

The United States

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Telecommunications in the United States began in 1836 with Samuel Morse and the electromagnetic telegraph. The first U.S. telegraph message, sent from Baltimore to Washington in 1844, was, “What hath God wrought?” The same question was being asked one and a half centuries later when there was fear U.S. telecommunications had been severely crippled by the policy of deregulation, and by the divestiture of the dominant telecommunications institution, American Telephone and Telegraph (AT&T).

24.1 History

The United States has always been at the forefront of change in telecommunications, partly due to internal and external geographic distances, partly due to a high level of technological innovation. From the beginning, the telecommunications system was never the centralized monopoly system prevalent in many other countries.

When private financing was slow to initiate telegraphy operations, the U.S. government, although with considerable reluctance, subsidized the new medium, inaugurating a tradition of alternating governmental rejection and the embrace of an active role in the telecommunications sector. Morse’s 1836 invention of a simple and workable electric telegraph faced competing companies and technical systems. In 1851, several telegraph companies consolidated into the New York and Mississippi Valley Printing Telegraph Company. It and Morse dominated telegraphy until the Civil War (1861–1865) by merging with smaller firms and aggressively expanding. The New York and Mississippi Company, renamed Western Union, was successful at securing protective rights-of-way from railroads, and adding patents. It soon became the dominant carrier and enjoyed healthy profits. By 1876, the year of the telephone’s introduction, Western Union had over 300,000 km of lines and 7,500 offices. However, its high prices as well as developments in technology allowed small competitors

dominance in basic domestic telegraph service remained until well after World War II (see Brock 1981).

In 1876, Alexander Graham Bell, a teacher of the deaf in Boston, introduced a workable telephone. The new device created a sensation, and Bell's father-in-law and other wealthy investors launched the Bell Telephone Company. Recognizing the huge task at hand, they first offered the patent rights to Western Union, but that company chose to protect its existing market rather than enter the new one. It considered the telephone a complement rather than a competitor because the telephone was then limited to local service, while the telegraph was primarily used over distances. Thus, Western Union declined to acquire the Bell patents, which were available for less than \$1 million. Western Union never recovered from its imperfect foresight, and its fate has always been a scary reminder to telephone companies to remain at the forefront of services.

The Bell firm grew and prospered. Telephony expanded nationally through the franchising of independent local operations. Later, when the original patents expired in the mid-1890s, Bell Telephone positioned itself to maintain its monopoly by a variety of means: vertical integration of equipment and services; development of interexchange long-distance service; aggressive pricing strategies; acquisition of substantial competitors; acquisition of additional patents; restricting interconnection of alternative equipment; and by preventing interconnection of rival local networks to Bell local networks and to the Bell (AT&T) long-distance system (see Brooks 1975).

By 1897 there were some 500,000 telephones in service across the United States, 80 percent of them on Bell lines. Once the basic Bell patents expired, independent competitors entered those areas not serviced by Bell operations or concessionaires, especially in rural districts and areas facing particularly high prices. In some cities several systems competed side-by-side without interconnection. As the number of independents grew, they began to form regional agreements to provide service among themselves.

After a few years the independents were nearly equal in size to Bell; robust competition existed in both the provision of local service as well as in the manufacturing of switching and customer equipment. The one main difference between the two segments, however, was interconnection. While the Bell Telephone system was fully interconnected on a national level through its long-distance network, the independents operated on a fairly limited regional scale. By 1907, when the population was 87 million, the total number of telephones had grown to 6 million.

The eroding market share of Bell Telephone, reorganized and renamed American Telephone and Telegraph, led to a more aggressive policy. Theodore Vail, who was brought back by Wall Street financiers led by J. P. Morgan for a second tour as president of AT&T, devised a three-prong strategy to increase market strength. This included aggressive acquisitions of independent telephone companies, the embracing of regulation in order to avoid antitrust suits, and a major increase in R&D in order to acquire a technological edge. Backed by Morgan, AT&T was also able to acquire a majority interest in Western Union.

brought antitrust complaints against the firm. As the number of lawsuits mounted, and as they were joined by Justice Department actions, AT&T chose in 1913 to negotiate an agreement with the U.S. government known as the Kingsbury Commitment. AT&T sold its stake in Western Union and left telegraphy. It also guaranteed existing independent telephone companies access to its long-distance network and agreed not to expand further geographically by acquiring competitors or entering their territories. This governmental action to limit AT&T from total market dominance was part of a general trend of antitrust policy. Americans had become concerned with the enormous growth of business entities in the late nineteenth century, in the decades following the Civil War. There has always been a strong populist current opposing domination by big firms. This distrust was shared by the political left, farmers, small businesses, and westerners.

The same political constellations led to the establishment of a regulatory system of utility commissions on the state level that supervised privately owned utilities, including telephone companies. This arrangement contrasts sharply with the system of state telephone administrations prevalent in most countries.

The Kingsbury Commitment did not confine AT&T's operations to markets related to telephone service. For the next twenty years, AT&T was able to enter new industries such as commercial radio and sound movie technology. During World War I the company played an important role in the military effort and was deemed to be of enough significance that it was briefly nationalized toward the end of the war.

By 1934 AT&T manufactured and owned 80 percent of all telephones in the United States and operated the only national long-distance network. It still enjoyed relative security, although its integration into equipment manufacturing was attacked by the Walker Report, authored by one of members of the new Federal Communications Commission (FCC). The FCC was created as part of the more general "New Deal" effort to establish stronger governmental controls on a depressed economy. World War II delayed any follow-up to the Walker recommendations, but once the war was over, the Justice Department filed an antitrust suit in 1949.

Intervention by the Defense Department, as well as the 1952 presidential election, stalled the case. In 1956, under a more supportive national administration, AT&T achieved a favorable consent agreement. It was not forced to divest itself of Western Electric, its manufacturing arm, but its activities were limited to telephony. Western Electric was confined to telephone-related research and manufacturing operations, and had to take a more liberal policy in the licensing of its patents. On the whole, however, AT&T had succeeded in avoiding a possibly disastrous antitrust judgment, although it had also, once again, watched its routes of expansion close.

New technologies and their innovative uses continued to emerge and their sponsors, seeking to compete, sought help from the FCC. By the 1990s, universal service penetration in the United States would be largely completed. The telephone reached most households, and an increasingly elaborate system of transfers kept residential rates low. This soon led to pressures for change.

the aggressive electronics industry, two key decisions in the area of terminal equipment were *Hush-A-Phone* (1956) and *Carterfone* (1968), which permitted non-AT&T equipment to be attached to the network.

In 1959, with the “Above 890” decision sought by microwave equipment firms such as Motorola, the FCC permitted large users to operate in-house microwave long-distance service. These users felt that they were increasingly subsidizing local service and small customers, and they had incentives to drop off the common system, at least partially. This soon led to major changes. By 1969 one microwave delivery company, MCI, won a court ruling against a reluctant FCC and an adamant AT&T to provide private-line service for other users as a carrier; eventually, all specialized carriers were permitted to provide private-line service. It soon offered service to large users that did not want to operate their own systems. This was soon expanded into general public switched service, with rights to interconnect with AT&T’s local networks in order to reach customers. By 1975 AT&T found itself facing regular facilities-based service competition in telephony for the first time in more than fifty years.

24.2 Policy Transformation

The policy changes were partly due to a general political and economic philosophy of limiting the role of the state, which made government institutions more receptive to allowing new entrants as an offset to corporate power. This philosophy far preceded the conservative Reagan and Bush administrations. Inspired by Lockean principles of natural law, the classic American ideology of government seeks individualism, fragmentation of private power, limitation of government (with the major exception of its role in national security), and protection of property rights and contracts. As applied to telecommunications policy, this philosophy justified a governmental role that is far narrower than in most other countries: It centered on permitting competitive markets to limit the exercise of dominance by any single firm and in permitting users to choose among service providers. This view is shared by those Democrats who are distrustful of concentration of private economic power and those Republicans opposed to government interference.

In the 1970s and 1980s telecommunications continued to undergo changes of structure and policy subsumed by the terms *deregulation* and *liberalization*. These developments eventually led to the break-up of AT&T, the world’s largest communications organization at the time. It was brought about by a 1974 Justice Department antitrust suit based on unfair business practices the firm allegedly employed to suppress its competitors. It resulted, after a 1982 consent decree, in the most massive reorganization in business history in 1984. The divestiture agreement put AT&T’s local operating companies—approximately two-thirds of its assets and employees—into seven regional holding companies (RHCs, often called Baby Bells or Regional Bell Operating Companies, RBOCs). These provided mostly traditional telephone service, but increasingly and ag-

gressively sought other opportunities inside and outside the communications field.

In further developments, through several so-called Computer Inquiry decisions by the FCC, AT&T and the RHCs were permitted to enter new and unregulated markets such as data processing and computer fields. By the late 1980s the FCC and some states were in the process of dropping rate-of-return regulation in favor of price caps regulation, instituting liberalized interconnection and access rules (Open Network Architecture), and introducing local service competition, starting in New York.

Thus, a centralized system of one near-monopoly telephone carrier, one dominant domestic telegraph company, and a handful of international telegraph companies was transformed within a few years into a highly differentiated system with a bewildering number of participants and institutions.

24.3 Regulatory Structures

The basic framework of government involvement in U.S. telecommunications is complex. Unlike most other countries, the public sector did not own or operate civilian services, except for a few small municipally owned cable television operations, rural telephone systems, and educational television broadcasting stations. Although almost all civilian telecommunications facilities are privately owned, their use is often—but not always—subject to licensing and regulatory oversight. These regulations are set on the federal, state, and occasionally the local level.

For all the talk of deregulation, the number of regulatory bodies, in two senses of the word, is larger in the United States than anywhere else. Federal policy emanates primarily from the FCC, a body of five commissioners, from both parties, appointed by the president and confirmed by the Senate, but thereafter independent from both, in theory and often in practice. It tends to be dominated by its chairman. The FCC, as other independent commissions, operates as a hybrid within the American constitutional order, exercising legislative powers (adoption of regulations), executive authority (enforcement of its rules), and a judicial role (adjudication of cases). It allocates frequencies and regulates all broadcasting, satellite, and other civilian uses of the electromagnetic spectrum. The FCC is in charge of *interstate* telephony (e.g., transmissions from one state to another) and everything affecting interstate communications. The FCC also has jurisdiction over cable television.

State regulatory commissions, generally known as Public Service or Public Utility Commissions (PSCs and PUCs), are independent of the FCC. They play an important role in regulating *intrastate* telephony, and in some instances cable television. Commissioners are appointed by the governor in most states; in others they are popularly elected. Municipal authorities regulate cable television through their power to grant franchises.

There was no *federal* regulation for the first thirty-five years of telephony until the 1910 Mann–Elkins Act, which gave an undefined regulatory authority

to the Interstate Commerce Commission (ICC). The ICC was established to oversee the railroads and showed little interest in telecommunications, which were regulated by the various state utility commissions that were created in the early part of the century. When the Communications Act of 1934 was drafted, creating a more specialized and potentially activist FCC, the states urged a statutory limitation on the new FCC's powers over intrastate wire communications. Congress responded positively. Its report on the bill stated that "some 97.5 or 98 percent of all telephone communications is intrastate, *which this bill does not affect.*" This assurance to the states proved empty, however, because separating the national from the regional regulation of an integrated network is difficult.

Public policymakers were under continuous pressure to reconcile the statutory fiction of separation of intrastate and interstate network components with the reality of their integration. What emerged was a system of coregulation, based on shared goals. For several decades, the cooperative spirit was so great that the federal level permitted a system of revenue transfers to the state-regulated domains to support low local rates for which the federal government had no direct oversight responsibility. The system, however, could not last when its constituents' fundamental goals diverged. This occurred when the FCC began to embrace the economic concepts of efficiency, competition, markets, and entry, while the state commissions continued to emphasize equity and redistribution.

The split between the states and the FCC emerged first in a serious fashion in the 1960s when the FCC and federal courts opened the terminal equipment market to rivals of AT&T. Many states, on the other hand, advocated a restrictive approach, largely for fear of having the phone companies lose revenue that subsidized residential rates.

The FCC prevailed, however, in the landmark *North Carolina v FCC* decision (1976). The court read the state-reserved part of telecommunications very narrowly and rendered it almost meaningless. Throughout the 1980s, preemption of state regulation by the FCC moved forward, but this trend was slowed in the 1990s by a pro-state's rights majority on the Supreme Court.

On the federal executive level, the Commerce Department's National Telecommunications and Information Administration (NTIA) helps to coordinate the executive branch's overall policy. It plays a role in international communications, together with the Office of U.S. Trade Representative and the State Department, which is the lead agency in international negotiations.

In addition, the Department of Justice plays a major role through its Antitrust Division, which oversees much of the telephone industry by way of enforcing the 1982 court order that broke up AT&T. The primary authority in that case is Federal District Court Judge Harold Greene, who frequently decides whether the Bell Companies and other parties are complying with his divestiture decree, and who has thus become a major presence in telecommunications matters.

Conforming to a broader policy trend in U.S. government decisionmaking process, other federal courts—particularly the Court of Appeals for the District

of Columbia—have also become a significant locus of de facto policymaking. These courts hear appeals from trial courts and administrative agencies; their decisions can be reviewed only by the Supreme Court, which hears only a small fraction of appellate cases. For example, the Court of Appeals in Washington, D.C., forced the FCC in the *Hush-A-Phone* case to allow non-AT&T equipment manufacturers to sell terminal units for connection into the local AT&T exchanges, making competition in the equipment market possible. The Justice Department and the Federal Trade Commission (FTC) also play a role in regulating industry competitive behavior and structural changes—primarily mergers and acquisitions—and by forcing divestitures as with AT&T.

The fundamental law is the Communications Act of 1934, which has rarely been amended, despite many attempts. Congress—the legislative branch—does often wield power indirectly, giving signals to the FCC through bills, resolutions, hearings, and the budgetary process.

The political parties of the United States have had at best an indirect impact on the formation and exercise of telecommunications policy. The nature of the political party in power generally did not greatly affect the direction of change in telecommunications policy, although it did sometimes affect its pace. There is a substantial amount of overlap between the two parties over telecommunications issues, and in the philosophy of rate setting, but the tone or emphasis can be slightly different. The Democratic position has been somewhat more oriented toward protecting residential users; conversely, Republicans have placed somewhat more emphasis on economic development and large users. This has translated into a greater reliance on market forces, although Democratic-dominated FCCs have been just as active in that direction, and indeed the AT&T divestiture case was initiated under liberal Democrats and was concluded under conservative Republicans.

Access rates to local exchange networks by long-distance carriers are of particular importance in the regulatory arena. In the past, complex financial accounting rules (“separations and settlements”) provided an internal contribution from AT&T’s long-distance service to local exchange providers—Bell and independent. Complicated FCC tariffs also governed the access charges paid by the rival long-distance carriers. After divestiture, this system was revamped, with equal access charges for all carriers phased in.

The rates and terms of service of intrastate communication are regulated by state commissions, traditionally on the principle of rate-of-return regulation. Several states have relaxed these rules either by outright deregulation or by instituting price regulation in place of rate-of-return rules. Due to the dominance of the local exchange companies in local residential distribution, full deregulation of local charges is unlikely soon, but substantial relaxation of such regulation is taking place. One state, Nebraska, has already largely deregulated local exchange prices.

The principle of rate-of-return regulation is to permit a “fair” return on invested capital. Because this return is aggregated, some cross subsidies can exist from one type of service to another. Furthermore, rates tend to cover less

and about 65 percent of the market defined as interLATA service, measured by revenues, according to the FCC. BOCs provide long distance within their own LATAs, accounting for about 20 percent of the market. The principal competitors in interLATA service are MCI, with about 11 percent of the market, and Sprint, with 8 percent. There are also hundreds of resellers.

Specialized companies—including data networks and VANs such as Telenet and Tymnet—provide packet switching and other value-added services. Satellite carriers lease transponder capacity to other carriers and private users.

Cellular telephone service in the United States operates as a duopoly. There were 6.5 million subscribers in 1991. Customers in each major service area have a choice of two licensed cellular providers, one being their local “wireline” telephone company. The other was an independent provider. There has been a major consolidation in the industry, with most independents being acquired by telephone companies from other regions. McCaw, the major independent firm left, leads the industry with 12 percent of the market. GTE and BellSouth follow with 11 and 8 percent, respectively. Revenues have been increasing at over 30 percent each year for much of the 1980s due to the growing subscriber base, but has plateaued in the 1990s. The systems are analog, but digital transmission is anticipated, as is the entry of microcellular service providers.

Packet-switched networks have existed in the United States since the early 1970s. They originated at the Pentagon, whose Defense Advanced Research Projects Agency (DARPA) had a private firm, Bolt, Beranek, and Newman (BBN), develop the “Arpanet” nationwide network to link researchers with each other. Arpanet was a major success, and it induced BBN to start Telenet, a commercial network in operation since 1975, as the precursor to packet switched networks around the world.

Telenet was eventually sold to GTE. Expansion was costly and the network broke even only after 1983. In 1986 GTE Telenet, together with GTE’s long-distance carrier, Sprint, were combined into a joint venture with United Telecom and its Uninet. United Telecom eventually controlled Telenet and Sprint.

Another packet-switched network, Tymnet served computer time-sharing customers. Tymnet and its parent Tymshare were acquired by aircraft manufacturer McDonnell Douglas in 1986 and subsequently sold to British Telecom in 1988.

Common carriage provides nondiscriminatory access and usage rights to all users, including resellers that compete with a carrier. Local exchange companies must grant access to all long-distance carriers and to all telephone users. Customers indicate their “primary” carrier to which domestic and international long-distance calls are automatically routed by a local exchange. Other carriers can be accessed by dialing a prefix number. Such a system may be extended in the future to intraLATA long-distance service. Large customers also can utilize their PBXs to select a different long-distance carrier for each call according to a programmed “least-cost-routing.”

The reselling domestic local and long-distance transmission is allowed and is anticipated. This includes sharing bandwidth on satellite transponders, resell-

ing local transmission, and competing coin and credit card public telephones. Resellers do not require an FCC authorization; to sell directly to the public, they need only file a notification with the FCC and some state PSCs. Where there is no general offering (i.e., one bank reselling its surplus transmission capacity to another) no filing is necessary. Private networking is prevalent for large users, usually on leased facilities under software-defined "virtual" arrangements, with equipment manufacturers often providing the integration and network management function.

24.6 International Services

The volume of international telecommunications traffic has grown much faster than international trade. Part of the impetus has been the dramatic decrease in the costs of circuits. In many countries this has not been matched by an equal drop in rates, where carriers did not face competition. Low international rates in the United States are partly the result of overcoming market segmentation. Numerous boundaries still existed in 1964, when the FCC prohibited AT&T from entering the international record market (telegraph, telex, and data transmission). Among record services, the FCC made a further distinction between *domestic* services, from which Western Union was restricted, and *international* services, which were provided by *international* record carriers (IRCs). IRCs could only operate in the United States from certain limited and approved gateways. A telegram from Cleveland to Singapore, for example, would be routed by Western Union to an IRC gateway, transmitted by an IRC to Singapore, and passed on to the Singapore PTT.

This market segmentation led to a lack of competition as well as to substantial profit margins. Partly because of the profitability, the situation became unstable and cracks began to appear. In a series of rulings in 1979 and 1980, the FCC largely removed the dichotomy of voice and record carriage. It also eliminated the rules prohibiting AT&T and the IRCs from entering each others' markets. It also removed many of the restrictions on the expansion by domestic and international record carriers to new gateway cities.

Prior to the 1980s, AT&T provided the bulk of international voice service. Other carriers such as MCI and Sprint now provide service to countries whose PTTs have allowed it. In the Pacific, Hawaiian Telephone, owned by GTE, handles a substantial portion of the international traffic.

Comsat, the U.S. signatory to Intelsat and Inmarsat, whose ownership had been shared by the government and private companies, subsequently became entirely privately held. Originally operated solely as a carrier's carrier for Intelsat service, it is now able to access users directly. For international civilian satellite communications (as distinguished from cable or microwave) Intelsat was the sole link, although this has also been opened up to new carriers. New international satellite carrier systems have been approved, with PanAmSat the furthest along in operation; similarly, rival transatlantic and transpacific cable operations emerged.

Most foreign administrations observed the changes in the United States with some misgivings, as it challenged long-established arrangements and rate structures. They also had a potential advantage in the situation. As the only address within their countries for AT&T, MCI Sprint and others, the Post, telegraph, and telephone services were in a position to force rival U.S. carriers to compete for operating agreements. To prevent such “whipsawing” the FCC established rules for uniform settlement rates for the same routes. It also embarked on a course challenging the traditional system of settlements prevailing in international telecommunications.

24.7 The Impact of Deregulation and Divestiture

The transformation of telecommunications in the United States from monopoly toward a more pluralistic system was accompanied by grave predictions of doom and gloom: residential rates would skyrocket; universal service could no longer survive; service quality would fall; productivity would suffer; research and development would decline; employment would drop; AT&T would dominate; and so on. However, most of these fears did not materialize.

For example, despite scenarios of several hundred percent in rate increases, local rates in real terms rose from 1985 to 1990 at an annual rate of 4.7 percent, while interstate long-distance rates declined by 6.0 percent annually in the same period. According to the FCC, overall telephone rates (long distance and local) rose from 1984 to 1990 by a total of about 17 percent, which is less than cumulative inflation (CPI) of 27 percent during that period. Furthermore, the telecommunications price index does not include the sometimes substantial savings from lower equipment costs. Rates did not rise as much as initially feared, in part because costs were contained through lower interest rates and taxes, higher productivity, and lower equipment prices.

Equipment prices fell as the Bell Companies gained the freedom to shop around. Central exchange equipment costs declined from \$230 per line in 1983 to less than \$100 in 1992. Overall, annual expenses per access line, not including reduced taxes, declined from about \$38 to about \$30. Revenue increased from about \$82 to \$95 per line.

The prediction of steep rate increases did not take into account the working of a political-regulatory system where strong commitment to social concerns protected local service rates. Furthermore, social safety nets were introduced. In New York, for example, subsidized “Lifeline” service of \$1/month for basic dial tone was instituted in 1987. An estimated 1.5 million users (about 15 percent of households) are eligible—defined as membership in one of several social support programs such as welfare.

Thus, despite fears, overall telephone penetration did not decline. Rather, it slightly increased from 91 percent in November 1983 to 93 percent in 1992. For the middle class (above \$30,000/year household income) penetration was 98 percent and higher, and 95 percent of all farms had telephones. Even for

some of the very poor (\$5,000–7,500 per year income), it rose from 83 to 84 percent.

Service quality held steady, at least for those dimensions that are not “labor intensive.” On the other hand, several major service breakdowns pointed to the increased vulnerability of society to any network failure.

There was a great fear about a technological decline because Bell Labs R&D might be curtailed. Actually, the opposite occurred. One study found that total R&D employment rose from 24,100 in 1981 to 33,500 in 1985. (AT&T and Bellcore, the RHC joint R&D firm, combined) (Noll, 1987). By 1988, the regional companies had added their own laboratories, and total R&D employment had risen to an estimated 35,600.

Labor productivity rose since the AT&T divestiture by about 40 percent, although at some expense of employment, which dropped from 953,000 in 1984 to 879,000 in 1990. The old system had permitted costs to drift upward, and the new environment put pressure on labor.

AT&T’s long-distance market share steadily declined each term, reaching around 67 percent in 1990. The market, although flat in dollar terms, grew strongly in terms of traffic, increasing by 13% annually and doubling usage from 37 billion minutes in 1984 to 75 billion in 1990. Americans make substantially more telephone calls per capita (1,700) than users in other countries—two and three times as many as the British (800), Japanese (550), Germans (500), and French (400). Similarly, American companies are very communications-intensive, and are steadily becoming more so.

The upgrading of the network proceeded after liberalization. For example, local Bell operating companies increased their fiber use in the network by 32 percent in 1990 and 28 percent in 1989 to 2.7 million fiber miles. Urban fiber carriers deployed some 55,000 fiber miles, and the interexchange carriers increased their fiber trunk lines by 12 percent, to 2.1 million fiber miles. According to the U.S. Department of Commerce, in 1989 96 percent of all lines were electronically switched, half of them digitally.

In ISDN, the United States is several years behind the high level of activity of several European countries and of Japan. On the other hand, fully digital lines that do not correspond to the CCITT 2B+D standard (and are therefore not considered “pure” ISDN) have become frequent. Usage of high capacity digital lines such as T-1 and DS-3 lines is high.

24.8 The Equipment Market

The connection of terminal equipment to the interstate network is governed by the Communications Act and FCC regulations. Part 68 of the FCC’s rules sets minimum technical standards equipment must meet. Vendors must register their products with the FCC before marketing them. Registration requires the disclosure of technical specifications so the FCC’s staff can identify any possible system degradation. There is, however, no approval necessary.

The U.S. market for central office (local exchange) switching equipment was

characterized in the past by foreclosure by AT&T, except for independent telephone companies, among whom GTE had its own equipment operations.

Although most analysts expected the BOCs to cling to AT&T as their equipment supplier after divestiture, they in fact embraced a wide variety of non-AT&T equipment quite rapidly. In central office switches, AT&T's share dropped from 70 to 46 percent in four years, mostly to the benefit of Northern Telecom, which transformed itself from a Canadian to a North American company.

Technical network standards are coordinated for the BOCs by Bellcore. There is no evidence that Bellcore is favoring AT&T or other U.S. manufacturers. Procurement of network equipment by local telcos is governed by their obligation to state regulators to pay the lowest possible prices. They are under pressure to keep rates low. The ability to compare cost trends for the LECs also forces them to seek low-cost equipment. Because of divestiture, BOCs no longer have an incentive to increase AT&T's profits, as none of those profits are returned to the BOCs.

However, in the equipment market the U.S. trade reversed from a slightly positive balance in 1983 to an over \$2 billion deficit in 1989. This was partly due to the general strength of Asian countries in consumer electronics, and partly the result of the divestiture-induced severing of AT&T's vertical integration of equipment and local exchange network services that had closed most of the U.S. market to other suppliers.

24.9 The Electronics Industry

The electronics industry in the United States is characterized by large and established firms on the one hand, and smaller entrepreneurial firms fueled by an active venture capital market on the other hand.

AT&T's Bell Labs invented the transistor in 1949, launching the age of microelectronics based on semi-conductors. In subsequent years the main development was the move from discrete devices to increasingly integrated circuits. These innovations made mass production easier and facilitated substantial component integration within one chip. Young companies that were wedded neither intellectually nor financially to the older ways moved into the new technology. These firms left the traditional, vertically integrated American and European tube manufacturers far behind.

Total sales of the electronics industry increased an average 9 percent in the 1980s and measured about \$300 billion by 1992. Total imports to the United States were \$79 billion in 1990; exports amounted to \$72 billion.

Large electronics manufacturing firms include AT&T, General Electric, Hewlett-Packard, IBM, Texas Instruments, Motorola, Digital, and Apple. AT&T's manufacturing arm used to be known as Western Electric and is now called AT&T Technologies. It operates mostly in the telecommunications industry but has been active in other areas of electronics and computers through its research arm Bell Laboratories. AT&T earned \$522 million on sales of \$63 billion in 1991, and had 317,100 employees, one-third of its predivestiture size

of over 1 million. Due to the U.S. Justice Department's 1956 Consent Decree, AT&T was originally prevented from entering the computer and electronic component manufacturing industry, except for internal use. These restrictions were lifted in 1984 with divestiture, but its financial success has been modest in these competitive lines of business. In 1990 it acquired the large computer manufacturer NCR; perhaps the oldest of all firms operating in the electronics industry. Formed as the National Cash Register Company in 1844, it produced a variety of business information systems. It had 62,000 employees and revenues of \$5 billion before it was purchased by AT&T.

IBM, founded as International Business Machines in 1924, initially manufactured Holerith punch card equipment. By the late 1950s, its primary business had become the development and manufacturing of computers. In 1991, IBM had 377,000 employees worldwide. As the largest U.S. corporation in 1990, IBM had net earnings of \$6 billion, but it lost \$2 billion in 1991.

IBM's market share is very large, and the firm often commanded a premium price for its products due to its reputation and ubiquity. IBM's power was at its peak in 1964, when it held 70 percent of the computer market. Its power was short-lived, however, as other companies successfully developed "plug-compatible" peripheral equipment, forcing IBM to sharply cut its prices. When it also employed non-price tactics to make compatibility more difficult, the U.S. government initiated a mammoth antitrust lawsuit (DeLamarter 1986). The government's lawsuit was dropped in 1981, partly because the market had not stood still in the meantime, and new types of equipment and new domestic and overseas entrants were challenging IBM in most markets. IBM was forced to compete in many fields: in the supercomputer market with Cray and with Japanese and European firms; in the component manufacturing field, with AT&T, Texas Instruments, Motorola, Intel, and their highly effective Japanese counterparts; in minicomputers, with Hewlett-Packard, Digital, Prime, and Data General; and in microcomputers, with a large number of small, inventive competitors such as Apple and Compaq, and with a host of Asian producers.

In telecommunications, IBM entered the competitive long-distance transmission field with Comsat and the insurance firm Aetna as partners by launching Satellite Business Systems (SBS), a venture that proved highly unsuccessful. In the PBX market, IBM acquired Rolm, but eventually sold it to Siemens.

General Electric, the third largest of all U.S. corporations, was formed in 1878 to pursue Thomas Edison's applications of electricity. It has a very broad range of activities in manufacturing, high-technology development, and service businesses. Its total revenues in 1991 were \$60 billion and profits were \$2.6 billion. It employed 284,000.

Texas Instruments (TI) was founded in 1938, and manufactures components and equipment. TI is pursuing semiconductor markets in the Pacific Basin area and is a major defense contractor domestically. Its sales in 1991 were \$6.8 billion, but it was financially in the red. It employs 63,000 people.

Motorola, which dates back to 1928, is a leading manufacturer of equipment and components. It employs about 102,000 and had profits of \$450 million on sales of \$11.3 billion in 1991.

Small electronics, computers, and software start-up firms tended to cluster regionally, creating economies of agglomeration where those of scale were absent. Perhaps the best known of these is "Silicon Valley," near Stanford University and San Francisco. It is the home to some 2,700 young electronics, high-technology, and engineering firms.

Hewlett-Packard Co. (HP) was the first major "Silicon Valley" electronics and high technology firm. It was started in 1947 by independent engineers with relatively modest funds. HP developed into a major designer and manufacturer with some 82,000 workers, and revenues of \$8 billion.

Another Silicon Valley firm is Apple Computer. Founded in 1977 by two young college dropouts, Apple employs 14,000 and its reported profit for 1991 was \$300 million on sales of \$6 billion.

Other high-tech centers in the United States include "Route 128" outside Boston, home to Lotus, and Digital; the Research Triangle in North Carolina; and the suburban districts of metropolitan New York and Los Angeles. In many instances, strong universities provided the nucleus around which industries grew.

24.10 Outlook: From the Network of Networks to the System of Systems

U.S. telecommunications is coming to resemble the rest of its economic system—a complex reflection of an underlying pluralist society and economy. Being farthest along in the transformation of its telecommunications system, the United States is likely to bear the brunt of new conflicts, both domestically among the numerous interest groups and participants, and internationally as new U.S. policies affect established global arrangements.

In the United States, the day is not far off, historically speaking, when entry will be wide open; when fiber is widespread in all stages of most networks; when radio-based carriers fill in the still substantial white spots in the map of telecommunications ubiquity; and when foreign carriers operate freely domestically.

Yet diversity can lead to fragmentation, noncompatibility, and inconvenience. From the user perspective, there is a great need for the functional integration of networks. To provide such coherence, a new category of "systems integrators," who create packages of equipment and services in a one-stop fashion, is emerging.

Today, systems integrators exist for large customers. They have also begun to be active in establishing group networks. In the future, however, systems integrators will also put together individualized networks for personal use, creating *personal* networks. As these personal, group, and interorganizational networks develop, they will access into each other and form a complex interconnected whole, sprawling across carriers, service providers, and national frontiers. The telecommunications environment thus evolves from the unified network to the "network of networks," in which carriers interconnect, and from there to the "system of systems," in which systems integrators link up with each other.

lation? Regulation in the United States had been essential to the old system, partly to protect against monopoly, partly to protect the monopoly itself. In the transition to competition, what was left of regulation was seen as temporary, shrinking reciprocally with the growth of competition.

At that point, could one expect the "system of systems" to be totally self-regulating, with no role for government? There are several public policy goals underlying regulation. They include universal coverage, affordable rates, free flow of information, restriction of market power, technological progress, and so on. To assure these goals, U.S. regulators in the past instituted a variety of policies, such as rate subsidies, universal service obligation, common carriage, interconnection rules, access charges, quality standards, and limited liability for carriers. Government regulation existed to right the imbalance of power between huge monopoly suppliers on the one hand, and small and technologically unsophisticated users on the other hand. In the future environment, however, systems integrators will act as the users' representative vis-à-vis the underlying carriers. They could, for example, protect users against carriers' underperformance in quality and price, and make regulatory control over these issues unnecessary. On the other hand, some traditional policy goals are not necessarily resolved that way, such as the maintenance of low rates for low-income and rural users, or the free flow of information across carriers, or the interconnectivity among carriers. This suggests some continuing role for government.

In the 1980s, U.S. telecommunications policy was centered on open entry. In the 1990s, however, a different emphasis is likely. Now, issues of integration of the various network parts come to the forefront. Reconciling the centrifugal pressures with the needs to interoperate and intercommunicate represents the main challenge to U.S. policymakers for the next decade. This means to provide a competitive system with tools of interoperation where they are not self-generating by market forces.

The openness of the evolving network system will not stop at the national frontiers, and the notion of each country having full territorial control over electronic communications will become anachronistic. This undermines attempts to administratively set rules for prices and service conditions. No country can be truly an island anymore, not even a large nation as the United States, and the international collaboration of its carriers, users, manufacturers, and governments with those of other countries will therefore be at the center of American telecommunications evolution and policy in coming decades.

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