are the primary advantages:

1. The lease does not create a debt for the university. Therefore, institutions in states where the constitution or statutes restrict debt financing can use a mechanism with features that approximate the traditional financing route.
2. The nondebt status of the lease-purchase agreement does not require the cumbersome process of legislative approval as in most financing.
3. The nondebt status also enables the university to avoid strict application of the coverage ratios that are so common in student-secured bond transactions.
4. The lease-purchase agreement can receive investment-grade ratings from Standard and Poor's Corporation and Moody's Investors Services.
5. It is flexible enough to allow the maturity schedule on the lease to match the previously budgeted operating lease (non-ownership) payments. No new money needs to be requested from the legislature since it is already included in the "base."
6. The lease-purchase mechanism allows title to the leased equipment to pass free and clear to the government unit upon the final lease payment.
7. The lease-purchase mechanism provides that control of the equipment that is financed vests with the government unit.
8. Lease-purchase financing provides for 100% of the equipment purchase price plus related expenses. No cash down payment is required. The governmental lessee only makes periodic lease payments.

9. Properly structured, lease-purchase transactions are exempt from federal income taxes, and may also be exempt from state and local income taxes.

- **Certificates of participation**

It has become clear that since new telecommunications systems involve major capital costs, a broader market for the sale of large leases must be developed. Telecommunications equipment costs alone at very large universities can now approach $40 million. In the late 1970s, investment bankers applied their experience in small-equipment lease financing to the design of a new lease-purchase finance program for multimillion dollar telecommunications systems. The program they developed provides cost-effective nondebt financing, with flexible repayment terms and conditions. Additionally, the leases can be sold at interest rates lower than small-equipment leases because of the marketing advantages of securing investment-grade ratings (from Moody's Investors Services and Standard and Poor's Corporation) and because of the emphasis placed by investment bankers on developing a much broader marketing approach.

Traditional small-equipment lease financing involved one lease for the total amount of equipment to be financed. Usually, the lease was sold as a whole to one investor because there was no legal mechanism for breaking the lease into smaller investment pieces. This structure would not be appropriate for the multimillion dollar leases necessary to finance telecommunications systems at many institutions.

The use of certificates of participation (COPs), representing a proportional interest in lease payments made by a lessee, has become an accepted security in the market and allows a governmental unit to raise funds outside of the legal definition of debt. The state institution selects an issuing company to issue the COPs, and the issuer uses the proceeds to finance projects. COPs are paid off through annual payments appropriated by the state government.

COPs are fractional shares of an obligation (i.e., a lease-purchase transaction), represented by a certificate which signifies that the investor owns an interest in the lease payments made by a governmental entity. While COPs have many of the same characteristics as municipal bonds, they do not normally constitute legal debt for the lessee.

COPs split the ownership of a lease into $5,000 denominations. These certificates are structured in a manner similar to bond issues maturing serially over the financing term, and they pay interest semiannually. The interest portion of the payment is exempt from federal income taxes and may, depending on state law, be exempt from state and local taxes as well. (The Tax Reform Act of 1984 did not affect the tax-exempt status of certificates of participation. The marketing of COPs can be enhanced by obtaining an investment-grade rating from Standard and Poor's or by insurance coverage. S&P looks primarily at the essentiality of equipment being financed, while the insurance companies will not insure beyond a seven-year maturity. The big equalizer is the coupon, which can be 10 to 25 basis points higher than the university's revenue bond.)

The structure allows the institution (i.e., the government unit) to make lease payments based on its cash-flow capabilities and on the estimated life of the equipment. Most lease-purchase agreements in the telecommunications area can be structured so that the lease payments coincide with the lease payment the university has made for decades under operating (non-ownership) agreements. Ownership of the equipment passes directly to the institution upon remittance of the final payment. The university's obligation to make lease payments is designed to ensure that the lease will not be considered a debt under applicable state statutes and that it will not require legislative approval or diminish coverage ratios for student tuition or fee-secured bond issues.

Legal documents pertaining to the transaction are a hybrid of traditional bond and equipment lease financing documents. The terms and conditions of the lease are contained in the lease and agreement between the university (lessee) and the nominal owner (lessor). The lessor can be the telecommunications equipment vendor, a commercial bank, or a university foundation. The responsibility for monitoring the transaction, collecting the lease payments from the lessee, disbursing principal and interest payments to the certificate holders, and liquidating the equipment in the event of default or nonappropriation rests with the trustee, and is detailed in the trust indenture. The trustee is a third party, typically a large commercial bank or trust company. COPs are sold by the investment banker pursuant to an official statement that summarizes the lease agreement and trust indenture and provides other pertinent information regarding the transaction and the university. These basic documents are drafted by nationally recognized bond attorneys and disclosure counsel.

Determining the Financing Option

It is important for the finance officer and the telecommunications manager to be familiar with the key variables that are unique to the institution's situation. Several factors influence selection of a financing method for a telecommunications system.

- **Legal constraints**

The most important legal issue to be resolved is the institution's authority (1) to issue bonds and (2) to enter into lease-purchase agreements. It is important to distinguish between traditional lease-purchase agreements and those that are publicly offered certificates of participation. Most universities have long used standard lease-purchase documentation for lower-priced equipment items. This documentation may or may not stand the legal scrutiny that publicly offered certificates of participation will undergo. In most cases, nationally recognized attorneys in the field of tax-exempt bonds need to be consulted.

- **Political constraints**

The nature of the relationship between the university and the executive and legislative branches of state government can significantly affect the choice of a financing method. If the legislature exerts strong control over the issuance of debt, the use of a lease-purchase agreement without the consent or knowledge of the legislature might have severe repercussions. Similar problems could also arise between a university system and the executive branch of state government if a financing mechanism that has not been approved or used previously is chosen.

- **Capital cost of the system**

A third factor in determining the financing mechanism is the acquisition cost of the system. Many institutions under 5,000 FTE without a dormitory system can purchase an adequate system for less than $2 million. It might be easier for such an institution to obtain a lump-sum appropriation from the legislature for this amount rather than issue bonds to finance the acquisition. Likewise, a large institution of 40,000 FTE, for example, with a significant dormitory population would be more inclined to issue bonds or certificates of participation.

- **Technological obsolescence**

The technology associated with telecommunications equipment is subject to rapid change and potentially rapid obsolescence. This factor affects the length of the financing more than the type of financing. The time standard that is becoming accepted as the preferable lease term is seven years, with some leases being extended to 11 years. The lease term is important in the lease transaction because the ultimate security is the system itself. In a debt transaction the ultimate security is the pledged revenue stream, so the life of the equipment need not be an important consideration. Underwriters and rating agencies view the "essentialness" of the telecommunications system as greater than that of most other equipment on the campus such as administrative data processing equipment. They are, therefore, more comfortable with a somewhat longer lease term for an integrated telecommunications system.

- **Budgeted cash-flow analysis**

The acquisition of a new telecommunications system can be accomplished within the framework of already budgeted appropriation, or what is commonly called the "base." Legislative or executive branch budget analysts will recognize the existence in an institution's budget of the current expenditure for telecommunications equipment. This will make it difficult for the institution to pursue "new" sources of revenue to finance a replacement system, whether by lump-sum appropriation or legislatively authorized bond payments. Such a situation could make lease-purchase financing attractive because the maturity schedule of the lease can be adapted to match the currently budgeted expenditure for the nonownership lease.

Independent Institutions

Generally, independent institutions have the same type of financing alternatives as do public institutions; however, the financial instrument used may be very different. Alternatives for the independent institution include:

Internal Financing:
- Endowment
- Reserves
- Operating funds

External Financing:
- Bonds—public or private
- Public (legislative) funds
- Secured lease
- Other (usually secured) debt

■ Internal Financing

• Endowment Funds

One area that may offer an attractive financing mechanism for an independent institution is the use of endowment funds. This can be done in one of two ways. First, in the event that the institution has sufficient available funds to support directly the acquisition of a switch, direct purchase can be considered. It is obviously very important to determine that this is the "highest and best" use of the funds, since expenditure of endowment funds for a project of the magnitude of a switch significantly reduces the liquidity of the institution's portfolio, and also affects future income streams. Further, the legality of such an expenditure of funds must be determined, particularly if restricted endowment funds are involved.

Alternatively, endowment funds may be used as an internal source of funds for borrowing. This should involve determination by the institution of the appropriate rate of return to be credited to the endowment earnings (and charged to operations), along with an appropriate amortization schedule to restore the endowment principal at the end of the communication system's life. An accurate determination of this rate should include such factors as the return received from the alternate investment of these funds and a reasonable estimate of the interest rate that would be charged in the financial markets for financing the switch. (Obviously, if the income rate exceeds the cost of financing, borrowing from endowment should not be used as a source of funds.) The legality of borrowing from endowment funds should also be determined.

• Reserves

Depending on the accounting methods of the institution and its fiscal policies, reserves may be available for equipment purchases. Since it is unlikely that large amounts of funds have been set aside for purchase of a switch, the accumulation of reserve funds toward a second purchase should be considered. To the extent that reserves are available, they can also be very useful as a source of funds for tactical projects, such as purchase of telephone sets or long distance controllers, to enhance the present system, or for short-term borrowing to structure a complete project. Using reserves, however, always requires proper accounting/auditing procedures and validation of the need for the funds.

• **Operating Funds**

It is possible to use operating funds to finance major acquisitions, at least in part. But the displacement of expenses is often miscalculated and overstated, as communications switches are dynamic and must always be expanded. Sufficient operating funds (or reserves for ongoing enhancements) must be available for the purchase of additional items needed as the switch expands. Thus, use of operating funds for direct financing should not be relied on unless the assumptions about growth and ongoing expense reductions can be shown to be reliable. Most of the unreliable assumptions in the analysis of financing plans result from overestimating the availability of funds.

Operating funds should, of course, be used for the acquisition of expendable items, or for the temporary payment of items until a long-term instrument can be prepared. It is advisable to avoid external financing of expendable items or the carrying of short-term items into long-term debt.

■ External Financing

The forms of external financing for independent institutions are quite similar to those that can be considered by public institutions. But the market and legal requirements may be quite different, reflecting the difference in control and the diversity of state legal requirements.

• **Bonds**

Bond issues have become increasingly important in the last few years and now account for a substantial portion of telecommunications placements. Bonds may be issued either on the basis of public authority—which will often yield lower interest rates—or privately through bond counsel and underwriters. (It should be remembered that legal and financial requirements for bond issuance vary from state to state.)

Placement and marketability are dependent on the guarantees provided and securities pledged against repayment. (The ability to place is very much dependent on the financial rating of the issuer—guarantees by a state authority or agency make placement easier. Bonds issued by an independent institution without guarantee have limited marketability.) In any case, bonds are an extremely important form of financing. There are strong arguments in favor of using bonds for acquisition of a communications system at an attractive interest rate, provided that the institution can secure a favorable rating in the financial markets and is willing to provide appropriate security for bond repayments in the form of pledged future income.

- **Public Funds**

In many states, provision has been made for the use of public funds by independent institutions. This may be in a form such as housing bonds or equipment allocations from the state legislature to the Board of Regents for distribution to independent institutions. Public funding may consist of grants for specific purposes (such as equipment), a portion of a state educational bond issue, and other items. The amount of these funds may be limited, with allocations based on institutional size, or they may be available on a "first come, first served" basis. There may also be specific conditions regarding the use of such funds—e.g., term, purpose, expected lifetime of the equipment to be purchased, and others. While such "strings" may pose problems, substantial interest rate advantages can be gained, and it is even possible that outright grants could be obtained.

- **Leasing**

Leases or lease-purchase agreements are often used by independent institutions to acquire a communications system. They must be arranged by the vendor or placed privately through institutional contacts. Leasing is most complex in relation to operational activities—it requires accurate identification of parts, inventory, and other items as to source, replacement, and ownership. Leases or lease-purchase agreements may be entered into directly with the manufacturer of the equipment, or, as is more frequently the case, with a third party as lessor. Only the very largest manufacturers are willing to enter into direct agreements; even in those cases the agreements can usually be assigned to a third party at the option of the vendor.

A variety of concerns must be addressed when purchasing a communications system under a lease agreement. These range from possession of title to the equipment during the lease to specification of remedies that may include liquidated damages. For example, if items are stolen or destroyed, or are outgrown, are sums due and payable immediately or are payments to be made over the remaining term of the lease? Do the institutional auditors take the same position as the lessor? Is the institution obligated to continue making payments on the lease to the third party or assignee while it attempts to recover from the manufacturer/distributor?

- **Other Debt**

Other debt can be used when the institution is willing to offer other assets as security against borrowings to keep communications equipment unencumbered. Unsecured debt will probably not be very attractive to lenders. Certainly, the use of other assets, such as stock or other investments, as security is an alternative that can be used to raise "equity money." The institution must determine—as a matter of policy—whether it is prepared to make such a commitment and whether this action is appropriate.

- **Fund Raising**

Administrators should not overlook the possibility that the financing of a telecommunications system may be an attractive fund raising opportunity for development personnel.

- **Student Long Distance Resale**

Another opportunity for earning institutional revenues to retire leases or debts, for both public and private colleges and universities, is resale of long distance and other telecommunications services (e.g., CATV, data network access/ Internet) to students. Students benefit since the institution provides them with attractive long distance rates, purchased at "wholesale." The institution benefits by charging rates which include a margin above actual cost ("revenue enhancement"), or even a per-call surcharge. The 1992-1993 ACUTA Membership Facilities/Services Index shows over 300 colleges and universities with student long distance resale programs in place, and another 70 in the planning stage.

Monthly billings from participating students living in residence halls average $20-40 per month, although some students' bills may run much higher. An institution can typically net 20-25% of the resale rate from margins, although this can fluctuate depending on calling patterns. Net resale revenues realized may vary from campus to campus. Such revenues can be added to the operating budget, where they may be applied to retirement of debt service on the existing campus telecom system. For example, if there are 1,000 residence hall students on campus nine months per year, the total long distance resale revenues could be $180,000 (at $20 per student per month), and the institution might "earn" $45,000 (25%) of that total. Unpaid accounts will normally be one percent (or less), due to institutional controls on students.

Factors involved in a student resale program include: available resources (staff and equipment capacity), developing a call accounting system (for preparation of usage reports and billings), negotiations with long distance carriers, enrolling students in the program, determining a deposit fee (if any), setting rates, and collecting fees. The latter may be undertaken by the telecom office, the business office, student housing, some other office, or a third-party vendor.

One factor generally enhancing the feasibility of student resale is that student use of trunk lines is heaviest during evening hours, when the institution's needs are lowest. This results in optimum utilization of the campus's installed trunk lines.

Structuring the Financial Arrangement

The institution must analyze its present cost of communications and determine what the future behavior pattern for this cost is expected to be, assuming no change in the system for one future "switch lifetime." After identifying this stream of revenue, which involves making some assumptions about regulatory behavior in the case of Centrex or vendor behavior in the case of a leased PBX, the institution will be able to identify the projected dollars for a "steady state." (The "steady state" cost of maintaining present equipment is often overstated: by vendors with a vested interest in doing so; by users fearing the ravages of the deregulation process; and by the regulated suppliers themselves, who are afraid that customers will accuse them of deception should their forecasts turn out to be too low. Suppliers from the unregulated side of the industry may be able to give more accurate long-term estimates of the cost of maintaining present systems.)

The institution must relate the projection (in net present value terms) to its strategic plan by citing the necessity to reduce projected costs, the desire to maintain competitive position by presenting a "state of the art" image, or other considerations.

How is a bid proposal evaluated, in financial terms? Obviously, analysis of the basic proposal for net present value or payment schedules is similar to that for any contract.

Certain items relating to the operation of a communications system should also be identified. The structure of the financial arrangement must take into account the variable life expectancy of the components of the system.

All too often, the total price is used to establish total dollar requirements without determination of the various periods of economic use of the parts. In many cases, such an analysis will change the parameters used to determine the viability of financing alternatives.

The following elements should be considered when calculating the overall cost of the system:

- **Cable plant**

  Interbuilding cable runs from building to building, or from a building to a telephone company demarcation point. This may be one or more points depending on the size of the campus or the configuration of the switch. Physical cable mediums can include twisted pair, fiber, coax, or others. *Intrabuilding cable* consists of horizontal wire runs, vertical risers, etc., and may also include conduit, plenum, and building code issues.

  Cable plant facilities should be oversized to accommodate potential growth, which will almost always occur as new facilities become available. While there is an element of danger, the amortization period of a cable plant can be spread over a longer time period than a switch.

- **Switch**

  The switch consists of the processor, matrix, port terminations, and memory, all of which have separate lifetimes and/or limitations.

  Certain ancillary functions are also often included—databases and management systems, station detail recorders, power failure bypasses or backup power supplies, processors for voice mail systems, and others.

  Switch proposals normally include a one-year warranty period. Depending on the bid specifications of the purchasing institution, this period may be extended. The typical bid cost for this longer-term maintenance is rolled into the five- or ten-year period of amortization, although no benefits are received beyond the first or second year.

- **Terminal equipment**

  This ranges from dormitory telephones (which could be treated as disposable) through single-line sets (which have a longer lifetime) and proprietary sets.

- **Linkages to the central office**

  This is usually treated as part of the switch. The revenue stream used to amortize the purchase of a switch must allow for inflation of the ongoing use of such linkages, and should project ongoing vendor prices. While not strictly a part of the financial arrangements, adequate financial forecasting of these items is necessary to determine appropriate arrangements.

■ Other Considerations

Given evolving and increasing campus telecommunications needs, attention should also be paid to providing for the possibility of major revisions in campus telecom capabilities. New or emerging voice processing, imaging, video, and data communications technology are increasingly merging voice and data communications onto the same cable systems or even into the same bitstream.

Alternative technological considerations such as ISDN, ATM, optical fiber cabling, networking, inter-networking, or other options, should be addressed when structuring the financial arrangement for a new campus telecommunications system. Some colleges and universities may require the assistance of a competent consultant when considering the complex variables involved in moving intelligently into the future.

The financing arrangements must address all the assumptions made earlier in the process of identifying the preferred bid, and, based on the complete and detailed analysis of that step, the financing agreement must be structured to ensure that proper amortization is occurring. A less-than-ideal decision regarding switch selection can be tolerated if the assumptions of switch cost and life cycle were accurately determined; if the financing arrangements were based on improper life cycles, the institution will face major financial problems in liquidating and salvaging its position.

The analysis of each of the components is extremely important in order to call into account all assumptions made in switch selection. If the financial analysis shows that an improper overall assumption was used to evaluate alternatives, the institution runs a substantial risk of being left with a "stranded" investment at the end of the switch's life cycle. With proper assurances that the switch financing will not exceed the useful life, the institution can be somewhat assured that even if the decision turns out to be less than ideal, a reasonable level of service can be maintained within financial constraints.

Analysis may show that switch selection has been driven by a preference for particular technology or by the availability of a specific amount of funds. It is important that institutions not allow either technology or financing alone to drive the choice. A balance must be reached so that an institution does not find itself with more equipment than it can pay for or with equipment that becomes outmoded too quickly because sufficient funds were not available to obtain an adequate system. The trade-offs at that point—or consideration of an alternate choice that was not previously looked into—must involve the range of communities of interests on the campus. An institution must live with a communications system for a relatively long time—it is a major investment, not to be replaced in one or two years. Thus, all segments of the community must be reasonably satisfied with the choice.

Chapter 5

Selecting A Consultant

There are several basic reasons why an organization engages a consultant of any type. One is to obtain the benefits of specialized expertise. The purchase and installation of a new PBX system, campus-wide data network, or multi-location voice/video/data network, for instance, are typically once-in-a-career events for most administrators in higher education. Such purchases frequently run into millions of dollars. The installation process affects many individuals on campus, may require physical facilities changes (sometimes dramatic), and establishes telecommunications operating parameters which will affect the institution's mission and programs for the life of the system.

It is most unusual to find a telecommunications staff with all the skills and experience needed to perform the many functions involved in such a large and specialized undertaking. There are many consultants, however, who have been through the process of system selection and installation literally dozens of times. They understand the process. They are familiar with the vendors and the ever-changing array of products available in the market. Their specialized expertise can be invaluable.

Another common reason for hiring a consultant is to get the benefit of an objective viewpoint. Even if an institution is

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In *Campus Telephone Systems,* Chapter 5, Selecting a Consultant, was written by **John M. Urban**, Telecommunications Management Corporation. Minor revisions for this book were made by **Marianne Landfair**, Telecommunications Analyst, Indiana University.

blessed with a highly competent, well-rounded staff, an "outside" opinion is useful given the enormous stakes and risks involved.

An objective recommendation given by a recognized expert from outside the organization can help resolve the internal and external politics that frequently cloud campus issues. Political pressure can come from the senior engineering professor who understands communications switch design but has never had financial bottom-line responsibilities, or from the member of the board of trustees who also happens to sit on the board of a local interconnect company. Although this pressure often is not easily defused, competent consultants may have better success than campus personnel who may have developed some "blind spots."

There are other reasons for hiring a consultant. Frequently a large project requires far more manpower than can be spared from day-to-day operations. Rather than attempting to add permanent staff, it is often less expensive to hire consulting services. This has been especially true in recent years with the rapidly rising price of experienced telecommunications talent. A fresh view of the institution's operations may make it possible to find solutions to problems that have resisted the best efforts of campus staff.

What Do Consultants Do?

The list of services available from consultants is long. Institutions may want to use only a few of the services, or get more deeply involved. Typically, the larger the task at hand, the more specialized are the skills and experience that are needed. If the institution has a small staff, or if assistance is needed in dealing with a specific political situation, more assistance may be required. The important point here is that the institution must determine the appropriate level of consulting involvement. This must be absolutely clear and must be conveyed to the consultant. From the following list it is evident that consulting firms are able to do almost anything an institution might want. Some of the more common consulting services include assistance with the following issues:

◆ **Long-range strategic planning**
What are the current roles of telecommunications in the institution? How is the telecommunications function going to further the institution's mission and goals? How should campus telecommunications management be organized, and to whom should it report? Should management of voice, data, and image functions be combined into a single function? Or even combined with others, such as the library, photocopy services, and/or other "information services" which support the institution's mission and programs?

◆ **Compiling an equipment inventory**
Quantitative inventory of termination, transmission, and switching equipment, statement of condition report, depreciation report, etc.

◆ **Current system evaluation**
How cost effective is the existing system? Is the system's service level adequate? Can growth be accommodated? What construction will be needed to accommodate new equipment?

◆ **Needs assessment**
What new functions are needed? How can the institution take advantage of newer technologies such as voice mail and electronic text mail?

◆ **RFI and/or RFP preparation**
Conversion of operational and management needs into technical terms that vendors can understand and deal with is a special skill.

◆ **Vendor proposal evaluation**
A thorough knowledge of system architectures, operating features, and vendor reputations from past installations is crucial in any evaluation, as is a detailed financial analysis of the proposals.

- **Contract negotiations**
What are the vendor's minimum expectations in terms of a firm and workable contract? What will the vendor likely concede?
- **Installation project management**
Turn-key contracts do not always run smoothly; an experienced installation manager is invaluable and often mandatory.
- **System acceptance testing**
Designing performance criteria for system acceptance and then ensuring that the system performs according to those standards.
- **Internal management systems**
As the responsibility for hands-on management of systems by end users continues to increase, there is a critical need for institutions to have a well-developed management system which will enable them to manage effectively in a multivendor environment.
- **Understanding current technology, and knowing which vendors offer which equipment and services**
An important corollary to this need relates to the development of standards for new technology and applications. Consultants must be aware of whether any particular system solution has been developed with strict attention to industry standards.
- **Network design**
What is the campus's relationship to other state, national, and global organizations? How should the institution optimize its communications capabilities?
- **Education and training**
New systems will require training programs for all users. Appropriate training of all users is critical to the acceptance and successful use of a new telecommunications system. Training programs customized to the needs of the specific institutional environment and telecommunications system must be developed and implemented.
- **Organizational structure**
How should the telecommunications function be organized? To whom will it report? How many staff managers and analysts will be needed once the system is installed and

operational? How many technicians, clerks, other types of employees?

◆ **Software selection**
What type of management software will be needed? Who will be involved in the selection of this software, and in the final decision on a vendor?

Consultants can get involved in most of these issues at varying levels. It is up to the institution to determine the level of support it wants and needs. One approach to compiling an equipment inventory, for example, would have the consultant designing an inventory system and in-house staff conducting the inventory itself. Some consultants have enough staff to perform the whole job. Typically, vendors supply a certain amount of user training for new systems. The consultant can, however, assist in specifying the nature and extent of training when writing the RFP, and can supervise the vendor's performance. Consultants will generally be of most value doing those things for which the institution does not have qualified, available in-house staff. While it makes sense to have a consultant assist in strategic planning or system evaluations, it makes little sense to pay consultants to count telephones.

Choosing the Right Consultant

Great care must be taken in selecting the right consultant for the task at hand. Consulting firms in the telecommunications arena have proliferated and range in size from one-person shops to divisions of large management consulting and accounting firms. Some corporations, having developed a sophisticated telecommunications staff to deal with their own internal problems, have later turned that staff into a new division which sells consulting services to outside users.

Size is not a good determinant of quality. There are advantages and disadvantages to both large and small firms. The personal attention and commitment that are frequently offered by small firms are harder to find with larger organizations. On the other hand, many one-person shops may lack the technical depth needed for very large, complex tasks. The reputations of the big accounting firms give them great credibility. They have large staffs that usually represent a broad spectrum of technical understanding and experience. Partly because of their size, however, they tend to operate in a more highly-structured and formal manner than smaller firms, and tend to be relatively more expensive. Many of the small firms are more specialized. Their approach can more easily be tailored to the needs of an individual institution. And such firms are frequently less expensive. However, a smaller staff may also entail less organizational stability and a limited perspective.

Cost is an equally poor means of choosing a consultant. The least expensive consultant may, in retrospect, turn out to be so inept as to be very costly. On the other hand, the most expensive is not necessarily the best either. Rates may run from $500 to $1,000 or more per day, plus travel, lodging, and related expenses. While this may seem high, it must be kept in mind that consultants pay office rent and require administrative support staff just as any other professional. In addition, they must spend substantial time just keeping up with new developments, time for which they are not compensated. In an age when the work of telephone service technicians is billed at $100 per hour or more, even $1,000 per day for competent consulting services does not seem exorbitant.

Most consultants will quote a fixed price, or a range with a minimum and maximum, for performing a specific task, usually with a stated per diem rate for extras outside the agreed upon scope of work. One important implication of this is that the institution must convey clearly to the consultant the exact scope of work, and the consultant must understand and agree. Negotiating a detailed contract with the consultant is advisable.

Other means of computing compensation are less common. For example, the use of contingency fees, where payment is a percentage of the annual savings realized as a result of the consultant's recommendations, has declined in recent years. This approach tends to produce large savings by promoting major surgery on the existing system, only to leave the "patient"—after the fee has been paid—near death's door because the level of service is no longer adequate. At this point, much of what was removed in the cost-saving effort must be replaced. Some consultants charge a certain amount per line based on system size. Obviously this can lead to over-building of the system. Whenever possible, both the contingency fee and the per-line approaches should be avoided.

Naturally, organizational size and cost should be two of the factors considered in selection of a consultant. A partial list of other factors includes the following:

- Does the consultant have any experience with systems of the institution's size and type? A 10,000-line voice and data PBX installed on a 500-acre campus requires many skills not needed with a 400-line switch confined to one building.
- Does the firm have experience working in the higher education environment? Most firms that do not have such experience find it difficult to understand that higher education institutions consist of loose confederations of independent contractors, and fail to understand or acknowledge the highly complex political nature of many colleges and universities.
- Has the consultant ever worked in a public bidding situation (if applicable)? Public purchasing rules are very different from those that apply to independent institutions, and a misstep on the consultant's part can invalidate the whole process and cost months of time and effort.
- Does the consultant understand and have current working knowledge of the regulatory changes affecting higher education?
- Does the consulting firm have any outstanding lawsuits? These are not necessarily a negative factor; in this highly

litigious society the consultant may indeed be innocent. Still, a lawsuit is cause for further investigation.

- Does the consultant have any apparent biases? Some consultants may favor particular vendors or products, for a variety of reasons. A worst case situation may be insufficient knowledge of technology and applications on the part of consultants who do not keep up with industry changes.

Answers to some of these questions can be supplied by the consultant. Other information can be obtained only through third parties. The consultant's references should be thoroughly checked with administrators at other institutions who have dealt with the consultant. Contacts available through membership in telecommunications organizations and industry-specific organizations such as the Association of College and University Telecommunications Administrators (ACUTA) or the National Association of College and University Business Officers (NACUBO) are invaluable and can provide a wealth of information. A consultant's membership in various organizations such as the Society of Telecommunication Consultants indicates a level of professional commitment and ethics as well.

Questions as to how a particular consultant "fits" the institution can be answered satisfactorily only through actual interviews with the prospective consultants. Many consulting contracts run for a year or two, especially for major projects, and it is important for the "chemistry" to be right. One of the advantages of a small-to-medium-sized firm is clearly that the individuals with whom the institution is dealing before the contract is signed are likely to be the same persons who will be doing the actual consulting.

Working with Consultants

Styles of operation vary greatly among consultants. At one extreme is the expert who is reluctant to reveal the reasons for making specific recommendations. This consultant spends time at the institution analyzing needs and problems, then disappears. Later he or she materializes with a complete set of recommendations and solutions. Those at the institution have no idea what goes on between meetings, and they are unlikely to find out. At the other extreme is a consultant who merely repeats the solutions that he or she thinks you want to hear, whether they are correct or not.

A more desirable approach to consulting is being not only an expert and a leader, but also an educator and trainer. One goal of both the consultant and the client should be to educate the institution and its staff. Eventually, the consulting contract will terminate and the task will be completed. From then on, the permanent staff will be expected both to continue to run the system and to justify and implement decisions and plans made with the consultant's assistance. A good understanding of the reasons for those decisions and of the operational basics of the system is crucial for the long-term success of any project.

It is essential to develop a good working relationship with a consultant. This is greatly simplified if the duties and responsibilities of the consultant and the institution are clearly established in the contract. During any project in which another vendor is involved, such as the installation of a new PBX, the relationship must include the vendor. Some consultants attempt to act simply as intermediaries between the vendor and management, dominating the project. A more beneficial structure is one in which the consultant helps the institution and the vendor to understand each other's problems and positions so that mutually agreeable solutions may be reached.

There is no easy formula that will always lead to the selection of the right consultant. The decision depends on the unique situation of the institution— its needs, the funds available, existing personnel, politics, and personal preferences. Consultants should be seen as simply one important resource among many. Exercising care in selecting and dealing with a consultant will provide many benefits to the institution.

Glossary

ACUTA	Association of College and University Telecommunications Administrators
ANSI	American National Standards Institute
ASCII	American Standard Code for Information Interchange
AT&T	American Telephone & Telegraph
ATM	Asynchronous Transfer Mode
BOC	Bell Operating Company
CAP	Competitive Access Provider
CCSA	Common Control Switching Arrangement
EDI	Electronic Data Interchange
FCC	Federal Communications Commission
FDDI	Fiber Distributed Data Interface
IP	Internet Protocol
ISDN	Integrated Services Digital Network
IXC	Interexchange Carrier
LAN	Local Area Network
LEC	Local Exchange Carrier
MAN	Metropolitan Area Network
NACUBO	National Association of College and University Business Officers
NREN	National Research and Education Network
OCC	Other Common Carrier
PC	Personal Computer
RBOC	Regional Bell Operating Company; any of the seven regional companies formed following divestiture
RFI	Request for Information
RFP	Request for Proposal
RHC	Bell Regional Holding Company; synonymous with RBOC; presently, the more commonly accepted term
OSI	Open Systems Interconnection
SMDS	Switched Multimegabit Data Service
SONET	Synchronous Optical NETwork
TCP	Transmission Control Protocol
TCP / IP	Transmission Control Protocol / Internet Protocol
UNIX	A complex operating system for computers, used for handling the needs of multiple users performing multiple tasks on multiple programs, simultaneously. Developed at AT&T Bell Laboratories in 1969.
WAN	Wide Area Network

AC Alternating current
access Point at which entry is gained to a circuit or facility.
access code The digit, or digits, that a user must dial to be connected to an outgoing trunk group. For example, the user dials "9" for a local trunk, dials "8" for WATS, etc.
acoustic coupling Coupling a data terminal or similar device to a telephone line by means of transducers that utilize sound waves to or from a telephone handset.
add-on conference Allows a station user to add a third party to any existing two-party conversation.
address Destination of a message in a communications system.
all trunks busy (ATB) All trunks within a group being occupied, or busy.
alternate routing Procedure of routing a call over another route when all first-choice routes are busy or unavailable.
American Standard Code for Information Interchange (ASCII) A code with seven information signals plus one parity check signal, designed for compatibility between computers.
amplifier Device that receives an input signal in wave form and gives out a magnified signal.
analog signal A continuously variable signal. Voice signals transmitted on telephone lines are analog, i.e., transmitted electrically in a form analogous to the spoken form.
analog switch Switching equipment designed, designated, or used primarily for circuit connections between users for real-time transmission of analog signals.
area/office code restriction Ability of the PBX system to screen the dialed digits (NPA or NNX), and then to allow or deny connecting of the call to the trunk. This is very effective for exchanges that dial only to weather, time, etc.
asynchronous Not synchronous. Having no set pattern, cycle, or speed of transmission.
asynchronous transfer mode (ATM) An emerging technology, designed to enable high-capacity, high-speed networks that can switch multimedia and full-motion video applications.
attendant Operator at a PBX console or operating position.
attendant exclusion PBX feature that "locks out" the attendant from an established call.
attendant recall PBX feature that brings the attendant into a circuit to provide assistance for unanswered calls.
automatic call distribution System designed to distribute heavy incoming traffic evenly among clerks or attendants.

automatic identification on outward dialing (AIOD) Ability of some Centrex units to provide an itemized breakdown of charges for calls made by each telephone extension.

automatic number identification Equipment that identifies the telephone number of the line initiating a call in order to send this information to a message accounting system.

backbone High-density portion of any communications network.

bandwidth Range of frequency from its upper to its lower limit.

baud Unit of signaling speed. In an equal length code, one baud corresponds to a rate of one signal element per second, or one bit per second.

Bell Operating Company (BOC) Any of the twenty-two companies comprising the Bell operating telephone network.

binary digit Unit of information in two-level digital notation that may be a "0" or "1." A member selected from a binary set.

bit Abbreviation for binary digit. The smallest unit of information that a computer processes. A bit can have two values--generally a "0" or "1," or in electrical terms an "on" or "off."

bit rate Speed at which signal bits are transmitted.

blocking Occurs when a call, arriving at random, finds an ATB condition for the trunk group used for completion of the call.

bridge Device that connects networks and forwards packets between them.

broadband Describes a wide range of transmission services generally requiring bandwidth greater than 64 kbps or in multiples of 64 kbps.

buffer (1) Interface unit designed to link circuits together but not allow excessive or unwanted variations in one to affect the other. (2) A routine or storage used to compensate for a difference in rate of flow of data, or time of occurrence of events, when data are being transferred from one device to another.

bug Problematic glitch in a computer software program, usually causing malfunction.

bus (1) An electrical connection which allows two or more wires or lines to be connected together (2) The name for a main power lead between rectifiers/batteries and telephone switching equipment. A bus can be a 100mm-diameter cable of stranded copper, or simply a track between circuits on a printed circuit board.

busy count Number of times all trunks in a group are busy.

busy hour The hour of the day the telephone system carries the most traffic.

byte Smallest addressable unit of information in data storage or memory (consisting of eight bits).

cable Insulated conductors assembled in a compact form and covered by a flexible plastic-like waterproof protective sheath.

cable, buried Cable that is placed in the ground without the use of a conduit (also referred to as direct buried).

cable, optical fiber Cable made of glass fiber protected by a plastic cover.

cable, pressurized Cable protected against moisture entry by the pumping of air or nitrogen under pressure from the central office. Leaks produce changes in pressure followed by an increased pumping rate allowing immediate notification of a problem.

call forward, don't answer Automatic rerouting to the attendant or a preprogrammed secondary station when a given station does not answer within a prescribed time period (usually three rings).

call forwarding, all calls Allows a station user to program a phone at any time to any internal station or the attendant. When activated by the station user, all calls—both internal and external—will be automatically rerouted to this preprogrammed number.

call forwarding, station busy Automatically reroutes incoming calls directly to a predetermined station or the attendant when the called station is busy.

call hold While conversing on any call in progress, the station user normally activates this feature either by first flashing the switchhook and then dialing the appropriate "hold" code or by depressing one of the feature buttons on the instrument.

call park Similar to the "call hold" feature and normally used in one of two ways: (1) an established call is placed in "park" condition by dialing the access code and then transferring the call to another number where it goes without ringing. The phone is simply answered from the new location; or (2) a call is placed on "hold" and then retrieved from any other phone by dialing an access code and the telephone number of the phone holding the call.

call pickup Allows a phone user whose phone is part of a preprogrammed group to answer another ringing phone within that group by simply dialing an access code to seize the call.

call transfer Allows all calls that come into any given station whether from within or without the system to be transferred to any other line in the system. To transfer a call, a user flashes the switchhook once, dials the desired station, announces the call, and hangs up.

call waiting Allows a station user to hear a tone whenever a second call is attempting to contact that station. Upon hearing the tone, the station user can connect with the second call by flashing the switchhook and dialing an access code. The station user can then go back and forth between the calls by repeating the procedure.

camp-on Allows holding of a call on a busy line terminal until the line becomes idle, and then passes the call through automatically.

Carterfone A trademarked, acoustically-coupled device intended to couple a two-way radio circuit with local or long distance telephone facilities. The "Carterfone decision," in which the U.S. Federal Communications Commission permitted interconnection of the device, opened up the telephone terminal equipment market by permitting subscribers to buy or lease such equipment from firms other than telephone companies.

central office Facility housing the telephone switching system and related equipment for providing telephone service to customers in the immediate geographical area.

central processing unit (CPU) Core of the computer, containing the logic, computation, and control circuits. Controls the interpretation and execution instructions and sometimes contains memory; performs calculations and processes data according to instructions specified in software.

Centrex Service (Central Exchange service) A telephone service provided by a LEC under the terms of a custom contract or general tariff. PBX equivalent functionality can be obtained but ownership and maintenance remain the responsibility of the LEC.

Centrex CO Site in the central office where the service-providing switch is located.

Centrex CU Site on the customer's premises where the switch is located.

circle hunting Lines or stations arranged or programmed in such a way so that calls to any number in the group will, upon encountering a busy line or station, progressively search through the remaining lines or stations at least once and establish a connection with the first available (nonbusy) line or station.

circuit, four-wire Circuit that uses electrically separate paths for the two directions of transmission.

circuit, two-wire Circuit in which information signals in both directions are carried by the same two-wire path.

circuit switch Direct communication between host computers via a dedicated line.

clipping Deforming of speech signals by the cutting off of initial or final syllables.

code, cable color Code that identifies cable pairs by color.

common carrier Company, such as a telephone or telegraph company, that furnishes public telecommunications facilities.

concentrator Switching system in which a large number of inlets are connected to a smaller number of outlets.

Common Control Switching Arrangement (CCSA) A private AT&T network for very large telecom services users.

competitive access provider (CAP) A commercial optical fiber-based network serving a metro area, in open competition with local exchange companies.

conference operation In a telephone system, that type of operation in which more than two stations can carry on a conversation.

crash Complete failure of a hardware device (usually the CPU) or a software system control program.

crossbar system Automatic switching system in which the selecting mechanisms are electromagnetically operated mechanical crossbar switches of vertical and horizontal paths.

cross-connect Connections between terminal blocks on the two sides of a distribution frame or between terminals on a terminal block.

crosstalk Where a signal is transmitted on one circuit or channel of a transmission system, creating an undesired effect on another circuit or channel.

data Any representation, such as characters or analog quantities, to which meaning is or might be assigned.

data set Device that converts the signals of a business machine to signals that are suitable for transmission over telecommunications circuits and vice versa. The Bell System name for modem.

dedicated circuit Circuit used for communicating only between two points.

digital Using digital (binary) or discrete signals; not a continuously variable analog-type signal.

digital voice transmission Transmission of analog voice signals that have been converted into digital signals.

direct distance dialing (DDD) Telephone service that allows a user to dial outside the user's local service area, without the aid of an operator.

direct inward dialing (DID) Incoming calls are directed to the desired PBX or Centrex extension automatically (the last four digits being the identifier for the desired extension), bypassing the PBX attendant.

direct outward dialing Any, all, or selected stations can call outside, bypassing the attendant.

directed call pickup Station user is able to answer calls ringing on any station within the communications system by dialing a unique answer code (access code plus station number) of the particular station to be answered. An optional arrangement provides that if the call has already been answered by the called station, the station user who dials the answer code will be "added on" (in a conference) to the connection, and a burst of tone will be applied to alert the first and second parties of the third party's presence on the line.

distinctive ringing Provides two different types of station ringing for audible distinction between internal and outside calls coming in to the station user. In some systems, more than two ringing patterns may be provided to accommodate other special types of incoming calls, such as those associated with automatic call back or call forwarding.

distribution frame Structure with terminations for connecting the permanent wiring in such a manner that interconnection by cross-connection can be readily made.

electronic switching system Any switching system whose major components utilize semiconductor devices. This usually includes semi-electronic systems that have core-reed, cross-reed, or cross-bar matrices.

end office Class 5 office in the North American hierarchic routing plan; a switching center where subscriber's loops are terminated and where toll calls are switched through to called links.

erlang The number of erlangs is the ratio of the time a facility is occupied (continuously or cumulatively) to the time that this facility is available for occupancy. Named after its inventor, Danish mathematician A.K Erlang.

Ethernet A packet-switched local area network design.

exchange Room or building equipped so that telephone lines terminating there may be interconnected as required. Equipment may include manual or automatic switching equipment.

exchange, private branch (PBX) Small local telephone office, either automatic or manually operated, serving extensions in a business complex and providing access to the public switched network.

executive busy override Preselected stations are provided with this facility via preprogrammed instructions in the common equipment. It enables users of those stations, upon encountering a busy signal, to dial a single digit or activate a feature button and gain access to the existing conversation. Some systems restrict the use of this feature to break-in only on internal-to-internal connections.

facilities General word describing elements of equipment that provide a service. Also used in reference to the operating or maintenance service features made available by a system.

fax Shortened version of facsimile, referring to the service or the actual machines by which a copy of a document or picture may be transmitted over a transmission medium.

Federal Communications Commission (FCC) In the U.S., a board of seven commissioners, appointed by the President, with the power to regulate all interstate and foreign electrical communications systems originating in the U.S. This includes radio, television, telegraph, telephone, facsimile, and cable systems.

fiber distributed digital interface (FDDI) A packet-switched LAN backbone transporting data at high speed.

fiber optics (FO) Branch of optical technology concerned with the transmission of radiant power through fibers made of transparent materials such as glass, fused silica, or plastic. Communications applications of fiber optics employ flexible fibers.

file server A specially-configured computer which directs the movement of files and data on a local area network.

foreign exchange service (FX) Provides local telephone service from a central office that is located outside the subscribers' exchange area.

frequency, voice For normal telephony purposes, the band 300 Hz to 400 Hz is transmitted. This is called the commercial speech band.

full duplex Simultaneous communications in both directions between two points.

gateway router, or IP (Internet protocol) router that allows incompatible protocols to communicate.

grade of service For central offices/telephone exchanges, the probability of a call being blocked (all trunks busy) during the busy hour because of insufficient equipment or trunks.

hertz (Hz) Unit of frequency: one cycle per second.

holding time Total time that a circuit is busy.

host (1) Another name for any computer attached to a network. (2) The main computer used in a network or a time-sharing operation. A host may be anything from a personal computer to a supercomputer.

integrated services digital network (ISDN) An all-digital transmission system designed to carry voice, data, video, and image signals. The proposed structure for the next step in global telecommunications.

integrated system Telecommunications system that moves analog and digital traffic over the same switched network.

interconnect Where a customer-provided piece of equipment is connected to or has access to the public switched telephone network.

interexchange carrier (IXC) A long distance company such as AT&T, MCI, Sprint, and others.

interface Process of interrelating two or more dissimilar circuits or systems. The definition includes the type, quantity, and function of the interconnecting circuits and the type and form of the signals to be interchanged via those circuits. Mechanical details of plugs, sockets, pin numbers, and other items may be included within the context of the definition.

Internet The global network of computer-based information networks, accessed by their computers through established communications protocols and logon procedures.

inward wide-area telephone service (INWATS) A particular service offered by AT&T Communications to allow other telephone users to call a particular number (long distance) without incurring a charge. The charges are met by the called subscriber on a measured basis.

jack Device in which a plug is inserted in order to make electrical contacts.

jumper Semi-permanent cross-connection wire on a main or intermediate distribution frame or other cross-connecting point.

kilobit (K) In the computer world, K means two to the tenth, or 1,024 in ordinary decimal figures.

key system Local telephone system (in-house) in a small office complex or home providing immediate access to all users, who press one or two keys. All users have access to lines on the public network and may communicate with each other without an operator.

light-emitting diode (LED) A pin-junction semiconductor device that emits optical radiation when biased in a forward direction, as a result of a recombination device. This is very often used in fiber optics where long life of the light-producing element is required.

local access and transport area (LATA) One of 161 metro areas, created following divestiture, within which a local exchange company may provide communications services.

local area network (LAN) Data communications network covering a limited geographical area

local exchange carrier (LEC) A local telephone company, whether a BOC, GTE, or other independent.

loop, local Line connecting subscribers' instruments or PBX to the local central office (CO).

line hunting Lines arranged or programmed in such a way that a call incoming to that group, upon encountering a busy line, will progressively search through the remaining lines in that group and establish a connection to the first available (nonbusy) line.

matrix A simple switching network in which a specified inlet (matrix row) has access to a specified outlet (matrix column) via a crosspoint placed at an intersection of the row and column in question. Synonyms: connecting matrix, switching matrix.

megabit One million binary digits.

message center Portion of the communications center responsible for acceptance and processing of outgoing messages and for receipt and delivery of incoming messages.

Metropolitan Area Network (MAN) Data communications network covering a metropolitan area.

mileage Distance used in tariff calculations. It is locally defined and usually refers to airline distance, rather than actual route miles.

modem Acronym for modulator-demodulator. A device that modulates and demodulates signals. Modems are used primarily for converting digital signals into analog signals for transmission over the voice-grade public switched network to another location to be converted back to a digital signal for computer processing.

modular In switching equipment, designed and manufactured in functional modules so that individual modules can later be replaced by updated versions (upgrades).

multiplex (MUX) (1) Use of a common channel to make two or more channels. This is done by splitting the common channel frequency band into narrower bands, each of which is used to constitute a distinct channel (frequency-division multiplex), or by allotting this common channel to multiple users in turn, to constitute different intermittent channels (time-division multiplex). (2) In telegraphy, simultaneous transmission of two or more messages in the same or opposite directions, using the same transmission path.

nanosecond One-billionth of a second.

network Organization of stations capable of intercommunication, but not necessarily on the same channel.

nonsynchronous data transmission channel Data channel in which no separate timing information is transferred between the data terminal equipment and the data circuit-terminating equipment.

office, central A 10,000-line switching center.

off-premises extension PBX extension located in a building that is connected to the PBX through public network cable-pairs.

on-hook (1) In telephone operation, the conditions existing when the receiver or handset is resting on the switch. (2) Idle state (open loop) of a subscriber or PBX line loop.

optical fiber Any fiber, made of dielectric material, that guides light. One of its uses is the transmission of signals.

outside plant That portion of intrabase communications systems extending from the main distribution frame outward to the telephone instrument or to the terminal connections for other technical components.

packet (1) A collection of data and control characters in a specified format, which is transferred as a whole. (2) Group of binary digits, including data and call control signals (computer commands), which is switched as a composite whole. The data, control signals, and error control information are arranged in a specific format.

packet switching (1) Describing a system whereby messages are broken down into smaller units called packets, which are then individually addressed and routed through the network. (2) Process of routing and transferring data by means of addressed packets so that a channel is occupied only during the transmission of the packet. Upon completion of the transmission, the channel becomes available for the transfer of other traffic. An advantage of packet switching is that multiple communications may occur among hosts simultaneously.

pair The two wires of a circuit, particularly those providing the subscriber's loop.

patch To connect circuits temporarily by means of a cable known as a patch cord.

peg count A count of the seizure, or attempts at seizure, of telephone trunks, circuits, or switching equipment or of calls handled by an operator during a specified time interval.

pen register Moving-paper recording device used for checking dial pulse speed and ratio.

permissive connection Connection to privately owned facilities that is permitted by the telephone company but that is not guaranteed by the telephone company to perform satisfactorily in all respects.

Poisson tables Tables based on mathematical probabilities. They can be used to calculate the number of circuits needed in a group to achieve a specified grade of service for a given level of traffic.

practices Set of standard instructions that describe work procedures and are issued by major telephone organizations.

press-to-talk Type of handset with a button to activate the transmitter (increase the volume) in areas where there is a high noise level making it difficult to hear the incoming voice signal.

pre-wiring Practice of laying telephone cabling within a building during its construction.

program Instructions placed in the memory of a stored program-controlled switching system.

protocol A set of rules or procedures relative to the format and timing of data transmission between two or more telecommunications devices. The three types of protocols are bit-oriented, byte-oriented, and character-oriented.

pulse code modulation (PCM) That form of modulation in which the modulating signal is sampled and the sample quantized and coded so that each element of information consists of different kinds or numbers of pulses and spaces.

quad Group of four wires composed of two pairs twisted together.

queuing Holding of calls in order of their arrival and presenting them automatically, in the same order, to an operator or to a trunk facility for its attention.

queuing theory Probability theory as applied to the study of delays.

raceway Covered conduit or channel for internal wiring and cabling.

rack, cable Light steel runway or ladder on which internal cables are laid in a central office and sometimes in private exchanges.

random access memory (RAM) Semiconductor chips within the computer in the telephone system. The CPU enters and retrieves information from RAM almost instantaneously.

read-only memory (ROM) If RAM is like a scratch pad, then ROM is like a printed book whose pages cannot be erased. Software to operate a telephone system is often stored in ROM.

real time Expression used in discussing the type of computer operation in which the computer is interacting with events in the world of people, rather than circuits. Generally, the interaction must take place quickly enough to influence or react to the particular "people" event in progress.

Regional Bell Operating Company (RBOC) Another term for Regional Holding Company.

Regional Holding Company (RHC) Seven were created under the 1982 divestiture, each owning two or more BOCs. The RHCs are: Ameritech, Bell Atlantic, BellSouth, NYNEX, Pacific Telesis, Southwestern Bell, US West, and are also referred to as the "Baby Bells."

relay Device (usually electromagnetic) by which current flowing in one circuit causes contacts to operate that control the flow of currents in other circuits.

repeater Device that amplifies an input signal or—in the case of pulses—amplifies, reshapes, retimes, or performs a combination of any of these functions on an input signal for retransmission.

ringdown Circuit on which the signaling is manually applied.

ring wire Second line wire (tip, ring, sleeve) of a telephone line, inside the office.

rotary dial Common telephone calling device that interrupts line current on the loop provided by the instrument, thus transmitting the digits of the called telephone customer's number to the central office or exchange.

router A system responsible for making decisions about which of several paths network (or Internet) traffic will follow.

run, cable Route followed by cables, either directly buried or in ducts.

run, conduit Route followed by cable conduits. Also called a duct run.

sampling Process of taking samples, usually at equal time intervals.

sheath Outer covering of a cable. Its purpose is to provide protection for the insulated cable pairs housed within.

shield, cable Metallic layer around a cable core designed to minimize interference from external sources.

shielded pair Pair of conductors (in a cable) wrapped with metallic foil or braided to insulate the pair from interference.

signal Information that is transferred over a communications system by electrical or optical means. Also, a type of message, the text of which consists of one or more letters, words, characters, signal flags, visual displays, or special sounds with prearranged meanings, and which is conveyed or transmitted by visual, acoustical, or electrical means.

solid-state circuit Integrated circuit with all the elements formed as a single block of semiconductor material.

solid-state memory Memory unit formed in a semiconductor chip.

speed dialing Allows a station user to assign abbreviated codes to certain frequently called numbers, usually associated with outgoing central office calls. This allows the user to dial selected numbers using fewer digits (one, two, or three, depending on the central PBX repertory) than normally required.

SS7 Signaling System 7

station message detail recorder (SMDR) Provides a record of the PBX station (or attendant) identity, starting time, duration, and the trunk group used for outgoing and/or incoming calls. The call duration is measured from about 10 seconds after the establishment of the connection in the customer's system to the time when the station goes on hook. Hence, busy signal, don't answer, and wrong number calls may also be recorded. A station-dialed account code may be recorded in addition to the calling station number.

station message detail recording Provides a record of the calling station or attendant number, starting time, call duration, all digits of the called number, and the specific trunk or trunk group used for outgoing calls. In almost all cases, these data are captured on magnetic tape or disk for future processing and pricing of calls. This information can be valuable in calling-area analysis and charge-back for telecommunications costs.

switch Mechanical or solid-state device that opens or closes circuits, changes operating parameters, or selects paths or circuits, either on a space- or time-division basis.

switch, analog See analog switch.

switch, digital Solid-state switch that switches digital signals by means of a time-division matrix.

switch matrix In a space-division exchange, an array of crosspoints that operates as a switch from a traffic point of view.

switched multimegabit data service (SMDS) A broadband service standard developed by Bellcore.

synchronous Having a set pattern, cycle, or speed of transmission.

synchronous optical network (SONET) An emerging digital carrier system

T-1 A digital transmission link with a capacity of 1.544 Mbps (million bits per second; also called megabits per second); handles 24 voice grade channels.

T-2 A digital transmission link with a capacity of 6.312 Mbps; handles 96 voice grade channels.

T-3 A digital transmission link with a capacity of 44.736 Mbps; handles 672 voice grade channels.

T-4 A digital transmission link with a capacity of 274.176 Mbps; handles 4,032 voice grade channels.

tariff Document filed by a communications carrier with a state Public Utilities Commission or the Federal Communications Commission (FCC) detailing services and equipment offered along with rate, pricing, and service prohibition information.

T-carrier General designation of any Bell digital transmission system.

telecommunication Any process that enables a correspondent to relay written or printed matter, fixed or moving pictures, words, music, or visible or audible signals or signals controlling the functioning of mechanisms, etc.; communication at a distance.

teleconference Conference between persons linked by a telecommunications system, either audio- or video-based.

terminal (1) Device attached to the end of a wire or cable or to an electrical apparatus for convenience in making connections. (2) Input/ output device connected to a processor or computer to enable communication with it and to control processing.

terminate (1) To connect a line to a terminal or equipment. (2) To connect a bridge across a circuit in order to make it stable.

tie line Trunk between PBXs. A tie trunk.

tie trunk Telephone circuit linking two private branch exchanges (PBX).

time sharing Method whereby facilities (usually computers) are shared by several users at the same time. The processor actually services the different users in sequence, but its high speed of operation in effect allows all to be serviced simultaneously.

time slot In switching, an interval in the time domain capable of providing a channel.

tip One of the two speech wires in a central office, the other being called a ring.

token ring A local area network access mechanism/topology in which a "token" is circulated from node to node.

toll Charge for a long distance telephone call.

toll center (TC) Class 4C toll office where operators give assistance in completing incoming calls in addition to providing other traffic-related telephone services. Class 4P toll center is an office where operators handle only outbound calls, or where switching is performed without operator assistance.

Transmission Control Protocol / Internet Protocol TCP / IP The two principal protocols operative on the Internet. These protocols have also been adopted for use by many large corporations, for use in applications such as hotel reservation systems, warehouse inventory systems, teleconferencing and multimedia systems, etc. TCP /IP is not vendor-specific, and may be used on equipment ranging from personal computers to supercomputers.

UNIX A complex operating system for computers, enabling a computer to handle multiple users and multiple programs simultaneously.

wide area network (WAN) Data communications network covering a large geographical area.

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