Chapter 2

Broadband Telephony

Today's telephones are not the telephones of yesteryear, nor are the types of services users get from telephone companies the plain old telephone services of past generations. Telephony has taken on a new identity; even the concept of a "telephone industry" has come to mean something quite different.

The AT&T Corp. and BellSouth Corp. brands are still in the U.S. phone books, at least for a while longer, but the technologies they own and the strategies they employ are radically changed. The new breed of telephone conglomerates bear names like Qwest Communications International, SBC Communications, Verizon Communications, MCI WorldCom, Global Crossing, and Time Warner Telecom. It's hard to keep up with all the businesses these companies are into but their offerings include data communications, high-speed Internet, and multimedia services, of which voice services is only one item on an extended menu.

Whatever services customers nowadays expect from the cable, wireless, satellite, broadcast, and Internet providers, those are the services they are coming to expect of telephone companies as well.

The telephone industry has the advantage that it was the first to deliver on demand two-way real-time communication in the form of local and long-distance voice services. Now the telcos are in an excellent position to become next-generation providers for whatever else residential and business customers might want in the way of broadband data and communications—yes, entertainment and commerce as well—all delivered on a single telecommunications line, all itemized on a single bill.

Local telephone providers have the incumbent advantage that comes with owning lines that link virtually every home and business. Slowly but quite deliberately those same operators are transforming their circuit-switched voice networks into networks
capable of high-speed digital processing in which voice and video and dozens of other applications are integrated. What is more, these companies have access to the capital it will take to make the necessary upgrades and secure the regulatory permissions needed to continue their control over first- and last-mile access.

Though they don’t always get credit for it, the old telephone companies set a high standard for 21st-century communications. In their earlier lives as regulated monopolies, universal service was a concept the telcos understood and embraced. Ensuring that everyone was connected was central to the telephone company mission; therefore they knew how to partner with others so that their networks were globally interoperable. And because the transport of voice and data was profitable, the telephone companies were able to attract world-class scientists and engineers, put money into research, and invest heavily in infrastructure that could guarantee high-quality services in both wireline and wireless communications.

In the last decades of the 20th century, the U.S. telephone operators lobbied hard for the right to diversify and grow their businesses beyond the boundaries government regulators had set, hoping to expand both the territories they could serve and the services they could offer. In 1996 they got their wish. Though regulatory controls were not removed all at once, the rules constraining the telephone business were greatly relaxed in the Telecommunications Reform Act that resulted in this industry adopting much more aggressive strategies for dominating first- and last-mile markets in the delivery of broadband programs and services.

How are they doing? The whole telecommunications sector suffered from the stock market free fall that occurred within months of the new millennium, and the telcos were also hit. Increased competition, huge debt loads, excess capacity, and poor management practices savaged the long-distance sector. The revenues that the number one carrier AT&T brought in from its long-distance voice and data services became less and less as rates were lowered to meet its competition from MCI WorldCom, Sprint, and a host of smaller players. The number two distance carrier MCI WorldCom was forced into bankruptcy when the company’s stock fell below $3 a share on the news that it had overstated income, having falsely portrayed itself as profitable in 2001 and 2002 to the tune of about $7 billion.

Revenue growth has been flat among the incumbent local telephone operators, but their business is picking up. The former Baby Bells are better capitalized than the long-distance carriers and better protected from competition.

Reconsolidation in the U.S. telephone business has been dramatic and continues unabated. Local operators have merged to gain market-share and diversify their services. Only four of the original seven Baby Bells remain of the RBOCs spun off when the AT&T monopoly was broken in 1984. Six years after the 1996 Telecom Act that introduced competition in local markets, 95 percent of local lines for homes and businesses were still under the control of Bell companies.

The great flurry of entrepreneurial activity and capital investment that launched numerous local access competitors was largely for naught, as most could not achieve profitability leasing lines from the incumbent operators and failed to survive the economic downturn of 2000–2002. By 2004, with only about 10 percent of access lines under the control of the CLECs, the Bells were congratulating themselves, consumer advocacy groups were furious, and regulators were ambivalent.

What follows is a brief overview of the status of the broadband telephone industry competition, focusing on emerging technologies and the changing marketplace.

What’s Happening in Telephony?

Deregulation
The Telecommunications Reform Act of 1996 was thought to be a turning point in U.S. telecommunications history. Its framers were consciously trying to introduce competition, reduce prices, and increase consumer options based on free-market principles. For local and long-distance telephony providers, the incumbents as well
as the aspirants were freed to pick their favorite markets and their technologies, deciding for themselves which services they would offer to whom at what price. The resulting changes were immediate and far-reaching, although in many ways quite different from the scenario regulators had hoped for.

In 1984, to settle a U.S. federal antitrust suit, AT&T Corp., the world’s largest corporation at $158 billion, agreed to spin off its 22 local affiliates into seven RBOCs. From 1984 until 1996, the RBOCs, plus independent GTE, were assured virtual monopolies in providing local telephone service. Relegated to being a long-distance carrier, AT&T found itself paying some 40 percent of its revenues in fees just to gain access to its former customers in the last mile. While AT&T faced both domestic and international competition, the Baby Bells were protected from competition by law, and guaranteed rates of return left them among the most highly capitalized companies in the United States.

Title I of the 1996 Telecom Act was written to promote increased competition in the provision of telecom services by opening the local exchange monopolies. The RBOCs were permitted to enter manufacturing and the long-distance services side of the business subject to a list of conditions, including the condition that the local telephone exchanges be “unbundled.” That is, the RBOCs would be required to open their lines and make their facilities available to competitors.

The ILECs, as the RBOCs came to be called, were in no hurry to hand over their customers to others, so they dragged their feet in compliance. There were reasons other than just turf protection. Sharing central office space and giving the new CLECs, ISPs, and application service providers (ASPs) access to their circuits and switches was not easy to do technically. As a consequence, the FCC, the FTC and the U.S. Congress found themselves monitoring and intervening on behalf of the competitive carriers much longer than anticipated.

For the sake of efficiency and improved performance, the Bells had spent years streamlining their physical plant and integrating their voice and data services. To now separate out those services, interconnect their local networks to competitors, provide excess capacity for resale at greatly reduced rates, and keep records of all those transactions for purposes of billing turned out to be onerous and time-consuming. Considerable extra effort was needed to accommodate to the CLECs and their affiliated service providers just when the ILECs were themselves making system-wide upgrades to become providers of long-distance, high-speed Internet, and information services.

CLECs were eager to tie into the already established networks, for those lines were the quickest way to reach residential and business customers. In almost every major U.S. market, wireless and wireline competitors began pressing the RBOCs to open their facilities and sell them access. Often the competitive strategy was to enter the local loop, buying capacity wholesale with hopes of building a customer base offering telephone, Internet, or data services while capital was being raised, alliances were forged, and facilities were built that would bring operations more under their direct control.

By 1997 the U.S. local-access market was experiencing its first real shake-up in 80 years. No longer restricted to being “common carriers,” the telephone companies were free to become full-service providers. Once they opened their facilities to competitors, the RBOCs could offer video and data services as well as local and long-distance telephony, and bundle those services as a package. Some of these services they would own outright; some they would host on their networks on behalf of others.

Under deregulation, the RBOCs not only were given permission to go after the long-distance telephony market—denied to them in the breakup of AT&T in 1984—but also were permitted to set up shop in the local access markets of other RBOCs. They could compete with or form strategic alliances with other operators, data networks, cable companies, broadcasters, and satellite providers. And almost all telephone companies moved quickly to take advantage of those opportunities.

The long-distance carriers were allowed back into the local markets. Thus AT&T, MCI WorldCom, and Sprint each went after local telephony, broadband Internet, VoD, and whatever other
telecommunications services they thought local customers might want. But they faced an insurmountable barrier. Since the long-distance networks did not own any local lines, they had the same problems as the CLECs and ISPs in gaining direct access to homes and businesses.

International telecommunications markets were also opening to competition. Both the U.S.-based Baby Bells and the distance carriers were quickly involved in international ventures through mergers, acquisitions, and alliances.

To illustrate, here are some examples of how telephone industry players, in the United States and abroad, responded to the opportunities of a freer but more competitive market.

**ILECs**

In 1996 Bell Atlantic Corp. was a $24 billion LEC serving the East Coast of the United States, including such states as New Jersey, Pennsylvania, Maryland, Virginia, and Washington, D.C. Shortly after the Telecom Act became law, Bell Atlantic merged with another former Baby Bell, NYNEX, serving states from New York to Maine. NYNEX assets were valued at $26 billion. Between them, the two companies shared about 26 million customers and about 3.5 million miles of interconnecting fiber-optic trunk lines.

The new company moved its headquarters to New York, retaining the Bell Atlantic name. Its publicly stated purpose was to quickly position itself as a major player in its region in the delivery of interactive digital telecommunications. The company announced it would be spending some $5.5 billion upgrading the capacity of its analog telephone lines for transmission of local and long-distance telephony in digital format and for the delivery of high-speed Internet and digital video. In 1998 Bell Atlantic entered the long-haul data transportation business with the construction of a packet-switched fiber-optic network competitive with the national carriers. Its transport network was among the first to support corporate intranet and extranet traffic, VPNs, videoconferencing, telecommuting, and electronic commerce.

Bell Atlantic closed on a $61 billion merger with GTE Corp., in June 2000 and changed its name to Verizon Communications Inc. GTE was the local phone provider with the broadest coverage in the United States. Its customer base consisted mostly of rural and suburban operations, about 20 million local customers in 28 states stretching from Hawaii to Florida. GTE was not a Bell operating company but an early independent that gathered up many of those areas not under the control of AT&T. With the addition of GTE, Verizon now has operations in 41 of the 50 states.

GTE was a forward-looking company as well. In 1997 it purchased Internet provider BBN and announced plans to spend $2.5 billion over five years on data gear. It leased capacity on Qwest Communication’s 13,000-mile national fiber network with the announced strategy of offering Internet access and high-speed data lines to business and residential customers within its regions. GTE also cut a deal with networking giant Cisco Systems Inc. to jointly design and manage GTE’s corporate data networks, and with Microsoft Corp. it began packaging voice, fax, and e-mail as a unified service.

GTE was the first telco to introduce xDSL access technologies for high-speed data services such as Internet. DSL technologies can deliver data faster than traditional dial-up connections using conventional copper telephone wires. Speeds range from 256 kbps to 1.5 Mbps or more. GTE Network Services pioneered use of xDSL in the local phone network and installed the broadband equipment in more than 500 of its central offices.

Verizon, the biggest ILEC, took the lead in 2003 to invest billions of new dollars in upgrading its phone networks to broadband, replacing many of its copper loops with fiber-optic technologies. Its strategy of bundling voice, video, and data and dramatically reducing prices for DSL services sent shock waves through the cable competition and served as a performance challenge to fellow ILECs and CLECs as well.

**CLECs**

NorthPoint Communications Inc. and Covad Communications Group Inc. were among the new generation of CLECs delivering
high-speed Internet service to corporate customers and local ISPs. They each took advantage of the opportunities presented by the Telecommunications Act of 1996 that required incumbent telephone companies to give them access to the facilities needed to reach local customers.

Calling itself a "data CLEC," NorthPoint set out to connect ISPs to much wider bandwidth at wholesale prices based on symmetric DSL (SDSL) technology in which the upstream transmission rate is as great as the downstream. SDSL services from the local CLEC eliminated the ISPs' need to lease copper lines from the incumbent telephone company or to manage modem pools or switches. In 1998 NorthPoint began offering two-way T1 (1.5 Mbps) service for $250 per month, which meant that ISPs could pass along to their customers faster access at lower cost. Comparable rates for T1 service from local phone companies were ranging from $350 to $1,500 per month.

Like NorthPoint, Covad started out providing super-fast Internet connections to businesses but used ADSL in the local telephone loop. Covad's asymmetric DSL was downloading data at 1.5 Mbps but uploading at a slower 384 kbps. Charges were about $250 a month plus a one-time cost of $550 for a DSL modem and $325 for installation. In order for this approach to work, Covad had to rent space and install special networking equipment in the field offices of local telephone companies. In each location, Covad was at the mercy of a former regional telephone monopoly that controlled the crucial last mile of copper lines to the businesses Covad sought to serve. Many of those incumbent telephone companies were also offering their own Internet services.

Covad and NorthPoint were themselves competitors in California, where they sought customers for their DSL services in the San Francisco Bay area and in Silicon Valley. When they each filed plans to compete in Boston and New York, and began looking for ways to secure national coverage, they publicly agreed that the market was so big and so underdeveloped that there was plenty of room for them both. At the turn of the millennium, however, they were each rapidly exhausting their available capital due to the high costs associated with moving into these new markets. Their stock prices were sagging from the long-term payback schedules. The Bells were proving tougher competitors than they had counted on.

By mid-2001, Covad Communications had accumulated 330,000 customers but lost $1.4 billion on sales of $159 million. The bottom fell out of its stock price. Covad sought Chapter 11 bankruptcy protection. SBC Communications, the regional telephone company formed in the merger of Southwestern Bell, SBC Telecom, Nevada Bell, Pacific Bell, and Ameritech, became a business partner to what remained of Covad once its debt was removed. NorthPoint, with 100,000 customers, had already filed for bankruptcy in January of that year and sold its installed central office gear to AT&T.

Regulatory relief came too late. The FCC censored SBC Communications in 2002 for denying Covad and other competitive carriers timely access to its networks, but by 2003 the politics of regulation had changed. The regulatory agency agreed to exempt the incumbent telco's high-speed lines, thus putting the CLECs in the slow lane by making the new DSL and copper/fiber connections available to competitors only on RBOC terms. After seven years of trying to make the 1996 Telecom Act work, the competitive carriers represented less than 13 percent of the total wireline market. The government basically gave up on the idea that it could bring competition to the local loop through legislation, or that competition was worth the effort.

**Distance Carriers**
A deal between the second- and third-largest of the U.S. long-distance companies, MCI WorldCom and Sprint, was to be the largest telecommunications merger in corporate history when proposed in 1999. Estimated at $115 billion, the merger would have created a long-distance telephone and Internet powerhouse with some 42 million customers in 65 countries.

Consumer groups and competitors in Europe and the United States argued that the merger would bring too much communications power under single management, and the antitrust lawyers at the U.S. Department of Justice agreed.
Sprint was the company that brought the first all-digital fiber-optic network to the United States in the 1980s, in competition with long-distance phone carriers AT&T and MCI. A decade later, Sprint was offering home and business customers the same “pin-drop quality and reliability” in its data calls as it did for voice. The number three long-distance carrier promoted what it called an integrated on demand network (ION) to deliver voice, video, and data services to the desktop for prices that were 70 percent cheaper for voice and 60 to 80 percent lower for other types of services.

Partnering with network equipment manufacturer Cisco Systems Inc. and software developer Bellcore, Sprint introduced customer-premises gateways that combined its voice and data signals into a single cell-based asynchronous transfer mode (ATM) data stream. These gateways enabled consumer signals to be interfaced with Sprint’s fiber-optic lines with the help of either wireline or wireless local access providers.

ATM is a switched-based transmission technology designed to accommodate the simultaneous sending of data, voice, and video at variable rates from megabit to gigabit speeds in a packet format. ATM information is segmented into fixed-length units or cells prior to transmission; the information is reassembled at the destination. ATM can be transported over twisted pair, coaxial cable, fiber-optic lines, or wireless connections.

Although Sprint’s ION network was ultimately withdrawn from service, the effort was significant because it demonstrated a new type of switched network called packet-switching. From its core network, Sprint supported a variety of IP services over ATM, facilitating the company’s transition from pure network provider to provider of network-based applications. The ION network, for example, allowed home and small business users to make phone calls and be on the computer at the same time. With ATM switching, the company was able to offer value-added services such as unified voice mail, voice command, and voice recognition over both wireline and wireless services, as well as more robust applications of the Internet over a single connection on a single bill from one provider.

But Sprint did not own its last mile. As a long-distance carrier, Sprint was excluded by regulation from direct landline access to its customers. For local access, Sprint had to rely on the ILECs or their competitors (CLECs). Beginning first with the urban enterprise markets, Sprint used Ameritech in Chicago, Bell South in Atlanta, and SBC Communications Inc. in Dallas–Fort Worth as local facilities partners. In Dallas, Sprint also had a deal with GTE Corp., the biggest of the non-Bell carriers, to extend its broadband services to last-mile residential and small business customers via DSL lines.

Sprint now hosts a highly successful, rapidly growing mobile wireless business called Sprint PCS. One of the reasons MCI WorldCom wanted to acquire Sprint was to gain access to its large PCS (personal communications services wireless) network. This move would have given WorldCom direct access to some eight million local wireless customers in 18 states, an asset it could have used to better compete with AT&T.

Sprint also had undertaken a dramatic departure from existing approaches to local access. In 1999 it acquired three struggling wireless cable companies: People’s Choice TV Corp., American Telecasting Inc., and Videotron USA. These companies were using a microwave broadcast technology called “fixed wireless.” Sprint had the idea to use the video spectrum of these fixed wireless providers as an additional local access platform for its iON voice and data services.

AT&T Corp. could boast of impressive assets but implementation problems in the new millennium have devastated the company. AT&T is the number one long-distance telephone provider in the United States, but its voice revenues have been flat. AT&T was the number one cable operator in the United States but was forced to sell its holdings in 2003 to cable MSO Comcast Corp at greatly reduced rates.

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2 A packet is a digital communications data format. A megabit refers to millions of data bits; a gigabit is a billion bits.
The Broadband Millennium

AT&T was the number one wireless provider some years before it was bought out by former RBOC Cingular. In business communications, AT&T is still one of the top providers for voice and data services. Its huge debt (estimated in excess of $48 billion) is a big problem, however, as is its lack of easy access to first- and last-mile customers. At this point in time, the 127-year-old company is in search of a future.

Almost from the beginning of the global Internet, WorldCom Inc. dominated IP—data transmission, and still does. In the first two years of the millennium, WorldCom's UUNet hosted the world's biggest IP backbone with 2,628 U.S. ISPs connected to it. This number compared to 1,483 U.S. ISPs served by Sprint and 810 served by AT&T. Even though ISPs were disappearing due to consolidation and the dot-com shakeout, the volume of IP traffic continued to expand. The exchange of larger and larger data files consisting of financial databases, consumer streaming of audio, video, and the like continued growing internationally.

MCI WorldCom also had some serious execution problems, leading in 2002 to one of the largest bankruptcies in U.S. history. The company's revenues from consumer long-distance phone services dropped to below-profitable ranges, the result of technological innovation and price competition, but the big problem was an accounting scandal that prompted the U.S. SEC to access a fine of $1.5 billion based on accounting irregularities amounting to as much as $11 billion dating back to 1999.

WorldCom networks spanning six continents and serving more than 70,000 businesses have been given an all-digital upgrade with faster, more capable routers operating at speeds of 10 Gbps or more. The company is moving away from the voice business to concentrate on its more lucrative data enterprises.

Whether WorldCom, under its new MCI Group name, will get the chance to demonstrate the merit of this strategy is still to be seen. Although it quickly emerged from bankruptcy with a mere $6 billion in debt, its growth projections are considered to be modest and its public share price reflects deeper troubles.3

Broadband Technologies

Beginning in 1984 a clear demarcation was established between local telephony and long-distance voice services in the United States. The long-distance lines were managed by the interexchange carriers, such as AT&T, MCI, and Sprint. The lines connecting homes and most businesses were the exclusive domain of the local exchange carriers, the designated local access providers for specific geographic areas, such as Bell South, Southwestern Bell, U.S. West, Pacific Telesis, and NYNEX.

In the telephone business, broadband has been used most frequently as a term to characterize the large information-carrying capacities of the transmission (transit) lines that interconnect the voice and data facilities of the public switched telephone network (PSTN), or those of the numerous private networks. The lines that link homes and small businesses to a central telephone office, the structures within which network equipment such as circuit switches are installed, have been characterized as narrowband.

The rate at which information can be exchanged between two points is called bandwidth. As a general rule, the greater the bandwidth, the greater the carrying capacity of telecommunications lines. The most common medium for voice applications within residential and business premises has been two copper wires twisted together as a pair (see Figure 2.1).

Figure 2.1: Twisted Pair Copper Wire

Traditionally, twisted pair telephone loops were limited to an analog bandwidth of 4 kHz, a rate considered to be the lower end of narrowband communications.

For full-motion video transmission much wider bandwidths are required. Six MHz per channel is designated for broadcast television. Metallic coaxial cables, the medium most commonly used in cable TV distribution, are considered to be broadband conduit, especially when two or more 6 MHz channels can be bundled together. Fiber-optic cables, which have been globally deployed in transport of telecommunications signals over long distances, can host bandwidths of 1 GHz or more per channel.

**Analog to Digital**

In the digital milieu, bandwidth is measured by bit rate, the number of bits of information that can be transmitted in a second of time. Bit rates are commonly identified in increments of 1,000: kilobits as shown in Table 2.1.

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<thead>
<tr>
<th>Kilobits (kbps)</th>
<th>1 thousand bits per second</th>
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<tr>
<td>Megabits (Mbps)</td>
<td>1 million bits per second</td>
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<tr>
<td>Gigabits (Gbps)</td>
<td>1 billion bits per second</td>
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**Table 2.1: Data Rate Increments**

The speedier of the dial-up telephone modems (see Figure 2.2) used to connect a personal computer to the Internet at a rate of 56 or 64 kbps, for example, is commonly thought to be a narrowband device. A high-definition television signal at a 19.4 Mbps rate is assumed to require a broadband channel. The dividing line between narrowband and broadband transmission rates has been somewhat arbitrarily set at 1.5 Mbps, the lowest rate at which a video image was thought to be transmitted over a telecommunications line and still be acceptable to viewers.

**Figure 2.2: Typical Setup Using Dial-Up Modem (Stallings, 2000)**

With the advent of digital compression techniques, all the old assumptions and definitions pertaining to bandwidth, channel capacities and data rates are changing. Hardly anyone could have imagined that HDTV, introduced as an analog service in the 1980s, would 20 years later be transmitted in real time over voice-grade telephone lines as a digital service. In the 21st century, not only is this possible but also the technologies by which this is done are off-the-shelf commodities.

Giant leaps forward in the compression of digitized information have made possible the squeezing of larger and larger quantities of data into smaller and smaller telecommunications channels, and the rates for processing that information through switches and routers and terminal devices have been greatly accelerated. Largely because of digital compression, narrowband telephone lines are now able to support 1.5 Mbps DSL “always on” high-speed residential and business Internet service. This data rate compares favorably with the competing cable modem services, and DSL subscribers still have enough capacity left over for an open fax or voice channel.

Internet users are not the only ones requiring faster rates of information transmission and exchange. Even in hard economic times, telecom providers were seeing steady increases in demand from global businesses for more powerful and flexible data networks capable of keeping employees connected to company computers whether they were in plant, at home, or on the road. Since higher transmission rates use more network resources, telecom providers have scrambled to upgrade their networks with ever more advanced technologies to secure their markets.

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Information compression, signal multiplexing, and signal reuse are techniques for sending more information faster over telecommunications channels of all types, whether broadband or narrowband, wireline or wireless, one-way or two-way. The daunting task facing telephone companies now is in the reconfiguring of their vast in-place facilities so that voice and video, fax messages, and large data files may be managed on the same lines. The potential advantages of end-to-end digital communications are great, but such changes are expensive and they do not happen overnight.

**Internet**

The Internet is now the world’s largest data communications network. Because the architecture of the Internet forms an interconnected web of data networks interfaced in such a way that computers of almost any type can interact with any other, the volume of traffic flowing over the Internet has been approximately doubling each year. The flow of e-mail and back-and-forth exchanges of audio, video, and graphic files is growing so fast that at times of peak demand, the public switched voice networks over which these data are transported can become clogged.

The early Internet was predominantly text-based. The voice and video being sent today—with some exceptions—are still transmitted in the same format. The information is relayed as IP packets of less than 1,500 characters each. Packet switching was developed in the 1970s for long-distance data communications. Packet technologies break the information into smaller pieces, each containing an address. Sending a packet is much like mailing a letter: many envelopes of data enter the network at the same time, and they may all travel over the same routes or take quite different paths to reach their destination.

IP networks are interconnected by routers. Routers are computers that have been programmed to read the addresses and make decisions about how to forward these packets over one network or another so that they arrive at their destination in a timely fashion. Once all the packets arrive, they are assembled for presentation in their original form. For the occasional transmission that encounters a problem along the way, a return request is automatically sent asking that the message be sent again.

Two of the great breakthroughs in the evolution of the Internet were (1) the creation of the World Wide Web (WWW), a method of presenting and linking information, and (2) the development and marketing of Web browsers, software that allows users to more quickly search for and get access to information stored on the Internet. The Web was introduced in 1989; the first Web browser was released in 1993. Since then, the exploding number of hosts (Web sites) being attached to these interconnected networks has been a principal driver for the growth in Internet traffic, thought to have been about 100 percent each year at least since 1997.

As dominant providers of data infrastructures, the phone companies are in an advantageous position when it comes to delivering Internet services. The number of residential and business computers has grown exponentially. In the more developed parts of the world nearly every home, school, and office has one or more telephone connections. The telephone companies have in place the means to interlink those computers on a global basis. Government deregulation permitting them to be more than “common carriers” assures them a role in developing Internet services as well as facilities.

Telcos now supply something like 98 percent of the lines over which world users access the Internet. Until recently, the World Wide Web ran almost exclusively over the PSTN, which telcos controlled. Now that telephone modems are affordable and ISPs are offering public connectivity services and attractive content, the telephone companies have found themselves benefiting from Internet growth. It is no longer acceptable to just be dominant carriers; telcos feel they must also be dominant providers of content and services.

In 1998 telecommunications backbone and equipment supplier Nortel Networks was predicting that by the year 2000 more than half the capacity on long-haul transport networks would be IP traffic. This was a remarkable projection, implausible for some, since the Internet had only emerged as a commercialized medium
in 1992. The percentage of the PSTN devoted to IP traffic in early 1996 was only 1 percent, and by early 1998 it was about 6 percent.

But the telecom vendor got it exactly right. By the turn of the millennium, so rapid were increases in demand that the crossover point for data had already occurred. More people were signing onto the data networks, more people were spending more time on-line, and more people were accessing multimedia programming and interactive services. Thus, many more of the big data pipes were needed to handle the load.

RBOC Bell Atlantic was reporting similar growth on its local networks. "Technologies are now converging into an integrated digital platform governed by IP's. Distinctions like telephone/computer and local/long distance are obsolete in this environment," Bell Atlantic CEO Ivan Seidenberg told the Chief Executive Club of Boston in 1999. "Already, 50 percent of the traffic on our network is data. By 2003, we expect that number to be 90-95 percent."

In 2001-2002, the transformed Bell Atlantic-Verizon Communications was spending some $18 billion on capital projects, up from $12 billion in 2000, in support of its efforts to provide end-to-end connectivity for customers using voice and data services through its new Global Solutions division. Verizon's 2003 capital budget of $13.5 billion was reported to have been one of the largest of any company in the United States, and this in difficult economic times. 6

**IP Networks**

The basic communication components in the local loop, the physical linkages between local providers and their customers, are undergoing radical restructuring not just among telephone companies but also among cable, broadcast, terrestrial wireless, and satellite operators. These transformations are motivated in significant ways by their needs, to convert to digital and to make all their networks IP-compliant in the first and last mile.

With the traditional circuit-switched networks, phone calls are temporarily assigned to a dedicated telecommunications path between two endpoints. The assignment is made at the telephone office switch. A particular transmission line is made available to the party signaling a wish to use it. Local telephone networks interface with those of other national and international telephone companies operating as a publicly shared, interconnected resource for on-demand communications. The switching system is an assembly of equipment capable of establishing prompt and private connections between lines, between lines and trunk carriers, and from trunk to trunk on an exclusive use basis.

Packet-switched networks operate somewhat differently (see Figure 2.3). Data traffic often occurs in short bursts, resulting in long inactive periods interspersed with high-volume information exchanges. While packet-switched networks can provide very efficient transport of data, the fact that packets will not all arrive at the terminating switch in the same order that they were sent can cause havoc with communications that operate in real time. An example is the burden placed on voice-grade telephone lines in the streaming of radio and television station signals and in two-way voice and videoconferencing when using IP transmission.

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5 Ivan Seidenberg, presentation to the Chief Executive Club of Boston, March 10, 1999 (see www.ba.com/speeches/).
The networks on which Internet messages are conveyed around the world today include the faster, more sophisticated Ethernet and token rings of the private data networks as well as the old public switched telephone systems. The dominant carriers include AT&T, MCI, and Sprint as well as London-based Cable & Wireless N.A., which entered the U.S. market with its 1998 purchase of MCI’s Continental IP Network. Before being reined in by the global economic recession and withdrawing from the U.S. market in 2003, C&W’s plans were to migrate its entire voice and data network onto an IP platform, a bold strategy not yet tried by any other major U.S. carrier.

An effort is afoot to provide a better bridge between the domains of voice and video switching and IP data, integrating routers and switches and merging their support software. A goal within the telephone industry has been to develop central office switches with IP-voice gateways built in, and to incorporate intelligent voice/data-access solutions using ATM, which more easily combines voice, video, and data in a single stream. To achieve faster delivery some companies are trying specific updates to IPS, such as IPv6 (version 6) and multiprotocol label switching (MPLS).

By these means, distance carriers hope to add voice to the data-transport side of their networks, and perhaps to eventually eliminate circuit-switching altogether.

In the local loop, exchange carriers and their competitors are facing similar problems in deciding which are the most efficient and economical ways to make broadband services available to their customers.

**T1 Lines**

An estimated 750 million copper wire access lines connect home and business customers to the PSTN worldwide. More than 95 percent of the local access loops consist of a single pair (two-wire circuit) of twisted wire designed to support voice conversations. As such, these narrowband channels are conditioned to deliver voice-quality connections and analog modem transmission speeds ranging from about 10–34 kbps. In recent years, analog modem speeds on voice-grade telephone lines have been increased to 56/64 kbps, although something less than those rates are actually delivered in most cases.

To speed up transmission, the plain old telephone service (POTS) lines are digitally encoded and multiplexed onto higher speed lines called T1s or E1s. The T1 is primarily a North American and Japanese standard supporting up to 24 digitized voice or data lines bidirectionally at 1.544 Mbps each. The E1 is an international standard supporting up to 30 digitized lines at 2.048 Mbps each. These T1/E1 lines are mainly used in the core switching network to interconnect telephone offices but can also be used to provide greater bandwidth and faster access speeds for customers with high-end needs, such as the private networks of schools, businesses, and home offices.

Connection rates at or higher than T1 are defined by the International Telecommunications Union (ITU) as broadband. Telephone companies charge substantially higher prices for broadband service. Monthly charges for T1 access in the United States can range from $350 to $1,500 compared to $15 to $20 per month for an analog phone line.
It is obvious why T1 has proven unsuitable for connecting to individual residences. There are too few applications currently serving homes that require such a data rate and justify such a cost. Also, the expense and installation problems associated with laying a new wire to the home make the option unattractive. For high-end residential users, a differently configured telecommunications service than T1 is often needed. For example, "downloading" of large files from distant servers to the corporate employee working at home normally has a higher priority than "uploading." As consumer requirements for high-speed Internet and movies-on-demand accelerate, the data traffic shifts to highly asymmetric bundles of information flowing downstream to the subscriber, and very little upstream.

A more perfect public network would be one that is both robust and scalable. This need was demonstrated in the hours after the September 11, 2001, terrorist attacks on New York and Washington, D.C., when the Internet was brought down. Future users will want more dependable access to on-demand services. They will want to send and receive information at will, whether those transactions involve text-based e-mail, multiparty conference calls, or the downloading of video files.

**ISDN Lines**

Integrated services digital networks have been around since the mid-1980s. ISDN is a well-established telephone industry standard for transmitting voice, data, image, and compressed video information over copper wire pairs. This is a 64 kbps service (1.544 Mbps when two pairs are used) developed to give customers on-demand access to greater bandwidth, with the goal of stimulating new applications on existing telephone networks. Where ISDN has been available, and that is by no means everywhere, broadband interactive services have been made easier for residential and business customers (see Figure 2.4).

*Figure 2.4: ISDN Channel Structure (Stallings, 2000)*

The integrated in ISDN means that many types of transactions can be supported in a single connection, using either the PSTN or a private telecommunications network. Applications can include higher-speed Internet access, computer file transfers, group faxing, or videoconferencing. ISDN is digitally switched, which means that the signal is transmitted in a digital format, and local-area, wide-area, or international networks can be formed using a common digital communications standard supported by the local telephone companies. The rapid development of computer technology and computer communications has pushed along the development of ISDN standards, and each year the ISDN global service supports a greater number of users.

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Universal implementation of ISDN has nevertheless faced technical, regulatory, economic, and political constraints. Since ISDN is a digital service, it was among the first of the DSL technologies to encounter resistance in being integrated into telecommunications structures hosting switches and wire that were not ISDN compatible. Since the U.S.-based Bell operating companies were not allowed to manufacture telecom equipment following the agreements of the AT&T divestiture in 1984, development of the ISDN product was left to private sector initiatives, thus its rollout was given less than highest priority.

The United States is surpassed by Europe and Japan in ISDN development for some of these same reasons. Also, ISDN proponents were rather late in acknowledging the role satellites could play in ISDN development, and some may even have had vested interest in keeping ISDN a terrestrial-based offering, thereby limiting global interoperability.

As a circuit-switched technology, ISDN fits well into the existing public network structures of many countries. It provides sufficient bandwidth for the more widely used applications such as telecommuting, remote access, teleconferencing, LAN inter-networking, and the Internet.

Germany has a large installed base of ISDN, roughly 2.7 million installed lines, or more than two-thirds of all ISDN installations in Europe. The majority of ISDN lines in Germany are used for voice services and many corporate switchboards are ISDN-based. These lines are not considered to be well suited for data traffic, however. The average voice telephone call lasts 3.5 minutes, whereas the average Internet session lasts 45 minutes. Switched services such as POTS and ISDN are based on statistical models calculated to the typical telephone conversation. When multiple end users utilize their ISDN lines for Internet, the telephone switch can get overloaded and customers may end up waiting for dial tone.

A further development in ISDN capability is called always on/dynamic ISDN (AO/DI). The AO/DI product can give an Internet service provider, for example, a continuous basic connection, yet be able to dynamically add more bandwidth (up to 128 kbps) when needed. The attractiveness of ISDN is not just in the data throughput; it is in the lightning-fast call set-up time. With Internet log-on taking 30 seconds or longer every time the dial-up user signs on, it is easy to understand why users are attracted to technologies that permit them to stay connected.

**xDSL Lines**

Voice-grade modems transmitting data at 56/64 kbps over common telephone lines are faster than the old 14.4 kbps modems. But they seem slow indeed compared to the megabit (1.5 Mbps or faster) modems connecting users to the new broadband cable, wireless, and satellite installations now providing services in the local loop.

Bandwidth limitations of voice-band copper are not necessarily the fault of the line. The slowdown comes principally from the low-frequency ranges used in transmission and from filters placed on the line by the central telephone switching office (CO) to ensure clean, prompt connections of voice services over distances of many miles. By shrinking the length of the local telephone loop (the distance between the subscriber and a CO-connected access node), data rates over existing twisted pair can be boosted to 1.5 Mbps and higher.

Distance is a major consideration among the several varieties of digitized copper, popularly clustered under the name *xDSL*. By installing access nodes closer to the user, creating subscriber loops of approximately three miles (18,000 feet, more or less), the telephone companies have found they can address several constraints at once. They can substantially upgrade line capacity and reduce signal attenuation and loss of power while increasing the number of premises served. Where local loops connect many premises, as in densely populated residential neighborhoods or multiuser apartment complexes, the number of customers that can be served by the loop dwindles as usage and distances increase.

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9 *xDSL* is the acronym commonly used to encompass any and all of the various formats in which telephone copper is conditioned for digital transmission. See www.dslforum.com.
When the predominant application of local users is Internet access, data rates of 1.5 Mbps per subscriber terminal downstream may be more than sufficient, and the service can be offered to customers within a range of three miles of the central office or nearest access node. When the application is live television, requiring data rates of 8 Mbps or more, the distance will perhaps need to be restricted to less than one mile, about 4,500 feet. When the application is full-HDTV, which can require line speeds as high as 19.4 Mbps, the loop may accommodate only those customers within a fifth of a mile, or about 1,000 feet.

With these extraordinary rates of service now possible, almost all of the telephone companies have moved to adopt one or more of the xDSL technologies as a path to increased revenues in the local loop (see Table 2.2). Luckily for the telcos, the modifications needed in their existing facilities are not that great. The DSL configuration requires two modems, one in the central office and one in the customer premise, with few changes (except for telcos with very old plant) required in the interconnecting lines. As an added benefit to the customer, since DSL modems are able to simultaneously receive and transmit digital data, the customer's existing telephone line is in effect doubled into two lines, keeping the voice line free.

<table>
<thead>
<tr>
<th>Service</th>
<th>Uplink Transfer</th>
<th>Downlink Transfer</th>
<th>Symmetry</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADSL</td>
<td>16–800 kbps</td>
<td>1.5–9 Mbps</td>
<td>ASYMMETRICAL</td>
<td>18,000 feet</td>
</tr>
<tr>
<td>HDSL</td>
<td>1.544 Mbps</td>
<td>1.544 Mbps</td>
<td>SYMMETRICAL</td>
<td>12,000 feet</td>
</tr>
<tr>
<td>IDSL</td>
<td>128 kbps</td>
<td>128 kbps</td>
<td>SYMMETRICAL</td>
<td></td>
</tr>
<tr>
<td>RADSL</td>
<td>1 Mbps</td>
<td>1.5 Mbps</td>
<td>ASYMMETRICAL</td>
<td></td>
</tr>
<tr>
<td>SDSL</td>
<td>1.5 Mbps</td>
<td>1.5 Mbps</td>
<td>ASYMMETRICAL</td>
<td></td>
</tr>
<tr>
<td>VDSL</td>
<td>3 Mbps</td>
<td>52 Mbps</td>
<td>ASYMMETRICAL</td>
<td>6,000 feet</td>
</tr>
</tbody>
</table>

**Table 2.2: DSL Configurations**

One form of DSL, called HDSL, is the equivalent to transmitting T1/E1 service over twisted pair copper lines. Using advanced modulation techniques, this high-bit-rate DSL can deliver a bidirectional 1.544/2.048 Mbps data service over lines more than two miles distant (12,000 feet) from the switch. A major application of HDSL is as a local backbone providing broadband interconnections between Internet servers, private data networks, cellular antenna stations, and PBX telephone networks. In such applications, existing copper transmission lines are used as a T1 replacement.

Installing either fiber-optic or coaxial cables are time-consuming and comparatively costly propositions. In the 1990s, strategists were calculating that it could take the U.S. regional Bell operating companies a decade to reach the majority of their customers through the use of fiber-optic or coaxial cables. HDSL is an alternative for the near-term since the copper infrastructure on which it rides is already in place.

Asymmetric digital subscriber line (ADSL) is the most widely used solution under consideration for first- and last-mile access to homes. The 1.54 Mbps ADSL format, dubbed the G.711 standard, has received the blessings of the International Telecommunications Union. G.711 is thought to be best suited to Internet-type access, where more capacity is needed for data traveling downstream to the subscriber with less traveling upstream. It also makes available a dedicated connection for high-speed data while leaving the phone line free for voice communications.

The DSL family of technologies is still under development, and providers of DSL services are still in the learning curve. Demand is high for residential as well as business use. Since the technology can be applied to circuit, packet, or ATM switched data, DSL modems can be configured to operate in the traditional telephone environment, on the newer IP networks, or with the emerging multimedia transmission formats.

The DSL Forum has carried out global interoperability tests designed to make it possible for consumers to purchase plug-and-play ADSL2 equipment at retail stores with faster bit-rate and less restrictive distance requirements. In 2003, DSL was the world's leading broadband access technology with 60 million subscribers. That figure is expected to grow to 200 million by the end of 2005. In the U.S. market, with only about 20 percent overall broadband
penetration, DSL at 6.7 percent lagged behind cable modems at 14.4 percent in 2003.\textsuperscript{10}

VDSL, the latest of DSL technologies, is less widely deployed than ADSL, but the very-high-bit-rate DSL format at 25 Mbps downstream and 3 Mbps upstream is expected to become the more widely adopted technology, according to a report from the International Engineering Consortium. VDSL cost and performance characteristics compare favorably with T1 lines, ISDN, and cable modems, making it a lead technology for transitioning to a fiber-to-the-home (FTTH) architecture.

Although several high-profile competitive carriers (CLECs) using DSL have faltered in the field, most notably Covad Communications, Northpoint Communications, and Rhythms Netconnections, the Bell operating companies appear to be on a fast track. SBC Communications led the pack in 2001–2003, adding an estimated 4,000 residential users per day, some of them through a new self-provisioning option. Fiber-optic networks were being pushed into neighborhood nodes to make DSL services more readily available. The company was projecting profitability on the service in the first quarter of 2004 based on a 10 percent penetration rate.\textsuperscript{11}

Verizon Communications was not far behind with plans to take DSL beyond voice and data by targeting high-density apartment buildings, office towers, hotels, hospitals, and college dormitories with VoD and pay-TV services. To solve the distance limitations of DSL, Verizon proposed to locate high-capacity video servers and DSL access multiplexer (DSLAM) equipment on institutional user premises. Equipment provider Alcatel was under contract to help Verizon increase its high-speed access penetration rate, including helping to pushing fiber all the way to the home.\textsuperscript{12}

Next-generation ADSL2 and ADSL2+ technologies that lengthen the loops that connect customers to central offices and increase throughput speeds at lower cost are also hitting the market, as are new ADSL/VDSL chipsets that reside on a single line card, allowing providers to switch from high-speed Internet to video services without the need to install multiple line cards for multiple services.\textsuperscript{13}

Fiber-Optic Lines

Fiber-optic networks can be a lot faster and more efficient than networks consisting of copper cables. With fiber in the local loop, a single fiber strand has the potential to transmit one gigabit per second or more of information. Such capacity allows a 10-strand fiber cable to deliver 500 HDTV programs at once, or its equivalent in data. On all-optic networks that same fiber strand can be subdivided by wavelength extending services all the way to the desktop, making possible a 100 Mbps wavelength of light per customer.

Fiber optics replaces electricity with laser light as the medium of transmission, and hair-thin glass fibers are substituted for the copper wires. A fiber-optic transmitter encodes computer data, human voices, text, graphic images, and motion pictures into modulated light waves. At the other end of the fiber path, a photodetector picks up the light and transforms the optical information back into electrical energy (see Figure 2.5).

\textbf{Figure 2.5: Light Propagation Inside an Optical-Fiber Cable}

Among optical fiber's biggest advantages is its ability to carry far more information in a given time over far greater distances than any currently available medium. Fewer signal-regenerating amplifiers are needed. Whereas copper requires frequent local

boosting to strengthen the signal, long-distance optical amplifiers are commonly separated 60–100 miles apart along the line. Submarine transoceanic cables are now being laid without a single amplifier covering a stretch of 3,000 miles.

The largest of the Internet backbone providers has been WorldCom. It aggressively augmented the capabilities of its data pipes to keep up with the growth in Internet traffic. One way it did this was to expect higher and higher levels of performance from its routing and switching technologies, adding 10 Gbps router interfaces that allow the carrier to process the same amount of data over a single optical connection that once required several separate streams. WorldCom also increased the number of wavelengths that could be provisioned over each fiber channel using dense wavelength division multiplexing (DWDM).

DWDM is an optical engineering device using individual wavelengths of light to multiply the number of separate channels that may be transmitted simultaneously over a fiber strand. Thirty-two channel strands are currently in use. By acquiring products made available by such equipment suppliers as Nortel Networks, WorldCom was looking to increase that number to 160–170 channels. Each wavelength would be tuned to deliver data at rates of 10 Gbps, with the result that WorldCom could be squeezing more than 1.5 terabits of data onto a single fiber.

In the 1980s, there was much talk within the telephone industry of end-to-end networks that would be all optical. Indeed, when AT&T was divested of its regional Bell operating companies, sales of fiber-optic cable and opto-electronic equipment soared as MCI and Sprint raced to build out their long-haul networks to provide competitive long-distance services. Some analysts were predicting massive deployment of fiber right to the home. For reasons of cost, complexity, and an uncertain market, FTTH is yet to happen except in very special applications and fiber in the local loop is mostly limited to business applications. The trend is nevertheless clear: all-optical networks are coming.

Fiber-distributed data interface (FDDI) and the fiber-based Ethernet are now common in corporate network backbones.

About 70 percent of corporate backbones use FDDI, which has an upper data rate limit of 100 Mbps. Even these rates are perceived by many to be too slow in modern corporations, thus the appearance of Gigabit Ethernet hosting speeds of 1,000 Mbps and more.

Data traffic is growing on a global basis. Global networking has resulted in radical changes in corporate traffic patterns. In earlier times, 80 percent or more of communications were contained within the LAN focused on resident work groups and departments, and that traffic was voice- and text-based. Only 20 percent or so of corporate communications went outside. Now the type of traffic is different and the entire world operates as a wide-area network (WAN) for corporations.

Workers go on-line to access content from distant Web sites. VPNs keep mobile employees connected to their offices. Large multimedia files are exchanged at a distance. Conferences bridge distant sites using real-time audio and video streaming. All these applications consume greater bandwidth and require more sophisticated computer processing. Fast and reliable execution of such applications demands larger backbone capacities and friendlier user interfaces with better security.

Broadband Business

As it turns out, the technology is the easy part. The hard part of broadband business is profiting from the technology at hand. The new millennium celebrations of the 21st century were in part celebrations of one of the most technologically resourceful and prolific times of human history. But the economic realities of the new millennium are that technologies must be creatively applied and managed, and the companies and individuals that do this work must operate with socially and environmentally sustainable ethical principles.

According to a 2003 Economist report on the IT sector, computing is rapidly becoming a utility like water, gas, and electricity. IT's most profitable layer will be in services such as software delivered as an on-line service, and in business consulting. "The industry has
entered its post-technological period,” IBM senior manager Irving Wladawsky-Berger told the Economist. “It is no longer technology itself that is central, but the value it provides to business and consumers.”

Broadband is where the mostly narrowband telephone industry wants to be. But identifying what kinds of future telecommunications services clients and consumers will want and figuring out how much money they will be willing to spend is a pursuit that employs teams of researchers at the head offices of every major provider.

If given the opportunity, will more families and more businesses opt for the higher-speed two-way connections that permit easier access to the WWW and faster exchange of text, graphics, audio, and video? Will they spend even more time, conduct more of their purchases on-line, and create more business to ride on the new digital networks? The telephone companies are predicting that they will and that there will be additional revenue streams to be found there. But if on-line computing is becoming a commodity under greater user control, what value can be added to telco-initiated content and services to make their brands “must have” for consumers?

Telephone Industry Options
Providing local voice service was a profitable business for a long time. With near-universal service achieved in the United States and phone rates stable if not in decline, the economies have changed. Regional operating companies can no longer realistically expect that their customer base will increase. The RBOCs are aware of this and have sought ways to expand beyond their common carrier businesses into the applications and information services markets. Wary regulators denied them those options until the mid-1990s.

Such constrictions in a country espousing competition and open markets seemed unfair, outdated, and no longer appropriate for the times. Most of the U.S. regional Bell operating companies were world-class corporations. Operators such as US West, Bell Atlantic, and BellSouth had developed successful track records running telecommunications operations in international markets, including management of multichannel video operations. Continued regulation of the telephone companies, they felt, would mean a cap on prospects for future growth.

By the mid-1990s, the time had come in the United States for the telcos to be freed to offer dial tone for video and multimedia services as well as voice and have a financial stake in the content that traveled over their lines. Elected officials in Washington agreed with the stipulation and condition that incumbents in good faith would open their lines to other providers and submit to a regime that fostered genuine competition.

With their in-place infrastructure, the telcos were certainly in a much better position than cable, wireless, or satellite to make available a full range of interactive services on a national basis. Regulators worried, however, about the overwhelming “market power” of the telephone companies. And they worried that, in abandoning the concept of the regulated common carrier, public policies of long-standing that committed the government to assuring “universal service” and open access could be affected adversely.

The FCC, the protectorate of the public interest, required reassurance that equal access would be given to all information providers, not just those aligned in some way with the telephone company. Were the telcos to be permitted to create and supply their own programming and partner with service provider companies making use of their lines, the FCC said, the customers they control must be given the means to dial into the services of competing providers as well.

In their public positions, the telephone industry got behind the Telecommunications Reform Act of 1996 enthusiastically, expressing willingness to give up their monopoly status in exchange for future growth. While such a strategy would mean major changes in the physical structures of the telco plant and

diversification of their core line of business, most thought the risk worth taking. Indeed, the former monopolies have thrived.

**Telephone Industry Mergers and Affiliations**

*Business Week* predicted in 1996 that the short-term effect of deregulating the telecommunications and electronic media industries would be to unleash a frenzy of restructurings, alliances, and mergers that could account for $1 trillion in annual revenues by 2000. Phone companies, publishing companies, Hollywood studios, broadcasters, cable TV operators, and IT outfits would go racing into each other’s business, they said, noting that AT&T had promptly filed in all 50 states to offer local telephone and other services.

“From all this deal-making will emerge a new crop of supercarriers,” the *Business Week* feature predicted. “Companies either on their own or through alliances will offer a full menu of electronic communications, a telebazaar with everything from video phones to Internet services to a single phone number that will follow you wherever you go.”

*Business Week* got it right. A merger frenzy did occur and the pace of restructuring within the industry and without continued unabated beyond the new millennium celebrations, accelerating as it went.

**Verizon Communications**

The beginnings of the transformation of the telephone industry were seen prior to 1996. In the early 1990s, it appeared that the regional operating company Bell Atlantic Corp. would reach outside the telephone sector and take over cable giant TeleCommunications Inc. (TCI). However, its bid of $12 billion to acquire TCI fell through in 1994. Four years later TCI was instead bought by long-distance carrier AT&T Corp.

By 1998 Bell Atlantic had pulled off mergers with NYNEX, a fellow Baby Bell, and had made its bid to acquire GTE, an effort that upon completion would bring one-third of the country’s local telephone lines under one umbrella. Bell Atlantic signed five-year agreements with network equipment supplier Nortel Networks and with DSL producer supplier Westell Technologies to expand its high-speed data services, including installation of fiber-optic systems. Through acquisition of GTE properties and other partnerships, Bell Atlantic found itself also hosting a wireless network covering 17 states, a nationwide long-distance operation, and one of the largest domestic Internet backbones.

The Bell Atlantic CEO, in addressing the National Consumer League in May 1999, spoke of the still-pending merger of Bell Atlantic and GTE. “Technology is a bridge to full economic participation in the 21st century information economy. Location, location, location” is no longer destiny. ‘Connection, connection, connection’ is. The same technologies transforming the economy make opportunity available to all—unfettered by time, distance and political borders; blind to race, social divisions, or disability,” he said.

“Like technology itself, this phenomenon is neither good nor bad; from my perspective it’s just necessary. It takes large, capable companies to address customers’ desire for global one-stop shopping for all their communications needs. What really matters is (whether) a given combination is good for consumers and good for competition,” he told the league. “A combined Bell Atlantic-GTE will improve service, accelerate deployment of cutting edge technologies, increase community support, and do more to open local markets to competition than anyone else—which is exactly what we’ve done after our merger with NYNEX.”

Four years after passage of the Telecom Act, Bell Atlantic was the first of the Baby Bells to gain approval of the FCC to offer long-distance telephone service. (As an independent serving largely rural areas, GTE already had permission to offer long distance.) The FCC approved the Bell Atlantic petition based on demonstrations

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16 Ivan Seidenberg, “National Consumers League’s First 100 Years,” May 17, 1999 (www.ba/com/speeches).
that it had opened up one million of its local lines to competitors in New York state.

In March 2000 the company started offering a bundle of DSL telephony, wireless phone, high-speed Internet, and video services to customers in Massachusetts. The video offering was the result of a strategic alliance with satellite provider DirecTV Inc. Customers purchasing the package received free installation of the DSL modem, free installation of a DirecTV dish, and up to two DBS receivers.

Some stumbling blocks appeared along the way. Bell Atlantic, renamed Verizon Communications following its merger with GTE, found itself in competition not with other local telcos but with cable companies. These included MediaOne Group Inc., the cable operators whose merger with AT&T Broadband was finalized at that time, with the well-funded cable overbuilder RCN Corp., and other non-telco providers of data, voice, and media services. Having invested in a European fiber-optic backbone with British carrier Flag Telecom, offering bundled communications and media services in six European cities, with related business in Hong Kong, Tokyo, and Sydney, Verizon also faced an excess capacity problem in global fiber.

Verizon is an acknowledged telecommunications' giant, now producing some $68 billion in revenue. But it is carrying a debt load in excess of $50 billion and its 2003 revenue growth was estimated at only 0.3 percent. Even though the FCC had removed all restrictions on its ability to offer long-distance phone service—a benchmark the company had worked valiantly to achieve—and the telco displaced Sprint as the third-largest U.S. long-distance operator, the profit potential in long-distance services had largely disappeared by 2003. Profit margins in its huge wireless business were flat, largely due to the competitive necessity for heavy discounting, and local phone revenues were in decline.\footnote{17 "Annual Report: The Information Technology 100," Business Week, June 23, 2003, pp. 90–98.}


\footnote{17 “Annual Report: The Information Technology 100,” Business Week, June 23, 2003, pp. 90–98.}


\footnote{19 SBC Communications, the smallest of the seven Baby Bells transformed itself into the second-largest U.S. phone company. SBC Communications, Inc., formerly Southwestern Bell headquartered in San Antonio, TX, is second only to Verizon in reach, and is the more profitable of the two, although it also suffers in the area of near-term revenue growth potential.

SBC made its first major acquisition in 1997 with its purchase of the California-based Pacific Telesis Group, a sister Baby Bell. It then acquired Southern New England Telephone Company in 1998, and in 1999 came to an agreement to purchase Chicago-based Ameritech. The $62 billion purchase price of Ameritech was one of the largest telecom deals ever. SBC’s U.S. holdings now stretch from California to Connecticut with international investments extending into Canada and Mexico. Fifty percent of all international calls to Mexico, for example, originate in SBC states, mostly from Texas and California. The company also holds stakes in telecom properties in several European countries and in South Africa.

Getting into long-distance was a top priority for SBC. The company saw long-distance service as requisite to providing a complete communications package for its residential and business customers. Moves in that direction, which required regulatory approval, faced stiff resistance from the likes of AT&T and Sprint and public advocacy groups who were quick to point out SBC’s poor record when it came to allowing competitors to access its local telephone lines. The FCC has now cleared SBC for long-distance operations even though it is apparent that few consumers within its territories can find an alternative phone company to turn to for local service.

SBC uses DSL technologies to make multiple voice channels available over a single copper line, and provide full screen Web-based video as well. SBC’s strategy has been to push fiber-optic lines sufficiently deep into its neighborhoods that 80 million of its 100 million customers will be within reach of its 1.5 Mbps ADSL service. This meant that fiber/DSL connectors could be installed within 12,000 feet of 80 percent of its customers. The company}
reported that 48 million customers—those within 9,000 feet of its fiber terminal—will be able to tap into its higher priced 6 Mbps service.

SBC is perhaps the first of the ILECs to also become a CLEC by extending its services outside its territory, one of the conditions placed on the company in the FCC's granting of permission to provide long-distance service.

When CEO Edward E. Whitacre, Jr., was asked in 1999 why SBC needed to build a bigger company, he said, "We have to have the customer base . . . You can't be a global player and be small. It just doesn't work."¹⁹

Quest Communications

US West was an enterprising regional telephone company headquartered in Denver, Colorado, covering 14 western states. As early as 1993 the well-funded telco made a $2.5 billion investment in Time Warner, representing 25 percent of the company. Then in 1996 it made a much bolder outright purchase of Continental Cablevision Inc., the third-largest U.S. cable operator, paying out some $10.8 billion. This acquisition was later spun off as a separate entity under the name of MediaOne Group Inc., offering in addition to cable services, telephony and fast-access to the Internet.

MediaOne was the first to use the term broadband in company promotions. In an ironic twist, cable operator MediaOne and telco US West were among the first of the broadband cross-platform players to find themselves competitors in more than one market.

With passage of the 1996 Act, US West lost no time enlisting computer and software vendors to help it expand its territory and services. US West envisioned third-party providers creating first- and last-mile applications in interactive multimedia, IP telephony, and electronic commerce using either telco or cable lines. US West signed agreements with Sun Microsystems Inc., Microsoft Corp.,

¹⁹Roger O. Crockett, "The Last Monopolist," Business Week, April 12, 1999, p. 84.

Hewlett-Packard Co., Digital Equipment Corp., and Novell Inc. to help bring its dreams to reality.

But US West never got to implement these changes. The MediaOne cable assets were sold at a considerable profit in 1999 to long-distance carrier AT&T and, shortly afterward, a deal it had made with Quest Communications International Inc. for interconnecting out-of-region markets turned into a hostile takeover of its telecom operations. Efforts to establish end-to-end broadband connections between its points of presence in the United States, Europe, and Asia led to US West being acquired by its own partner, long-haul fiber-optic data carrier and Internet provider Quest. This was the beginning of a very troubled time for the Denver-based RBOC, leading to its breakup.

In the period from June 2001 to July 2002, largely due to loss of investor confidence in the company, Quest Communications stock fell from $32 a share to less than $2. Press reports revealed that Quest management had been exaggerating revenues while understating costs. Under SEC investigation, Quest officials were forced to restate more than $1 billion in transactions improperly accounted for. It was revealed that Quest executives had been encouraging employees to invest in company stock while covertly selling their own holdings, making millions.²⁰

A new management team was left facing $26.5 billion in debt. This debt was pared to $16 billion by selling Quest's Yellow Pages business and buying back bonds at a discount. Some 3,500 jobs were cut and 27,000 union employees were persuaded to trade 3-4 percent wage increases for performance-based bonuses. Several Web-hosting centers affiliated with Quest's 25,000-mile fiber-optic network were closed. Even so, with Quest's local phone business shrinking at a rate of 5 percent a year, the company was expected to lose $470 million from continuing operations in 2003.²¹ With the angry attention of investors, banks, employees, customers, and

regulators focused on seeing the company radically restructured, Qwest Communication’s short-term prospects did not look good.

**AT&T Corp.**

Four years after Bell Atlantic failed in its attempt to purchase the largest cable company in the United States, Tele-Communications Inc., long-distance provider AT&T Corp. upped the ante from $12 billion to $48 billion and entered the cable business. AT&T’s idea was to use TCI’s coaxial TV cables as a way to bypass the local telephone companies and save some of the $6 billion it was annually paying in access tolls to get to its customers. AT&T was gambling that it could run voice and Internet as well as video over cable networks and that those networks would come to be the residential and small business pipelines of choice in the local loop.

Based on a well-deserved legacy as one of the most innovative telecommunications providers of all time, AT&T was confident it could figure out how to transition first- and last-mile traffic onto an IP infrastructure. Basic cable would take on a whole new definition. Subscribers would be able to access the Internet, shop on-line, play games, pay bills, and interact with their TV screens using the cable modems built into a new generation of set-top boxes. HDTV and movies on demand would be candidates for “always-on, all-band” access to home users. Local and long-distance calling services would be just another item on a menu of services.

The merger of these two corporate giants was approved by the U.S. Department of Justice in 1998 and by the FCC in 1999. The stockholders of AT&T and of TCI gave a near-90 percent approval to the deal. Shortly after, AT&T made an offer to acquire MediaOne Group, the third-largest U.S. cable MSO. The surprise was AT&T’s willingness to pay $38 billion to seal this deal, about two-thirds more per subscriber than it had paid for the TCI holdings. The cable community was shocked to learn that cable subs could be valued as high as $4,700 each.

AT&T also was in the process of negotiating a 20-year alliance with Time Warner, the second-largest U.S. cable operator—a deal that would ensure that nearly half of all U.S. cable homes would be potential customers for AT&T telephony services. This agreement was made easier by the fact that, in the purchase of MediaOne, AT&T had acquired 25 percent ownership of Time Warner, worth an estimated $14–$18 billion. Time Warner could see only benefit in the deal since it had no significant cable telephony strategy of its own.

Time Warner officials had high praise for the joint venture and announced that the two companies were agreed in their plans to construct packages of services that made the most sense to consumers, using every product line available between the two companies. Time Warner thought the bundling of branded telephony services with more advanced digital video and high-speed Internet offerings would boost overall cable penetration.

AT&T had in 1994 already consummated a $13 billion takeover of McCaw Cellular Communications Inc., an early strategy to fill out its national coverage and bypass the regional carriers with a wireless solution. McCaw controlled more than seven million cellular telephone subscribers in 100 U.S. cities. That deal had made AT&T the nation’s largest provider of mobile wireless telephone services.

AT&T picked up the Teleport Communications Group Inc. (TCG) for $11 billion in early 1998, to gain control of the largest CLEC with access to 66 major U.S. markets. In collaboration with TCG, it began testing xDSL over copper phone lines as an additional way to access small and mid-sized businesses. AT&T and British Telecommunications (BT) had also reached an agreement to combine their international businesses and jointly develop a new global IP voice- and data-network.

By mid-2000 the AT&T express train began hitting the brakes. The new millennium’s optimism faded from the economy. The FCC approved AT&T’s merger with MediaOne Group, but placed conditions on the number of subscribers the combined company could control. As attractive as AT&T’s new IP-centric scenario was on paper, the company was having trouble in execution. The technology was unproven. AT&T had moved too quickly and paid too much for its acquisitions, investors were impatient for evidence of profitability, and the stock market was unforgiving. Having lost
half its value during 2001–2002 and carrying a debt load of over $60 billion, AT&T could only retreat.

AT&T proceeded to split the company into four stand-alone units to strengthen its balance sheet and extract greater value from its stock: business (enterprise services), consumer (local, long-distance, and Internet services), broadband (cable services), and wireless (mobile services). By 2003, a new tracking stock covering AT&T’s consumer long-distance operations was created. AT&T wireless had already been spun off as a separate company. Its cable assets had been acquired by MSO Comcast Corp. at $54 billion, $52 billion less than what AT&T had paid for them a few years earlier.

**MCI WorldCom**

WorldCom Inc. was a small Mississippi reseller of long-distance telephone services that managed to transform itself through acquisitions to the number two position among distance carriers in the United States. In 1996, in a bid to compete with AT&T, WorldCom concluded a $14 billion acquisition of MFS Communications Co., prized for its UUNet division that controlled the world’s biggest Internet backbone. In an even bolder move, WorldCom launched a hostile takeover of MCI Communications Corp., a merger that set off international antitrust concerns when it became clear that a majority of Internet traffic would be traveling on MCI WorldCom lines.

In 1997 WorldCom bought on-line service provider CompuServe from H&R Block for $1.2 billion in stock. CompuServe’s consumer on-line services unit was then sold to AOL but WorldCom retained its data management and networking services operations and its corporate on-line customers. WorldCom also bought AOL’s networking unit, ASN Communications, and got a five-year agreement that AOL would use WorldCom transmission lines, making WorldCom a major Internet networking agent.

An alliance was forged with Bell Canada, the dominant Canadian telecommunications company, which meant that MCI WorldCom could provide end-to-end connectivity the length of North America. On its IP-based VPNs, WorldCom was able to offer secure communications for corporations over the Internet worldwide.

MCI WorldCom was not to stop there. Its goal was to be one of the world’s telecommunications giants in supplying data and wireless services to businesses, as well as long-distance services. In October 1999 WorldCom went after Sprint Corp. in an attempted $128 billion takeover expected to be one of the largest acquisitions in corporate history. WorldCom wanted Sprint on its team not just to remove a competitor, but because it coveted Sprint’s fiber-optic backbone and extensive wireless facilities to help link its networks more directly into customer homes and offices.

The deal fell apart largely around antitrust concerns that the combined companies would dominate Internet traffic. The Department of Justice and the FCC each thought the merger ran the risk of reducing innovation and choice while raising the cost of communications services for end users.

By mid-2002 when WorldCom Inc. was spiraling toward bankruptcy, it had become clear the extent to which company managers had overreached. The nation’s number-two long-distance carrier admitted in an SEC investigation that some $3.8 billion in expenses had been wrongly listed on company books as capital expenses. In the reorganization in which some 17,000 employees were laid off, sale of assets was thought to be insufficient to pay the company’s $32 billion in debt. And regulators were worried about the potentially devastating effects on service to customers worldwide.

Subsequent investigations detailed accounting errors of some $11 billion dating back to 1999. The CEO was ousted and the CFO and comptroller were under federal indictments. In the bankruptcy reorganization, the result of which was estimated to cost as much as $175 billion to investors, the name of the company was changed to MCI (WorldCom) in an attempt to distance itself from the scandal.  

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Telephone Industry Constraints
Almost everyone who is asked will say the problems of the telephone industry are economic, a logical answer during a period of economic recession. But the challenges facing the industry are much more fundamental: they have to do with businesses’ inability to operate with integrity, their misuse of market power to gain regulatory advantage and avoid competition, and their need to reestablish public trust. Economic issues will be considered first.

Economic Issues
There is an element of extreme unfairness in the way the U.S. economy works, or does not work. Business is supposed to serve the public interest but too often does not. This was first evident on a massive scale with the collapse of energy trader Enron. Wall Street analysts, investment banks, public accounting firms, and elected officials were all found to be complicit in hiding from investors, stakeholders, employees, and the general public the bad news that the company was cooking its books to give the mistaken appearance that it was healthy and profitable.

The unfortunate part of the Enron debacle is that Enron did not prove to be an isolated case. Some of the largest media and telecommunications companies in the United States were shown to have been doing the same thing. Loss of public confidence in the basic honesty of business executives and the institutions that surround them appears pandemic. The necessary link between capitalism and basic democratic values has been seriously eroded.

When telecom executives at WorldCom, Qwest Communications, and Global Crossing realized they couldn’t deliver on their promises of revenue growth of 20 percent or more, they resorted to manipulating their accounts to create an illusion of profitability. Company officials, paid at salary rates beyond all reason, rushed to cash in their stock options before their value fell, while workers saw their own jobs disappear and their pension funds vaporize.

These are classic examples of corporate-sanctioned greed and abuse of trust. When employees, customers, investors, vendors, and others, who are dependent on the success of these companies for their livelihood, are hurt as a result of management failures and

lapses in ethical judgment, faith in the basic concept of free enterprise suffers.

This is no small matter. It needs to be on the future agenda of telephone companies, as it must be for other sectors of the business economy. Writing in the *Economist*, editor Bill Emmott said of Anglo-American capitalism’s troubles, “the economic and financial-market boom of the 1990s was so extreme that its bust is also producing extreme results: a pile of corporate scandals, resentment at an extraordinary widening of inequalities of income and wealth within the rich countries, a ghastly hole in the retirement funds of millions of ordinary people and, most crucially of all, a gathering disillusion about the ability of democratic institutions to hold culprits accountable for their sins.”

Regulatory Issues
Fundamental to the free enterprise system is the value placed on protection of competition. Telephone companies around the world have tended to be protected monopolies. In the deregulating legislation that passed the U.S. Congress in February 1996, the telcos got most of what they asked for: the old monopoly provisions were broken and they were basically set free to provide all sorts of services in any territory they chose.

One condition of the 1996 Telecom Act was that the regional operating companies must open their lines to competitors through interconnection of networks. To be permitted to enter the lucrative long-distance business so coveted by the RBOCs, they were required to demonstrate that substantive competition was a reality in their markets. Since these requirements turned out to be burdensome, the Baby Bells used their Washington-based lobbyists to get them overturned, or at least ignored.

In the absence of regulatory oversight, it appears the Bell companies came to the conclusion that it was more expedient to merge rather than compete with each other. Where competition in local telephony did appear in their markets, the incumbent players

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went to great lengths to stifle it. Since neither legislators nor the courts did much to enjoin such anti-competitive behavior, the result is that the first- and last-mile in U.S. markets remains a virtual monopoly for wireline phone services.

Thoughts about the regulatory process, its goals and effects were changing throughout the 1990s and into the new millennium. The FTC, the Department of Justice, and the FCC were all reexamining the basis for regulation, mostly to justify using free-market solutions to address issues of competition and the public interest. Regulators were agreeing to almost any reasonable business initiative proposed by corporations so long as the appearance of competition and innovation would be protected. Definitive criteria for assessing the presence of real competition and genuine innovation were rarely ever established, leaving an open door to abuse.

The degree to which elected officials supported removing constraints on the telephone companies was perhaps not surprising. The telcos poured vast dollars into the campaign coffers of politicians, especially Republican politicians. In 2000 for example, under a Democratic administration with multiple communications mergers and many new public-interest issues such as open access, universal service, and privacy protection on the docket, the Republican-controlled Appropriations Committee cut the FCC’s staff and capped the agency’s budget. The action could only have been interpreted as punitive since the Democrat-controlled FCC at that moment was seeking to impose public-interest conditions on merger approvals and license transfers, a role it was legislatively required to carry out. The intent was quite clear from the debate. Republican legislators wanted to get the regulatory agencies of government out of the way of business.

Under the George W. Bush administration, with a Republican-appointed FCC chairman at the helm, corporate libertarianism was given a full test. A new view of competition was articulated. The focus was less on whether the incumbent telephone companies were competing with each other and more on whether there were viable cable, wireless, and satellite businesses keeping them in check.

Indeed, multiservice competition seemed a plausible measure for regulators to use but, in reality, meaningful competition rarely appeared. A host of start-ups failed and many investment dollars were lost when incumbent telcos were allowed to wipe potential competitors from their markets. So many corporate abuses were in evidence that even the Republican administration was forced to rethink its “no regulation is the best regulation” policies.

Social Issues
Consumer groups have rarely given the U.S. government high marks for its protection of the public interest, especially so in the economic implosions of the new millennium. Public advocacy organizations tend to find the government much too accommodating when the decisions involve the interests of big business. They see politicians more concerned with appeasing and meeting the demands of industry than with considering the ultimate impact on consumers.

Even in the economic downturn, and perhaps because of it, many consumer costs continued to rise. In the presence of competition, long-distance and wireless charges dropped substantially; in the absence of competition, local telephone, DSL, and cable rates did not. Telephone and cable rates were in fact steadily increasing as providers bundled their services. Both ILECs and CLECs gave their attention to the largest urban markets, which is logical since the wealthiest households and the most profitable businesses were the only ones that could be counted on to produce the revenues needed to meet short-term shareholder expectations of growth.

Digital-divide issues relating to the widening of the gap between the information rich and the information poor are still on the public agenda. U.S. households with incomes of $50,000 to $75,000 are at least 20 percent more likely to have computers and Internet access than those with incomes of $25,000 or less. Research suggests that in 2004 only about 20 percent of U.S. households were subscribers broadband telephone, broadband cable, broadband wireless, or broadband satellite services.

The vast majority of telephone customers are still at home waiting for some improvements in the speed and quality of computer and
communications services over dial-up telephone lines. The big
ADSL/VDSL experiments and rollouts of fiber optics into the
neighborhoods sound promising but, as yet, are reaching only a
small percentage of potential users.

**Technological Issues**

Even though manufacturers of equipment and vendors of
technology were also hard hit when telecom and media businesses
failed, information technologies kept getting faster, cheaper, and
more capable. This is a very good sign for all involved.
Technological solutions will be needed in economic recovery.

A big technology driver will be the Internet. The Internet and the
World Wide Web have emerged as a major platform for human
interaction, a way for users not only to locate the resources they
need but also to develop and make available to others information
services and applications that they have created. With Web tools
for finding, accessing, retrieving, creating, posting, and delivering
information, the Internet is destined to be much more functional
and pervasive.

The Internet is unique in that it is not the captive of the telephone
or the cable companies, the wireless or the satellite providers, the
datacasters or the Web-based media streamers, or any user group.
With sufficient bandwidth and processing power, the IP platform
will host text messages, voice services, TV and motion picture
images, and business data delivered almost anywhere, on demand
or in real-time. This has got to be an exciting prospect for future
providers of communications, entertainment, and commerce. The
added social benefit is that the Internet is very difficult for any one
player to control.

The telcos are the principal managers of the globally
interconnected circuit-switched network of local and long-distance
voice facilities. Which parts of their businesses and their legacy
plant should remain dedicated to voice services and which parts
moved onto IP-conditioned networks is still to be worked out.
Conversion takes time and capital, and it is not yet clear how much
capacity is going to be enough. With higher-speed connections,
more and more network capacity will apparently be needed, for
users can be expected to do more things and stay connected longer.

"You would have thought that by increasing the bandwidth
available to the end user, that they would get their business done
faster," MCI senior vice president and former president of the
Internet Society Vinton Cerf once observed. "Instead they hang
around longer because they have more satisfactory experiences on
the Web—for example, pulling pages and other things."24 The
telephone companies have the challenge of figuring out how to
devote more capacity to individual users over longer call times.
New software and hardware will be needed to solve such problems,
and that will be good for the technology manufacturers and
vendors.

**Applications**

Key technological breakthroughs benefiting businesses and their
clients have occurred in the fields of microelectronics, digital
systems, software, and photonics. It is no coincidence that the
origins of many of these technologies were in Bell Laboratories, a
legacy from the days when Ma Bell (AT&T Corp.) was a
government-regulated monopoly with a vision to create the finest
telephone system in the world.

Many of the next-generation customer solutions in both wireline
and wireless networking and service creation have been and will
continue to be built on this pioneering work. A brief look at what
some of these developments will be is helpful in thinking about
future applications.

**Microelectronics**

The power of semiconductors doubles every 18 to 24 months. It's
been happening for more than 30 years.

Semiconductors are the memory chips, integrated circuits, and
digital signal processors installed in virtually all electronic devices to
make them smaller, faster, and more capable. Intel Corp. brought

the first microprocessor to market in 1971 based on an early-1950s invention of Bell Laboratories: the transistor. IBM Corp.'s development of silicon-based on/off electrical switches making use of these transistors became the basis for calculating the ones and zeros of computer instructions.

Today, the microprocessor is a silicon chip no larger than a postage stamp on which millions of tiny transistors have been wired together for maximum power and performance. It was the Intel Pentium processors, the IBM/Motorola PowerPC and Sun Microsystems chips that propelled the desktop computer to its ascendant role in the world today. Now, these same processors are showing what they can do in the up and down the broadband business and residential networks, driving the new age of communication, entertainment, information, and commerce.

The telephone industry makes use of a certain type of microprocessor, called a digital signal processor (DSP), in the dial-up modems that connect subscribers' PCs into their digital networks when mediating a connection to the Internet. An elementary example of this is the 56 kbps voice-band modem that the remote subscriber uses to connect to an Internet service provider. The ISP, who employs a digital modem of higher capacity, decodes the signal so that it will connect with the telephone company's digital network. In both the subscriber's analog modem and in the ISP's digital modem, DSPs run the software that makes it possible to establish the network connection.

The telcos also employ digital signal processors in handsets and infrastructure equipment of their wireless voice, data, and paging networks. Handset DSPs must of necessity be small in size, low in cost, high in performance, and not overly demanding in terms of power. Base stations, however, require a higher level of sophistication and complexity in supporting many users at once, establishing call setup, hand-off, and retransmission. Greater digital signal processing power is needed in these stations. While DSPs may cost only $5 to $10 each for handsets, costs can range from $100 to $1,000 for the switching station interfaces.

IBM and Intel each entered the nascent network processor market in 1999. They now compete with others producing communication chips that add greater flexibility and intelligence to a host of new Internet appliances. Some of these advanced technology devices being used to facilitate voice and video communication, creation of VPNs, and application hosting can be instantly reprogrammed through software.

Many of the new network processors are compatible with open development environments, such as Java and Linux, which enable network equipment makers and third-party programmers to develop innovative services and bring them quickly on-line. Because these router/switche processors can be reprogrammed centrally, changes in networking protocols can be accommodated without changing out the appliance.

An example is the next-generation cell phone that can be reconfigured (using a computer program called software-defined radio) rather than being discarded when the user moves from one service provider to another, or changes from one wireless standard to another.

Almost every aspect of modern life touched by telecommunications is being affected by the increased speed, greater capability, and lower cost of microprocessors. Smart processors are being installed in the residential and corporate gateways that will give future users easier, more timely access to the personalized services being provided by telecom and media players. These same microprocessors will also become the hidden engines of surveillance and marketing that give governments the means to monitor citizen behavior and provide businesses with new opportunity to target sell products and services to the public.

Digital Systems
An estimated 95 percent of small businesses in America use 12 or fewer phone lines. A T1 line to integrate and relay the voice, video, and data services needed by small office/home office (SOHO) enterprises is not always practical due to cost. In this respect, conversion of the old analog telephone line signal into the multiple varieties of DSL is a great breakthrough, for xDSL technologies
now permit a voice/fax line to be in use while simultaneously relaying high-speed data and other interactive services.

CLECs such as Rhythms NetConnections and Covad Communications, and the long-distance carriers MCI WorldCom and Qwest Communications were among the first to incorporate voice over DSL (VoDSL) technologies, permitting them to bundle local and long-distance voice with high-speed data for small and mid-sized businesses that need multiple lines but can't afford the expense of T1 service. Digital technologies have captured the interest of telcos everywhere as an expedient way to begin offering data services at higher speeds right away.

The basis of DSL is the magic of digital. By transforming their lines into data networks, the telephone companies are able to now compete with cable companies as full-service providers offering broadband Internet and digital TV services. Qwest Communications’ Choice TV and Internet service competes head-to-head with cable operator Cox Communications in Phoenix, Arizona, based on implementation of very high speed DSL (VDSL).

The basis for converting voice-grade telephone lines into high-speed data lines is digital. Packetized information and digital compression are two additional innovations that will make it possible for HDTV as well as two-way videoconferencing to be supported as a consumer service over the Internet of the future.

Software
The intelligent coding that tells computer-like devices and networks what to do is called software. In open architecture environments, such as telephone networks, it is important that the provider community agree on common instructions, called protocols. In this way, the network does not become a proprietary instrument of only one set of hardware companies, one group of content providers or users, but a future-oriented platform capable of evolving to meet much larger constellations of need.

The success of IP is an illustration of the ability of the computer and telecommunications industries to agree on a set of instructions to manage the convergence and growth of multiple, separate information networks. The IPv6 Forum was launched in 1999 to oversee the upgrade of the current communications protocol with the adoption of IP Version 6 (IPv6). Forum membership consists of carriers, service providers, equipment makers, and users worldwide who are concerned that IPv4 is running out of available IP addresses. The IPv6 specification is expected to improve traffic handling and make the Internet more reliable, predictable, and secure. It will expand the current 32-bit addressing scheme to 128-bits.

Standards agreements can also exist between companies. Microsoft Corp. often seeks out partnerships to back its product lines. Microsoft agreed, for example, to back Nortel Network’s 1-Meg modem for faster data access over copper phone lines, and Nortel agreed to develop its IP telephony applications on Microsoft’s Windows NT server. They each were sponsors of the Universal ADSL Working Group (UAWG), the consortium that developed a standard for lower-speed (1.5 Mbps) ADSL. Microsoft’s stated goal has been to have a PC on every desk and to have that PC connected to a worldwide network, ideally with high-speed access.

A software developer with a very different model is Sun Microsystems Inc. whose Java programming language gained International Organization for Standardization (ISO) status. Sun promotes an open-systems interactive television software platform called Java TV. Java combines powerful, object-oriented programming with the ability to run on any computer platform—Macintosh, Windows/Intel, Linux, Solaris, and other machines—without the need for translating or recompiling.

Java language allows developers to create applications for advanced TV services that work with multiple microprocessors, operating systems, and set-tops. Such applications include Web browsing, electronic commerce, and datacasting, as well as applications that enable viewers to select more than one camera angle covering a sporting event. Instructional code called a Java applet can be embedded in a Web page. When a user comes across a page while browsing the Web, the applet downloads with the page and
automatically executes its application, regardless of the type of device being used.

**Photonic Technology**

AT&T's Bell Laboratories was an early developer of fiber optics applied to communications. The state of this science has developed at such a pace that current optical networking systems can now carry the equivalent of the per-second traffic of the entire worldwide Internet over a single strand of fiber.

Optical technologies have moved very fast and the end is not yet in sight. In the 1990s, the industry was talking about the wonders of being able to put a gigabit of information on a single fiber. Shortly into the new millennium a terabit of information was considered quite manageable. From a decade of laboratory development, the industry has seen a thousand-fold increase in fiber capacity.

What is being built into the backbone networks is an optical core with unprecedented bandwidth and the flexibility to handle any network protocol—including ATM and IP as they converge. Optical carriage gives telecommunications providers the platform for convergence of all their disparate networks into a highly integrated network of networks.

Fiber-to-the-curb, and eventually to the desktop in homes and businesses, is widely thought to be the ultimate platform for satisfying the appetite of end users for bandwidth, an appetite that seems to grow at exponential rates. All these developments have slowed in current economic reality as corporations search for the business plans with which to proceed, but fiber is no less favored as a long-term answer to many communication problems.

Lucent Technologies Inc. was a spin-off in the 1984 divestiture of AT&T and is the current parent to Bell Labs. Lucent designs and delivers networks for some of the world's largest communications service providers, a company with 38,000 employees worldwide.

In 2000 Lucent's New Ventures Group, a unit formed to take technological innovations from Bell Labs and grow them into independent companies, launched a startling new type of networking venture. GeoVideo Networks, which Lucent promoted as the first video network designed solely for the Internet, was designed to provide HDTV-quality, real-time, bidirectional video over metropolitan and long-haul optical fiber networks for business applications.

Lucent's plans were to develop video hubs in key markets around the world to facilitate business-to-business video distribution for financial, medical, government, news, and entertainment communications. Bell Labs was to provide a customized browser, enabling users to view as many as 16 simultaneous video sequences during a videoconferencing session.

Unfortunately, the technology was doable but the business was not. GeoVideo Networks was just another great idea that was too early for its time. In seeking to pare down to the more profitable core of its offerings, Lucent sold 80 percent of its equity in its New Venture Group in 2002 and redirected its attention to helping others make their networks more robust, secure, and profitable.

Fiber optics will be the solution to numerous future business applications, but the market has to be there for the technology to ever get out of the lab.

**Conclusion**

The telephone companies will be among the dominant and lasting providers of broadband communications everywhere in the world. These are most often the companies with the strongest brands, valued assets, market power, and experience in delivering on-demand service.

With the advent of xDSL, fiber into the first and last mile, and innovative new capabilities for managing voice, video, and data on networks that they control, the telcos will have the means to be technologically competitive.

In most countries, the telephone companies will continue to enjoy the privileges of the incumbent network provider but the days of the protected monopoly will be gone. Their territories will be
gradually opened to multiservice competitors sporting similar telecom platforms, or some other platform that will have emerged from the cable, wireless, satellite, or utility sectors.

Whether any of the old telephone companies, in the United States or elsewhere, will be recognizable, carrying their old names and providing the same kinds of services, is impossible to predict. With the recovery of the global economy, however, some of them are certain to emerge wrapped within broadly based telecommunications and media companies doing business globally as well as locally.