Chapter 3

Rural America and the Changing Communication Infrastructure

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Chapter 3

Rural America and the Changing Communication Infrastructure

Findings

If rural areas are not to experience further decline, measures will need to be taken to assure that they have access to the necessary infrastructure. The previous means and methods of providing access are no longer viable. New ways need to be developed for delivering communication services to rural areas. With divestiture and greater competition in the communication industry, urban models are no longer valid in rural areas. What are required are Rural Area Networks (RANs) that allow rural communities to devise new and creative ways of achieving economies of scale and scope. Just as businesses are taking advantage of advances in technology and the unbundling of the network to develop local area networks, wide area networks, and metropolitan area networks, rural areas will need to develop networks that are customized to their own needs. To do so, they will need a far greater understanding of the possibilities that new technologies afford, and of how these technologies can be used cooperatively by all rural citizens, allowing them to share in the benefits of the information age.

Introduction

The communication infrastructure that supports the flow of communication in society is a critical part of the social structure. Its makeup and the rules that govern its use greatly affect all social interaction.[1] The technical features of the infrastructure, for example, determine the types of messages that can be exchanged, the ease and speed of their delivery, and their accuracy. Similarly, the infrastructure's architecture-the way that facilities are arranged, distributed, and interconnected-determines who is able to communicate, under what conditions, and how effectively.

Rural areas characteristically have low population densities and are generally distant from urban areas. For them, one of the most critical aspects of the communication infrastructure is that related to the costs associated with providing services to few people over large areas. Thus, access in rural areas is likely to be affected most if technological advances or regulatory decisions alter the distant-sensitive costs of providing these services. Because of this, innovative ways must be sought to share resources and costs.

How rural communication systems are designed and the technologies that comprise them will also affect rural areas. Communication technologies are not equal. They give rise to different impacts. Some communication technologies and network architectures tend to reinforce community ties, whereas others serve to undermine them.[2]

Rural communities must also maintain the quality of their communication infrastructure (its capacity, reliability, interoperability) vis-a-vis communication networks in urban areas. If modernization in rural areas lags behind that in urban areas and other countries, rural residents may be unable to link to other critical communication facilities, such as private business networks. In order to interconnect efficiently, communication networks must be comparable.

The form that the communication infrastructure takes will be determined by decisions made in the marketplace and by government. These decisions are greatly influenced by technological advances.

[1] The communication infrastructure is both nested in and sustains the larger social system of which it is a part. For communication is the basis for all human interaction and one of the means for establishing and organizing society. Communication is the process by which all social activity is conducted; without it a society could not survive. It is the means by which group norms are established, expectations are voiced, individual roles are assigned, change is enacted, social control is maintained, and activities are coordinated.

Communication also allows the individual to function in society. Only through interaction with others do individuals acquire the tools of language and the shared sense of reality they need to establish intimate relations and to cooperate to achieve common goals. Through acts of communication, people define themselves-their sense of uniqueness as well as their self concepts-and negotiate and sustain a position and place for themselves in the world. See for discussions, Martin Lawrence LeFleur, Theories *of Communication (New* York, NY: David McKay Co. Inc., 1970); Lucian W. Pye (cd.), *Communication and Political Development* (Princeton, NJ: Princeton University Press, 1976); and Dudley D. Cahn, Jr., *Communication in Interpersonal Relations* (Albany, NY: State University of New York Press, 1985).

[2] Richard Kielbowicz, "The Role of Communication in Building Communities and Markets," contractor report prepared for the Office of Technology Assessment, November 1987.

All of these developments are, together, reconfiguring the Nation's communication infrastructure in ways that present both problems and opportunities for rural America. To formulate policies that allow rural communities to benefit from information-age technologies, decisionmakers must understand how the changing infrastructure may affect rural areas.

The Impact of Communication Technologies on Rural Areas in the Past

Communications technologies change relationships of time and space. This is particularly important to remote, sparsely populated rural areas. One way of assessing the potential impacts of communications on economic development in rural areas is to examine how the emergence of new communication technologies affected it in the past. The impacts of communication technologies on rural areas have not necessarily been favorable.[3]

The transformation of the rural American landscape at the turn of the century was facilitated, if not actually promoted, by improvements in transportation and communications.[4] Advances in these technologies were particularly important in the development of a national market.[5] Improvements in intrafirm communication, through the use of telephones and telegraphs, allowed businesses to expand their spheres of operation and centralize decisionmaking in distant headquarters.[6] Firms grew larger and extended their reach; distance no longer insulated local firms from competition with out-of-

Photo credit: Russell Lee

Street car employee in Oklahoma City, OK, reports over the telephone, 1939.

[3]For what may be considered the classic discussion of how communication technologies can disadvantage local, vis-à-vis metropolitan, areas, see Harold Innis, *The Bias of Communication, 1951* (Toronto: University of Toronto Press, reprint, 1971). According to Innis, comm that served to overcome the barrier of distance and time tended in the long run to make rural areas overly dependent on url notes with reference to Innis' work, "Innis attempted to show how localities and regions resisted the spread of Communi was decided by a protracted series of conflicts over the spread of standard time, the mail order house, parcel post and rural store and the regionalized corporation." James W. Carey, "Space, Time, and Communications: A Tribute to Harold Innis," James W *Communication as Culture: Essays on Media and Society* (Boston, MA: Unwin Hyman, 1989), p. 143.

[4]As described by James Carey, the development and deployment of new transportation and communication technologi process of decentralization and recentralization that moved forward in a dialectical way as small hinterland communities at influence, only later to be absorbed back into it." James Carey, ibid.

[5]The development is clearly illustrated by a convergence of prices across the Nation. As Richard DuBoH notes with re "Data on cotton prices in New York show diminishing fluctuations over time. The average spread between lowest and hig narrowed steadily, except during the Civil War and its aftermath, and the steepest declines in high-low price ranges and dispersion of prices in the 1850s—'the telegraph decade,' as it might well be called." Richard B. DuBoff, "The Telegraph and the Structure of Markets in the Un 1845-1890," *Research in Economic History*, vol. 8, 1983, p. 257.

[6]As both Alfred Chandler and James Beniger have pointed out, specialization can only take place, and productivity can o that goods can be moved, processed, and distributed and that the production process itself can be coordinated. It was only railroads in the 1830s and the telegraph in 1844 that the requisite speed and control in the process of production and ex increasing the speed of communication and extending the range of possible control, the railroad, the telegraph, and later tl growth of large-scale organization with modern management structures, a first step in the centralization of production and distrib discussions, Alfred D. Chandler, Jr., *The Visible Hand: The Managerial Revolution in American Business* (Cambridge, MA: Harvard Uni 1977); and James R Beniger, *The Control Revolution* (Cambridge, MA: Harvard University Press, 1986).

town businesses. Although competition was greater, increasingly it took place among larger and larger firms located primarily in urban rather than rural areas.[7]

The advent of the mass media also encouraged the development of a national marketplace. The trend toward national distribution of printed matter culminated with the emergence of inexpensive popular magazines such as *The Saturday Evening Post, The Ladies Home Journal,* and *Country Gentleman. The* mails, of course, were crucial in the delivery of these publications, and the inauguration of Rural Free Delivery in the 1890s enabled magazines to flow from publisher to country lanes.[8]

However, the impact of the mass media on rural economies was also problematic. The explosive growth of popular magazines intensified competition for advertising among segments of the publishing industry, and the winners in this competition reflected shifts in the Nation's marketing system.[9] The small, local retailers, which had once served their communities with little competition, suddenly faced a succession of new challengers---department stores, mail-order fins, and chain stores. The metropolitan press increasingly tied its fortunes to department stores and chains; and magazines were well positioned to run advertisements for nationally marketed consumer goods that were sold through all kinds of outlets.

Notwithstanding the problems associated with the deployment of communication technologies, rural areas could not have afforded to forgo them, for the shifts in the national economy were not accidental. They were closely associated with the development of regional and national infrastructures, and a rural area's proximity to these trade networks proved to be a critical factor in determining its ability to survive.[10]

The deployment of some communication technologies also served to undermine the cohesiveness of rural communities, weakening their sense of autonomy and resolve. This made it more difficult for economic development to take place. The impact of the telegraph is a case in point. Because of high costs, telegraph use was confined largely to businesses and the press; few people used it for social communication, at least in the United States. Among the press, the telegraph fostered the standardization and central processing of news reports, allowing all Americans to read the same national and international news stories for the frost time. But standardized content diminished the community's importance in the eyes of local citizens, while centralization shifted the locus of control from local editors to national press association headquarters and bureaus.[11]

7As Richard DuBoff has described, ". . .The telegraph dramatically enlarged information networks; it saved time, reduced the need for large inventories, decreased financing requirements, and prompted dimination of middlemen. But 'competition' and 'monopoly' are not, as neoclassical theory implies, polar opposites. The telegraph improved the functioning of markets and enhanced competition, but it simultaneously strengthened fores making for monopolization. Largerscale business operations, secrecy and control, and spatial concentration were all increased as a result of telegraphic communication. " DuBoff, op. cit., footnote 5.

8Theodore Peterson, Magazines in *the Twentieth Century,* 2d ed. (Urbana, IL: University of Illinois Press, 1964), pp. 1-43. For a discussion of Rural Free Delivery, see RFD: *The Changing Face of Rural America* (Bloomington, IN: University of Indiana Ress, 1964).

9The emergence of a special kind of syndicate, called readyprint companies, worked to encourage the development of national advertising and a national marketplace. By buying paper in bulk, insertting ads from national marketers, and printing in centralized plants, these readyprint firms furnished weekly newspapers with bundles of half-printed sheets for barely the cost of the blank paper. But to take advantage of the economies of scale presented by readyprint, local editors had to relinquish control over half of their news and advertising columnsAdvertising agencies discovered the efficiencies of placing clients' ads with readyprint firms so their messages would appear in thousands of country papers. By 1889, a handful of companies furnished "patent insides" and "patent outsides" to 3,089 of the Nation's 8,633 weeklies. See S.N.D. North, *History and Present Condition of the Newspaper and Periodical Press of the United States* (Washington, DC: U.S. Government Printing Office, 1884), p. 94.

10Louis Swanson, ''Rethinking Assumptions About Farm and community, ' **A.E. Luloff and Louis Swanson (eds.), *Amen"can Rural Communities* (Boulder, CO:**Westview Special Studies in Contemporary Social Issues, 1990), p. 21. As one observer described the situation in 1850: **"[Business merchants, farmers, bankers, shippers, and others soon learned the] great advantages of this mode of instantaneous communication of intelligence [which] is with them not so much as a matter of choice as of necessity, for, without availing themselves of it, they must necessarily be behind others in that which is essential to the success of their business. " As cited in ibid.**

11For a discussion of early news associations, see Frederick Hudson, *Journalism in the United States (New* York, NY: Harpers, 1873). For a discussion of the impact of the telegraph on news-gathering, seeF.B. Marbut, *News From the Capital* (SouthernCarbondale, IL: Southern Illinois University Press, 1976). Changes in William Allen White's *Emporia (Kansas) Gazette* during the 1920s illustrate some of the consequences for rural areas. According to Griffith: "The net effect, then, of the *Gazette's increased* advertising and greater access to syndicated materials was to diminish the very centrality of its community. Emporians could no longer gain the impression from reading their local newspaper that Emporia-or their own lives-matered much in the scheme of things. . . .[The community's citizens] may also have been aware of a concomitant waning of a sense of the legitimacy of their day-to-day lives. For, rather than focusing on local events, the paper dramatized far-away people and places. Instead of recording the life passage of their neighbors, it reported the abnormality of strangers." As cited in Kielbowicz, op. cit., footnote 2.

Rural experience with the telephone was notably different, however. Although for businesses the telephone continued to accentuate the effect of the telegraph, for individuals, it reinforced social interaction at the local level. Between 1907 and 1927, the average person's local point-to-point communication—letters, telegraphy, and telephony—increased primarily because of growing telephone use.[12] This reinforcement of social interaction at the local level played "a part in the preservation and even in the enhancement of local patterns of attitude, habit and behavior, and serve[d] as an inhibitor of the process of cultural leveling which is so often assumed as an outstanding and unopposed tendency of American life."[13]

The value of telephony to rural communities and markets was reflected in penetration levels: some Midwestern States had more phones per-capita than Eastern States. The benefits of the telephone were many: rural households used the phone to summon doctors, visit each other, obtain weather reports, learn about sales in towns, and follow prices for agricultural commodities in local or regional markets.[14] Not surprisingly, residents of rural areas heralded the telephone's potential to end their isolation. While American Telephone and Telegraph (AT&T) promoted the development of the long-distance network, a number of towns and cities launched their own systems. Impatient with the slow deployment of lines, some farmers even constructed crude systems using barbed wire attached to fence posts.

This brief look at how previous communication technologies affected rural America reinforces the notion that sorting out the effects of deploying new communication technologies is a complex and complicated business. Different technologies have different impacts, depending on their capabilities and the circumstances under which they are deployed. While the telegraph generally undermined rural America's independence and its influence vis-a-vis other areas, the telephone tended to reinforce it.

One should keep this lesson in mind in considering how the new communication technologies will affect the prospects of rural economic development, and in determining what, if anything, policymakers need to do about their deployment. Without making reference to the characteristics and capabilities of new technologies, or to the socioeconomic context in which they are deployed, these technologies will likely give rise to a number of unintended consequences. Thus, policymakers at all levels of government must try to determine the particular circumstances under which rural areas-in all of their many varieties-might gain a fair share of the economic benefits afforded by information-age technologies.

The need to understand this issue is becoming increasingly acute. Not only is the communication infrastructure being altered in response to technological advances and regulatory changes; the strategic value of having access to communication and information services is also greater than ever before. Because people living in rural areas are today inextricably linked to external events and conditions, policymakers must consider how the evolution of the communication infrastructure might affect them.

Recent Regulatory, Marketplace, and Technological Developments Affecting the Evolution of the Communication Infrastructure

The breakup of the Bell Telephone System radically altered the U.S. communication infrastructure. This event has major consequences for rural America because it undermined the pricing structure that traditionally supported rural communication sevices. Divestiture also shifted a great deal of communication decisionmaking from the government policymaker to the business user. As a result, rural users' needs and interests may not be taken sufficiently into account. Rural users are not well represented among large business users.

[12] In 1907, an average of 4.5 months elapsed between each toll telephone call but only 3 days between each local call. Malcolm Wiley and Stuart A. Rice, *Communication Agencies and Social Life (New* York, NY: McGraw Hill, 1935).

[13] Ibid., pp. 153-154.

[14] These latter two applications were among the fe_w by which the telephone enhanced the competitive position of small producers and retailers. 'or discussions of the impact of telephony on rural communities, see Wiley and Rice, op. cit., footnote 12; Michael Olsen, "But It Won't Milk the Cows: Farmers in Colfax County Debate the Merits of the Telephone,'' New *Mexico Historical Review*, vol. 61, January 1986; and Ithiel de Sola Pool, *Forecasting the Telephone: A Retrospective Technology Assessment of the Telephone* (Norwood, NJ: Ablex Publishing Co., 1983).

The regulatory agreement that Theodore Vail, General Manager of AT&T, worked out in 1910, gave rise to the Bell System, which had as its operational goal, ‘‘one system, one policy, universal service. As Vail described his vision of the telephone industry in the *Annual Report of 1910:*

> *The* position of the Bell System is well known. . . The telephone system should be universal, interdependent and intercommunicating, affording opportunity for any subscriber of any exchange to communicate with any other subscriber of any other exchange. . . annihilating time or distance by use of electrical transmission.[15]

Comprised of AT&T and its subsidiaries and affiliates, the Bell System offered a complete range of telecommunication services including research and development, equipment manufacturing and sales, local and long-distance services, as well as access to international transmission service. Having a total of $150 billion in assets in 1983, prior to divestiture, it constituted the world’s largest corporation.

The regulatory framework that governed the Bell System and remained intact for more than half a century was decidedly American. While operating in a capitalist framework, it provided some social control over the negative impacts of the single-mindedness of the marketplace.[16] Moreover, taking the form of a monopoly, the Bell System provided for interoperability and was able to take advantage of economies of scale and scope.[17] By most accounts, this system worked well.18

From the perspective of rural America, the most important aspect of the Bell System was its provision for subsidies. To subsidize the expansion of telephone services, AT&T adopted a pricing structure based not on cost of usage, but rather on value of use. Such a system assured that toll users (disproportionately represented by business users) would pay some proportion of the nontraffic-sensitive (the fixed) costs of the local exchange. The formula for establishing the amount and distribution of these costs was inexact. Therefore, the tendency over time was to shift more of the service costs from local exchange users to toll users. Increasingly, this formula fostered residential service at the expense of long-distance users.[19]

By continuing to adjust the cost allocation formula in favor of the local exchange, the Federal Communications Commission (FCC) and AT&T created a situation where the costs and prices of telecommunication services were increasingly dissociated from one another. In 1941, the FCC adopted a policy of ‘‘equal charges for equal service’ that was intended to eliminate interstate rate differentials.[20] This rate-averaging system worked in favor of rural customers whose long-distance service was generally more costly per call.

These subsidies served well as a means of fostering the development of universal telephone service. The prospect of attaining the goal of universal service was well in sight by 1950, with 80

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[15]As cited in Richard Victor, “AT&T and the Public Good: Regulation and Competition in Telecommunications, ” Harvard Business School, unpublished paper, April 1987, revised March 1988, p. 3.

[16]Michael D. Reagan, Regulation: *The Politics of Policy* (Boston, MA: Little, Brown, and Co., 1987).

[17]Vietor, op. cit., footnote 15, *p.* 17.

[18]As Glen Robinson *pointed* out: ‘‘ . . .She [Ma Bell] was held in fairly high regard. In contrast to other monopolists we’ve loved to hate—railroads, gas utilities, broadcast stations, and countless other enterprises with protected market positions—AT&T’s monopoly seemed not only natural but relatively benign. . . .The system pioneered and developed by AT&T was justly acclaimed the world’s freest. Telephone rates were comfortably affordable; furthermore, in the heyday of the telephone monopoly the rate system was generally perceived as fair. Servicinnovation, while not rapid, nevertheless did proceed more rapidly than in other sectors of the economy. ’ Glen O. Robinson, “The Titanic Remembered AT&T and the Changing World of Telecommunication,’’ *Yale Journal of Regulation*, vol. 5, 1988, pp. 517-518.

[19]Some have argued that, in the long run, given technological changes and efforts to upgrade the network for the business user, this subsidy has actually worked in reverse. According to Pat Aufderheide, for example: “Cost shifting is justified on the grounds that the individual user is th‘cost-causer’ and that the local loop must now ‘pay for itself.’ This rationale ignores the changing pattern of technological costs. More elaborate and sophisticated digital switching equipment, making possible services of great immediate value to large users and increasing capacity to carry huge data transmission demands, incurs tremendous investment costs while lowering the cost of switching and transmission.’ Patricia Aufderheide, ‘ ‘Universal Service. Telephone Policy in the Public Interest,’’ *Journal of Communication.r,* vol. 37, No. 1, Winter 1987, p. 83.

[20]Vietor, op. cit., footnote 15, p. 23.

percent of American homes equipped with telephones.[21] By 1952, AT&T operated almost entirely under a nationwide average pricing system. However, for political as well as economic reasons, subsidies such as these could only be sustained under a regulated monopoly. Over time, the policy of maintaining the telephone monopoly became less and less viable.

Technological developments helped undermine the traditional Bell System. With the convergence of information (computers) and communication (telephones) technologies, there was no clear distinction between a monopoly—and hence regulated—service, and competitive market-driven services. This convergence led to changes in network architecture, with the intelligence (control) being increasingly dispersed. As a result, network unbundling (purchasing separate, individual services) was greatly facilitated. As new technologies increased in capability and declined in cost, the barriers to entry into the telecommunication market were reduced. Under these circumstances, newcomers were able to make significant inroads into AT&T's traditionally protected market. Their chances for success were greatly enhanced because AT&T was required to provide universal service while its competitors could target products and services for the lucrative business markets and offer them at a lower price. Thus, competitive entry put pressure on the subsidy pricing system that had been elaborately constructed over the years.

Economic developments also greatly increased the incentives for others to enter the telecommunication/data communication market. As information came to play a more important, strategic role in business, large users sought alternative, more efficient ways of purchasing telecommunication services.[22] Where their needs were great, or where they wanted more control over their operations, users created their own internal telecommunication networks. In other cases, business users were able to make the best deal by bypassing the Bell System and purchasing services and equipment in the unregulated market. Since expenditures on these services constituted an increasing portion of their overall business expenses, large users had tremendous stakes in how the telecommunication regulatory structure evolved. Recognizing this, they joined forces with the burgeoning new service providers to press for greater competition.[23]

Changes were also taking place in the way regulators viewed the regulatory system.[24] As early as 1962, a number of regulatory economists began to question the public utility concept. Together, their work—if it did not itself give rise to the new deregulatory climate-served at least to legitimate it.[25] This changed attitude was also evident at the FCC.[26]

Although perhaps not fully aware of the final outcome of its actions, the FCC took its first steps toward divestiture and the Modified Final Judgment (MFJ) in 1959 with its "above 890" decision. This decision, which liberalized the licensing of private microwave systems, allowed the newly created Microwave Communications, Inc. (MCI) to offer a new product-discount private-line service.[27] With the subsequent Carterfone decision in 1969, the FCC also opened the customer-premises equipment market to entry. Finally, with the decisions on Execunet in 1976 and 1978, requiring AT&T to provide connections to MCI, the FCC struck a final blow to the 100-year-old AT&T monopoly by opening the

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21 It should be noted that the goal of providing universal telephone service was greatly facilitated by Federal support of independent rural telephone companies. In response to a decline between 1920 and 1940 in the number of farms that had telephones, Congress, in 1947, authorized the Rural Electrification Administration to make low-interest loans to persons, public bodies, and cooperatives to improve and extend telephone service in rural areas. By the end of 1985, REA had provided loans or loan guarantees to approximately 1,000 small, independent rural telephone companies totaling $7.7 million. U.S. General Accounting Office, *Issues Affecting Rural Telephone Service* (Washington, *DC: Mar. 17, 1987),* p. 12.

22 For a discussion of the changing role of large business users, see Dan Schiller, "Business Users and the Telecommunication Network," *Journal of Communications,* vol. 32, No. 4, autumn 1982, p. 35.

23 Ibid.

24 For one discussion, see Alfred E. Kahn, "The Passing of the Public Utility Concept: A Reprise," Eli Noam (cd.), *Telecommunications Regulation Today and Tomorrow (New* York, NY: Harcourt Brace Jovanovich Publishers, 1983), ch. 3.

25 See, for instance, Roger G. Noll, "Regulation After Reagan," *AEI Journal on Government and Society, No. 3, 1988,* pp. 13-20.

26 As the former FCC Commissioner Nicholas Johnson noted when the FCC decided to approve MCI's application to set up a long-distance private-line service: ". . .1am not satisfied with the job the FCC has been doing. And I am still looking, at this juncture, for ways to add a little salt and pepper of competition to the rather tasteless stew of regulatory protection that the Commission and Bell have cooked up." *Microwave Communications, Inc.,* 18 FCC 2d, 953,971-972.

27 *Allocation of Frequencies in the Bands Above 890 MHz, 27* FCC *359 (1959) 29* FCC 190 *(196@.*

long-distance telecommunication market to competition.

Implications of a New Regulatory Framework for Rural America

The divestiture of the Bell System undermined the pricing structure that traditionally supported rural communication services. In particular, it led many communication providers to price access closer to real costs and to base their prices on measured usage, thereby eliminating the sources of subsidies.[28] In this deregulated climate, where competition is allowed and fostered, differences between costs and prices are untenable. Wherever prices are kept artificially high, users will seek alternative, private solutions to meet their communication needs.

To avoid the bypass of the public telecommunication network, the FCC is shifting costs from interstate interexchange service to local exchange service by imposing subscriber line charges and by limiting the interstate share of local plant costs assigned to interstate calls. Making the local exchange companies responsible for a larger share of the nontraffic-sensitive costs (NTS)[29] is likely to affect low-density rural areas more than high-density urban areas because these costs tend to be higher in rural areas. In the past, rural telephone companies allocated as much as 85 percent of NTS costs to the long-distance, interexchange carriers. Under FCC's new provision, they can allocate no more than 25 percent. The newly imposed subscriber line charges are intended to eventually makeup for past subsidies.

The amount of subsidy available for communication services is also likely to decrease in the future as business-users, who have traditionally subsidized rural users, leave the public network to set up their own telecommunication systems. Under such circumstances, less money will be available to support publicly shared communication services. Similarly, if communication services that were once provided through the public network, and thus served to cross-subsidize one another, are unbundled and sold in the marketplace, many small users may have to pay much more for services.

Changes in the communication infrastructure have also increased the transaction costs (design, installation, standardization) that rural residents and businesses have to pay to take advantage of new communication technologies and networks. In the past, many transaction costs, especially in telecommunication, were hidden. For example, as part of the product they sold, providers of telephone services included their technical expertise and assured interconnection and connectivity. In addition, they provided services such as directories, maintenance, protocols, and routing. Today, while residential and business users benefit from a greater choice of communication services, they must absorb these transaction costs on their own.

Many businesses regard this post-divestiture development as an opportunity to employ their communication and information systems strategically as a competitive, economic weapon. However, assembling and maintaining a communication network is costly, and requires considerable expertise and technical skill, as many businesses developing their own private networks have discovered. Whereas in the past, vendors performed a number of key functions-e.g., providing network management, developing industry standards, designing system architecture, planning the introduction of new technologies, and evaluation and assessing alternative products and services-today these tasks are the responsibility of the business-users themselves.[30]

[28]One of the most serious problems results from the ''deaveraging'' of toll rates. With deaveraging, a call of equivalent distance would cost more On a low-volume rural route than would a call on a high-volume urban route. In this case, long distance rural calling would diminish along with the toll incomes of the rural telephone companies. Large business customers and telephone companies also wish to reduce toll settlement payments to small telephone companies. These events may not only hinder rural network modrnization and service quality, they may also threaten the very survival of many rural telephone companies. Bruce Egan, "Bringing Advanced Telecommunications to Rural America: The Cost of Technology Adoption," contractor report prepared for the Office of Technology Assessment, October 1990.

[29]Nontraffic-sensitive costs are those costs that a local telephone company incurs in providing its subscribers with a connection to the company's central offices. The nontraffic-sensitive portion of the company's plant is largely comprised of the telephone lines (referred to as "local loops") running from the subscribers' premises to these central offices. A company's nontraffic-sensitive costs primarily depend on the number of its subscribers and the average length of its subscribers' local loops. Nontraffic-sensitive costs do not vary with the amount of telephone traffic carried over the loops, which is why they are generally considered "freed" costs.

[30]To meet the needs of business-users, new companies are emerging and old ones are reorganizing to better position themselves to take part in what is now a very lucrative systems integration market. According to the market research firm, International Data Corp., the system integration market is growing at an estimated annual rate of 20 percent, with revenues increasing from $8 billion in 1987 to $22 billion in 1993. Mark Breibart, ''Systems Integration Surge,' *Computer World Focus on Integration, special issue,* Feb. 6, 1989, pp. 29-33.

Shifting the burden of transaction costs to the communication-user raises questions of fairness. In particular, it is likely to disadvantage rural areas, where few businesses will be able to assume these transaction costs.

Aware of the problems that rural areas might face in a post-divestiture environment, the Federal and State governments took a number of actions to alleviate some of them. For example, within a year of divestiture, the FCC initiated a targeted subsidy program that waived all of the monthly $2 Federal subscriber line charges if the State contributed at least another $2 to reducing an eligible subscriber's monthly bill. In addition, the Universal Service Fund was established to reduce the impact of divestiture on high-cost subscribers. It allocated about $180 million to high-cost areas in 1988. In April 1987, the FCC began the Link Up America program-using funds from charges on long-distance carriers to contribute up to $30 towards installation fees. The Rural Electrification Administration also provides direct subsidies to rural telephone companies in the form of low-interest loans. A number of States also provide subsidies. For example, in 1983, California adopted a Lifeline plan, according to which customers with incomes below specified levels obtain a 50 percent discount on basic local service plus other benefits.[31]

While these measures may limit the negative impact of deregulation with respect to providing rural citizens 'plain old telephone service,' they are unlikely to deal with the problem of how new capabilities are to be deployed throughout the network in the future. To understand the magnitude of this problem, one must look frost at the condition of the rural communication infrastructure as it is evolving today.

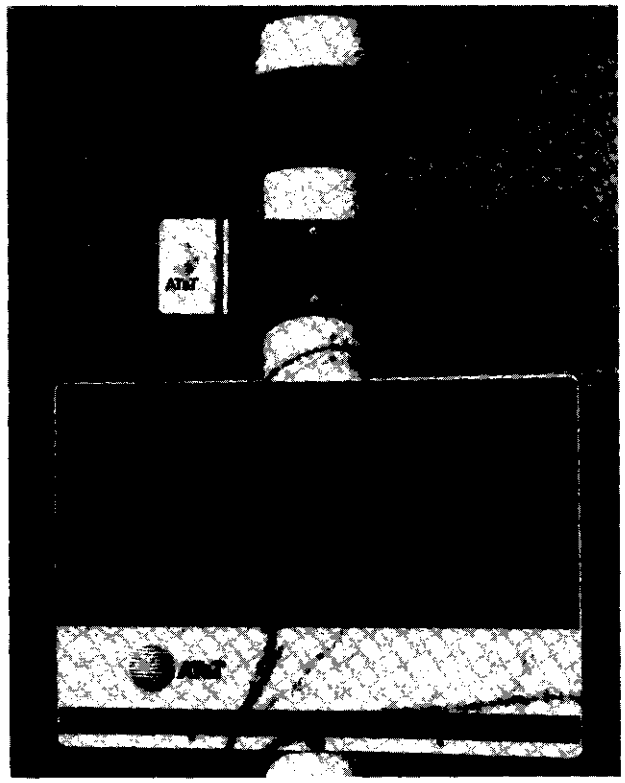


Photo credit: Mark G. Young

A sign marking the route of AT&T's intercontinental cable through Bowling Green, KY.

The Rural Communication Infrastructure

It is useful to subdivide information-age technology into information technologies, access and transmission technologies, and switching and networking technologies. It is important to note, however, that the boundaries among them are not always clear cut, and are eroding in the face of technological change.[32]

Information technologies allow individuals to store, process, and reorganize data into a more useful form. Examples include computers, modems, facsimile machines, and answering machines. Access and transmission technologies are the means by which individuals can transmit or receive information from other individuals or information systems. Some examples are cables, radio waves, and satellites. Network technologies are the means by which transmitted information can be managed, routed, and

[31] See for a discussion, Leland L. Johnson, Telephone Assistance *Programs for Low-Income Households: A Preliminary Assessment* (Santa Monica, CA: Rand Corp., R-3603-NSF/MF, 1988).

[32] With the deployment of fast packet-switching and the integration of further intelligence into the telecommunication network, it will become increasingly difficult to distinguish between the functions of switching and transmission. See Gihong Kim, "The Evolution of Transmission Systems for the Next 10 Years," *Telecommunications,* Aug. 10, 1987. Some examples noted by the author are statistical multiplexer, digital cross-connect systems, concentrators, and switches with built-in optical interfaces such as DS3. See also, A.M. Rutkowski, "Telecommunication Sandcastles: Boundaries That Have Outlived Their Usefulness,"*Telecommunications,* June 1987, p. 8; and Richard Solomon, "Broadband ISDN: With Computers, the Sum Is Always Greater Than the Parts," *International Networks,* vol. 5, No. 2, Sept. 5, 1987.

interconnected. These include, for example, switches, bridges and routers, local area networks (LANs), and signaling systems.

Information Technologies

Information technologies encompass a vast array of storage and processing devices. The most important is the personal computer. In 1989, there were 16 million personal computers deployed in business, 20 million in residences, and 2 million in the educational and scientific communities.[33]

Computer applications are also multiplying rapidly due to increased storage and processing capacity[34] dispersal of intelligence thoughout communication systems,[35] as well as digitalization and the convergence of media.[36] According to one estimate, by 1993, office workstations will be able to handle 32 million instructions per second; have 16 megabytes of random access memory, and cost approximately $350.[37] Given such performance/price improvements, market analysts expect that, by the early 1990s, the total number of computer workstations in Europe, Japan, and the United States will surpass 100 million.[38] Many of these will soon provide multimedia access at the desktop[39] (see box 3-A).

Rural areas have been much slower than urban areas to adopt information-age technologies.[40] There are a number of reasons for this lag. One is cost. Even when the price of customer premises equipment is not excessive, the cost of network access and transmission can be prohibitive. To access major databases, or to network their computers, people living in rural areas generally have to make long distance calls. In urban areas, this is often not the case.[41]

The poor quality of the rural infrastructure also inhibits the use of information technologies. As discussed below, in many rural areas the communication infrastructure is still unsuitable for simple data transmission. With faster speeds and more powerful applications, the need for a high-capacity, high-quality infrastructure will be even greater. CAD-CAM applications, for example, require broadband capacity of 45 megabits per second.

The lack of technology awareness and expertise also helps explain the low levels of computer ownership in rural areas. Rural people who own computers have more education, income, and professional experience than those who do not.[42] Although information technologies are becoming

33 Mark Cooper, *Expanding the Information Age for the* 1990's: *A Pragmatic Consumer Analysis,* written for the American Association of Retired Persons and the Consumer Federation of America, Jan. 11, 1990, pp. 15-16.

34 A critical factor in this regard has been the rapid advances in microelectronics resulting from the development of very large scale integration (VLSI). VLSI allows the placement of over 10^6 logical operations on a single integrated circuit chip, and this number is doubling every 18 months. Given this level of integration, communication within computers can take place much more rapidly and efficiently; bits no longer have to travel between chips over shared buses when the source and destination both reside on the same chip. Over the past 20 years, chip densities have increased several orders of magnitude. See, for a discussion, Debra Estrin, 'Communication Systems for An Information Age: A Technical Perspective,' contractor report prepared for the Office of Technology Assessment, December 1986.

35 More and more systems are becoming defined and driven by software. This development will make future communication technologies and systems more flexible and more versatile. See, for a discussion, U.S. Congress, Office of Technology Assessment, *Critical* Connections: *Communication for the Future,* OTA-CIT-407 *(Washington DC:* U.S. Government Printing Office, January 1990), ch. 3.

36 As Stewart Brand has described this Phenomenon "With digitalization all of the media become translatable into each other—computer bits migrate merrily-and they escape from their traditional means of transmission. A movie, phone call, letter, or magazine article maybe sent digitally via phone line, coaxial cable, fiber optic cable, microwave satellite, the broadcast air, or a physical storage medium such as tape or disk. If that's not revolution enough, with digitalization the content becomes totally plastic—any message, sound, or image maybe edited from anything into anything else." Stewart Brand, *The Media Lab: Inventing the Future at MIT* (New York, NY: Penguin Booka, 1988), p. 19.

37 Denis Gilhooly, "Welcome to a Future Where Less Is More," *Communications Week,* CLOSEUP, Sept. 4, 1989, p. C4.

38 Ibid.

39 Although currently in its infancy, the multimedia industry is growing rapidly and expected to constitute a $7 billion market by 1994.

40 Don Dillman et al., for instance, showed that people living in Washington State's rural counties tended to own fewer information technologies that might be used in business applications. Don Dillman, Lesli Peterson Scott, and John Allen, *Telecommmu nications in Washington: A Statewide Survey,* for the Joint Select Committee on Telecommunications of the Washington State Legislature, Social and Economic Science Research Center Washington State University, Pullman, WA, January 1987, p. 17.

A similar study by Clifford Scherer compared computer ownership in metropolitan and nonmetropolitan New York. It found that 18 percent of the people living in metropolitan counties owned computers as compared to 14 percent in nonmetropolitan counties. Clifford Scherer, *Data Book: A Study of New York State Residents—Getting Information for Daily Living,* Department of Communication Cornell University, Ithaca, NY, 1988.

41 Paul Yarborough, "Information Technology and Rural Economic Development: Evidence From Historical and Contemporary Research," contractor report prepared for the Office of Technology Assessment May 1990.

42 Ibid., p. 22.

Box 3-A-Computer-Aided Design

Computer-aided design is becoming the norm for businesses to efficiently design and test products and design and monitor the machines and factories that make and assemble the products. With the help of computers, designs for buildings, machines, consumer products, semiconductor components, etc. are electronically simulated and tested. CAD/ CAM (computer-aided design/manufacturing) replaces the construction and testing of actual models. Because designs are stored in electronic form rather than on paper, they can be quickly and easily updated and transferred.

Integraph Corp. recently introduced a product, the CAD Conferencing Module, that permits people at as many as eight different locations to simultaneously view and edit computerized blueprints and designs. Engineers and designers, for example, can simultaneously and interactively work in real time on a file with each other or with a client. The electronic blueprints are transmitted and loaded into each of the separate workstations so that they can be called up during the networked conference to be viewed and edited. Modifications to the still-frame image, such as zooming or highlighting features, by one person are registered at all the participating workstations. This conference arrangement expedites the design and engineering process by minimizing the encumbrance of mailing blueprints back and forth, and increasing the communication between the firms' various departments.

SOURCE: Charles Bruno, "Intergraph Ushers in CAD Conferencing Era," *Network World, Nov. 12,* 1990, p. 37.

more user-friendly, the difficulties entailed in linking technologies and systems will likely continue to discourage use.

Access and Transmission Technologies

Access and transmission technologies transport information among and between other users and networks. They may provide point~to-point interconnection, as in the case of the telegraph and the telephone; point-to-multipoint interconnection, as in the case of radio and television; or multipoint-to-multipoint interconnection as in the case of bulletin boards, electronic mail systems, and local area networks (LANs). These technologies can have either one-way or two-way capabilities.

Telephony

Telephony is by far the most important and ubiquitous two-way medium for transmitting information. There are today, in the United States, over 1,300 telephone companies and a total of 130 million access lines. The top 25 companies account for 90 percent of the access lines. The Bell telephone companies serve about 80 percent of the market with about 50 percent of all central offices. The remaining companies are quite small by comparison.

A wide variety of new and more specialized service providers have emerged since divestiture. For example, some providers, such as Telenet and Tymnet, sell packet-switched data communication services.[43] Other carriers specialize in high performance, point-to-point T1 service.[44] And others, such as Teleport and Metropolitan Fiber Systems, provide metropolitan area networking (MAN) services. Many private businesses have also taken advantage of the unbundling of the communication network and the availability of a wide range of new, advanced products to develop their own communication systems.

In rural areas, about one-half of all service is provided by small independent telephone companies, with the Bell operating companies (BOCs) providing 53 percent.[45] Few, if any, Of the larger or more specialized providers are trying to enter or develop rural markets. Given a highly competitive, post-divestiture environment, they are focusing their efforts on the more lucrative business market, generally to be found in urban areas. The regional Bell operating companies (RBOCs), for example, have been concentrating on the deployment of their switched multimegabit data service (SMDS)[46] in an effort to forestall bypass by alternative providers.

[43] Packet-switching makes efficient use of a transmission channel. It breaks messages up into small bundles, or packets, each of which carries with it its own address; then interleaves them on a channel, taking advantage of the "silences" present in the information stream, and finally routes them throughout the network to their destination where they are reassembled.

[44] T1 circuits operate at 1.544 megabits per second and consist of 64 kilobits persecondvoiceor data, plus a framing bit. For a description see, Victoria A. Brown, "T1 Networking and Open Systems," *Telecommunications,* January 1989, p. 56.

[45] REA provides investment and financial data for over 900 small telephone companies serving over 5 million customers in very thin markets. This data is considered for the purposes of this report to be representative of "rural" subscribers.

[46] SMDS is a high-speed, fast packet. switched service provided in a campus type arrangement situated within a 5&tie radius.

The RBOCs' early ISDN trials were also conducted to the same end with large business users located in metropolitan areas.[47] This urban focus means that even when rural businesses are large enough to economically justify the delivery of advanced services, they are often the last to be served. This can have a spiraling effect, since businesses sometimes will not locate in rural areas for lack of an adequate communication infrastructure.[48]

A comparison of the circumstances under which urban and rural telephone companies operate illustrate some of the problems of providing service in rural areas. Costs are higher in rural areas because, with low-density populations and low-volume traffic dispersed over large areas, costs are harder to share. The Bell companies, which serve primarily urban areas, have about 10,000 lines per central office, whereas REA borrowers-generally the smallest of the independents-average only 2,500 lines per central office.

Moreover, whereas Bell companies have, on average, almost 130 subscribers per route mile of outside plant, REA companies average only 6.[49] In addition, the average length of a large company's subscriber loop (the wire between the central office and the user's premises) is about half that of REA companies (10,787 v. 20,330 feet) .50 The Bell companies also have many more higher paying business access lines than rural companies. Not surprisingly, revenue per line for small companies is $682 per year or $56 per month, as compared to $757 per year, or $63 per month for large companies. If rural telephone companies did not have significant cost efficiencies relatively to large companies,[51] or access to low-cost financing through REA, the gap between urban and rural telephone revenues would likely be higher.

The quality of rural access is also inferior to that in urban areas. Poor quality stems, in part, from the number of multiparty lines still found in rural areas. Multiparty lines cannot transmit data because of possible interruptions. Although their number is declining, multiparty arrangements are much more prevalent in rural areas than in urban areas. In 1987, multiparty lines accounted for only 1.2 percent of Bell access lines as compared to 7.4 percent of independent telephone companies' access lines.[52]

Long local loops also diminish the quality of rural access. When loops exceed 18,000 feet, they require special treatment to maintain the quality of voice transmission. Loading coils are used, for example, to reduce voice frequency attenuation and range extenders are used to amplify a distant voice signal. But these treatments limit the usefulness of the line for data. Loading coils, which are present on about 40 percent of all rural subscriber loops, introduce delay distortion that limits data transmission to a few hundred bits per second. And range extenders may garble data, requiring retransmission.[53]

Advances in technology are helping to reduce the costs and improve the quality of access in rural areas. One important development has been advances in loop plant technology. Of great importance has been the introduction of the serving area concept in current plant designs. This design was first introduced by the Bell System and adapted for use in rural areas by REA companies in the mid- 1970s. In accordance with this design, logical groupings of subscribers are arranged so that they can be served by relatively short and large pair-size distribution

47Carol Wilson, "PacBell Launches Primary Rate ISDN," *Telephony*, Dec. 10, 1990, p. 11.

48For such instances, see *Telecommunications and Rural Economic Development* (Redondo Beach, CA: MESA Consulting, Oct. 30, 1990).

49U.S. Department of Agriculture, "1988 Statistical Report, Rural Telephone Borrowers," REA Bulletin #300-4, 1989.

50Egan, op. cit., footnote 28.

51One reason for the-companies' relatively low costs is the savings from arrangements to share large company toll facilities and traffic and billing Systems. Thus, these operations are treated as operating expenses, while the same activity for a large company may require capital outlays. Nevertheless, even operation and maintenance expenses per line are consistently and significantly lower for smaller companies. Large companies have a more mobile access line base, and service quality on their loops tends to be higher (while their loops are shorter). Moreover, labor costs for both craft and management functions are much smaller for rural telephone companies.

52Edwin B. Parker, *Rural America in the Information Age: Telecommunications Policy for Rural Development* (Lanham, *MD:* University Press of America, Inc., 1989), p. 69. The actual number of multiparty lines may overestimate the number of persons or firms for whom such service is a hindrance. Many customers with multiparty lines do not use them for data transmission and may voluntarily choose multiparty lines over single-party lines in order to pay lower rates.

53Egan, op. cit., footnote 28, p. 47.

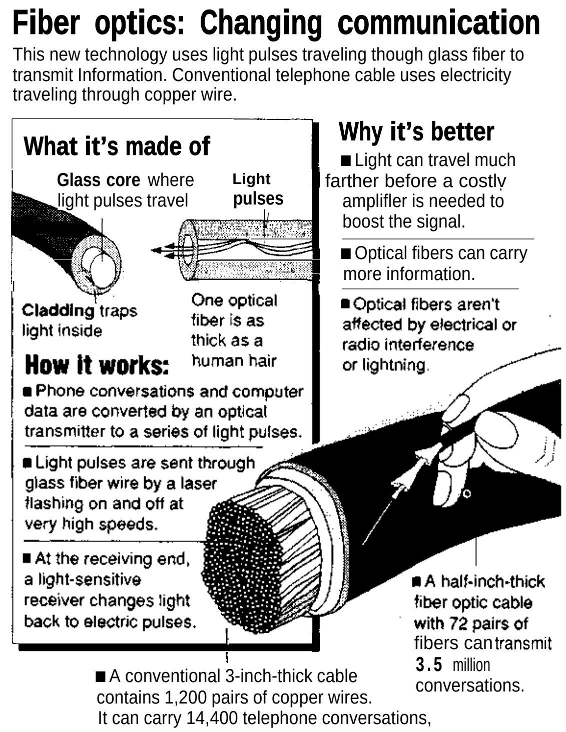
cables from an intermediate field location called a Serving Interface Point.[54]

Two significant developments in loop technology—the introduction of loop carrier systems and digital remote electronics and switching technology—helped implement this design. Loop carrier systems concentrate access lines by combining many customers into one or more shared trunks. Previously, each customer needed a dedicated (nonshared) loop. The introduction of digital switching reduced the amount of dedicated loop plant by allowing remote nodes to be connected to the host digital switch.

The deployment of fiber optics will also greatly improve rural access. Fiber optics generally provide more capacity, reliability, flexibility, and functionality than existing metallic cable. With minimum transmission loss, fiber allows more signals to travel over longer distances with smaller numbers of repeaters than does copper wire.[55] Thus it can support new broadband applications such as video telephony, multi-media services, and very high speed data services (see box 3-B). Already, commercial systems have been developed that transmit 1.7 billion bits of information per second on a single pair of glass fibers, an amount equivalent to 24,000 simultaneous phone calls. And the capabilities of lightwave transmission are doubling every year, a trend that is likely to continue for at least a decade.[56]

Constraints on the deployment of fiber are clearly economic, not technological. Although fiber is increasingly being used for interoffice trunk lines. and even in some local loop facilities for business users, it will not likely be extended to the home (with the exception of new construction) for a number of years.[57] Fiber loop systems are still uneconomica1 for most of the residential communities; splicing and cabling costs are still high.[58] The residential demand

Box 3-B—Fiber Optics



SOURCE: Judy Treible, Knight-Ridder Tribune News, adapted from *Popular Science Magazine, World Book Encyclopedia,* and *The Re-Wiring of America.*

for fiber in the local loop also remains uncertain; most residential service can be provided through the existing network, or as in the case of video services, through alternative distribution channels such as cable TV and videocassette recorders.[59]

The deployment of fiber will be driven by business demand. It is cost-effective for businesses

[54] Relatively long feeder cables connect the SIP to the central office switch. Subscriber circuits are created by cross-connecting pairs from the feeder and distribution cables to the SIP points. Egan, op. cit., footnote 28.

[55] Commercially available fiber optic technology operates in the 500 million megabits-per-second range. Rates should increase in the future with the use of single mode fibers and coherent modulation/demodulation schemes. Estrin, op. cit., footnote 34, p. 17.

[56] Eric E. Sumner, "Telecommunications Technology in the 199@" *Telecommunications,* January 1989, p. 38. See also, Lee Greenfeld, "Optical Computing," *Computerworld,* June 26, 1986, pp. 83-89; and Estrin, op. cit., footnote 34. In the future, the use of laser systems and wavelength division multiplexing on a single fiber will push transmission capabilities into the range of 20 gigabits per second. With wave division multiplexing, eaeh fiber optic cable can accommodate multiple channels by assigning each data stream a different wave length or color.

[57] For one discussion, see Robert Pepper, "Through the Looking Glass: Integrated Broadband Networks, Regulatory Polities, and Institutional Change," working paper No. 24, Federal Communication Commission, Office of Plans and Policy, 1988.

[58] To speed up the deployment of fiber, providers are focusing on the intermediate step of delivering fiber to the curb.

[59] For discussions, see Graham Finnie, "The Disciples of Fiber," *Telecommunications,* and Graham Finnie, "Lighting Up the Local Loop," *Telecommunications,* January 1989, pp. 31-32,37-38,40; and Lloyd F. Brisk, "Neighborhood Fiber: Putting a Laser in Everyone's POTS,*Telephony,* Feb. 20, 1989, pp. 27-28.

to adopt fiber long before residential users, because they typically share network facilities among a number of telephones. However, rural businesses may be unable to drive demand because they are generally too small in size. To have such an impact, they will need to pool their demand, either with other businesses or other large users within a community.

Cable Television

Cable television is an important one-way communication system serving rural areas. The Community Antenna Television Association (CATA) estimates that cable penetration (homes passed) in rural areas is higher than in urban and suburban areas [about 60] percent). However, while the actual subscription rate in nonmetropolitan counties may be higher than in metropolitan counties, communities with fewer than 3,000 residents had a subscription rate of only 46 percent compared to 69 percent for more populous places in the same County.[60]

Cable is valuable to rural households as a source of entertainment and access. Cable television can be accessed using wire or satellite. In urban areas, access is almost exclusively through coaxial cable provided by a cable company. In rural areas it is available primarily through coaxial cable, with 10 percent of it provided by satellite. To gain access via satellite, rural residents must buy a television receive only (TVRO) satellite dish that costs between $750 and $1,800.[61] Ownership ranges from 6 percent in the open country to 11 percent in rural mountain areas.[62]

One-way communication systems, such as cable TV, are less important to rural businesses because they do not presently support the information exchange required in most business communications.[63] They are, however, being used in the public sector, especially in schools (see box 3-C).

> ***Box 3-C—Berks Community Television***
>
> Berks Community Television (BCTV) was created in 1977 as a nonprofit organization, supported by the citizens of Berks County, PA, and its largest city Reading (famous for the railroad to which it lent its name), to provide “to the community the best possible educational and informational programs. ” The programs are organized and produced by volunteers. Its programming is fed into the cable system and delivered as a regular subscriber channel.
>
> In contrast to larger regional or national formats, BCTV uses television as a live, two-way, interactive medium that depends on audience participation and feedback. For example, BCTV, through a series of National Issues Forums raises relevant issues, such as the day-care dilemma and drug crisis, while permitting and encouraging home viewers and the studio audience to actively take part in the discussion. In addition, community agencies, such as the chamber of commerce, county bar association, and hospitals and medical firms, use BCTV “to continue their outreach, information, and referral services. ” Productions can be organized at two different locations and shown simultaneously on split screen.
>
> **SOURCE: Berks Community Television, Reading, PA.**

Nonwireline Media

In remote areas, where the cost of providing wireline service is prohibitive, microwave, radio and satellite technologies can be used to provide less expensive access to communication services. With technological advances, these technologies provide services that are increasingly comparable to wireline service.

Microwave has long been a mainstay in telecommunications network technology. Historically, its primary use was high-capacity, long-haul toll service, and it will likely continue to be important in such

60 Egan, op. cit., footnote 28, p. 57.

61 Joseph N. Pelton, ''Satellite Communication for Rural and Remote Applications in the United States,'' contractor report prepared for the Office of Technology Assessment, December 1989, p. 13.

62 Yarborough, op. cit., footnote 41, pp. 45-46.

63 The coaxial cables used for CATV transmissions can transmit very wideband signals; this fact, plus the fact that a majority of U.S. residences are passed by CATV systems, has generated much interest in the use of cable television technology to offer services beyond one-way video programming, including two-way switched voice and data. The attractiveness is clear: aside from the wide availability of CATV service, the cable medium is relatively inexpensive, and electronic interface equipment for subscriber applications is also inexpensive to design and produce. There are, however, a number of regulatory concerns surrounding the issue of CATV-based local exchange telephone service, and cable companies have been slow, if not reluctant, to move in these new directions. Dale Hatfield, “Information Age Technology and Rural Economic Development” contractor report prepared for the Office of Technology Assessment, October 1989, p. 23.

Box 3-D—Digital Radio Service

In the United States, the International Mobile Machine Corp. (IMM) has developed a wireless digital radio service called Ultraphone, which is now being used to provide telephone access in a number of remote rural areas. As of the end of 1989, IMM had installed approximately 40 Ultraphone systems serving about 15,000, mainly rural, customers.

A digital radio transceiver at the customer's premises encodes the analog voice to digital format to be transmitted through the radio waves (rather than through the more traditional terrestrial copper or fiber-optic wires) to the Radio Carrier Station, where the signal is then routed to the central office switch and along the public-switched network

Radio telephony is particularly advantageous for rural areas where the expense of extending wires to the customers—which may involve digging trenches, clearing rights of ways, or crossing difficult terrain-can become prohibitive. It is thus especially useful when extending service to only a few, widely dispersed customers. Another inherent advantage of wireless technology is that telephone companies have much greater flexibility in adding on additional customers and reconfiguring their facilities than with conventional cable routes/kind lines.

Digital radio also has a number of advantages over analog radio:

- greater degree of security because of more complicated encoding schemes for the digital transmission,
- digital transmission is inherently better suited for handling data transmission,
- greater ability to operate in the presence of interference,
- higher capacity,
- time division multiplexing conserves spectrum and reduces costs because less base-station hardware is required to support a given subscriber population, and
- ultraphone is software-based and thus more open to further technological improvements.

SOURCE: George M. Calhoun, "Wireless Access and Rural Telecommunications," contractor report prepared for the Office of Technology Assessment, 1990.

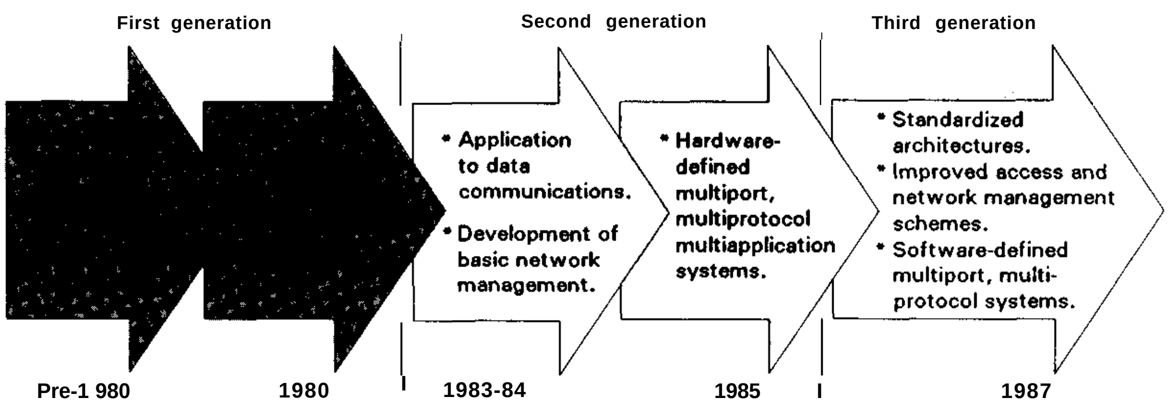
markets. Recent technological advances in microwave, as well as increases in the usable spectrum for telecommunications, have made it a popular technology for high-capacity, short-haul applications. Microwave is used for both digital and analog services.

One of microwave's advantages is its relatively low construction costs for rural applications compared with other technologies. Unlike terrestrial wireline technologies, it does not require placement of physical cable plant, usually the highest component of deployment costs. Rooftops, hills, and mountains can often provide an inexpensive base for microwave towers. Unit costs of microwave service are also falling, as more high-powered systems expand the usable spectrum. Very small capacity systems with only a handful of circuits are also now available. One major disadvantage of microwave is that it requires line-of-sight of the transmission path and is subject to electromagnetic interference.

Like microwave, radio technology relies on the electromagnetic spectrum and has long been used in various forms for telecommunications and broadcasting services. Its use in providing basic rural service has only recently been approved by Federal regulators, who must approve all private uses of the spectrum.[64] This technology is sometimes referred to as the "wireless loop," and its immediate advantages in terms of speed and ease of installation are clear since there is no requirement for placing physical transmission plant. The term "radio" in this case refers to certain frequencies assigned to the service that are distinct from those assigned microwave toll service. As an over-the-air technology, radio service supports both analog and digital applications and has the same relative advantages and disadvantages as microwave (see box 3-D). Unlike microwave, rural radio provides short-haul telecommunications, and requires different power, performance, transmission, and reception capabilities and devices. Digital radio systems capable of carrying four DS3 lines-each with a capacity of

[64] Documents filed in FCC CC Docket #86-495 (BETRS) provide detailed information on this service.

Figure 3-l—Evolution of VSAT Technology



The evolution of very small aperture terminal (VSAT) technology: three generations.
SOURCE: Art reproduced by permission of *Telecommunications* magazine.

45 megabits per second—are expected to be available in the early 1990s.[65]

Clearly the most advantageous feature of radio technology is its low cost in rural service applications. Unlike wireline service, its cost is based on total demand rather than on population density. Thus, whereas it can cost, on average, $10,000 per subscriber to provide access lines via copper wire, the average cost of digital radio is about $3,000 per subscriber. According to present estimates, rural radio service is now the most cost-effective option for serving about 900,000 remote subscribers who do not have service at all, or whose service upgrades using other technologies are not cost-effective.[66]

The idea of using satellite systems to provide low-cost communication services to isolated areas is not new.[67] In the United States, the Alascom Satellite operating through the Aurora satellite system has served to meet the communication, health, educational, and entertainment needs of the people of Alaska for two decades. In addition, over 25 developing countries have leased capacity on the INTELSAT satellite system to meet their domestic communication needs. A number of countries—including among them Brazil, India, Indonesia, and Mexico-have deployed their own satellite systems.

Advances in satellite technology will lead to even greater rural applications in the future. The development of very small aperture terminal (VSAT) technology has been particularly important in improving performance while reducing costs (see figure 3-l). The mobile satellites being designed now for launch in the early 1990s will carry sufficient power to enable the use of a large number of small, mobile terminals on the ground.[68] Portable units will be self-contained and lightweight, capable of fitting on a company or family car. They will allow users to link up with private networks or the public telephone network to access a variety of services, including voice, data, facsimile transmission, and computer-to-computer communications.

Many businesses are shifting from wireline to VSAT technology (see box 3-E). VSATs are particularly cost-effective when businesses need to communicate with remote sites. Thus many major corporations-e.g., Chrysler, Nissan, Toyota, K-Mart, Thrifty Stores, and Frito-Lay-are using VSATs to develop wide area networks (WANs). Hughes Network

[65] George Calhoun, "Digital Radio Technology and Rural Economic Development" contractor report prepared for the Office of Technology Assessment, October 1989.

[66] Ibid.

[67] For a discussion, see Joseph Pelton, "Satellite Technology and Rural Economic Development," contractor report prepared for the Office of Technology Assessment, October 1989. See also, S.S. Kamal, "Advanced Telecommunications for Rural Applications, " *Satellite Communications*, October 1989, pp. 21-23.

[68] See Tariq Kahn, " 'Third-Generation' Technology Fuels VSAT Growth," *Telecommunications*, September 1990, pp. 29-34.

Box 3-E—VSAT Technology

As the technology for very small aperture terminals (VSATs) develops and their costs decline, many companies are finding that VSAT networks are more advantageous than terrestrial networks for the transmission of large amounts of data between widely dispersed locations. A $200 million industry in 1988, markets for VSATs are expected to now exceed $1 billion. VSATs' "inherent performance advantages [include] fewer discrete points of failure, simpler network deployment, more flexible network configuration, and simplified network management." The technology is proving especially valuable to manufacturers and retailers, such as Chrysler, K-Mart, Thrifty Stores, and Frito-Lay, with many retail and plant facilities spread over large areas.

Smaller companies that cannot afford to install their own systems can take advantage of shared-hub networks. For example, Terra International, Inc., based in Sioux City, IA, recently chose a shared-hub VSAT network to connect its outlets spread throughout the country with its centralized computer center, which provides an array of business support applications. Terra, which manufactures and sells agricultural products, cites a reduction in communication costs in excess of 25 percent since VSAT was installed in 1989. Another benefit is increased reliability of the transmission of data. The VSAT network eliminates the need to deal with many phone companies, each with different pricing structures and technical capabilities.

SOURCES: "VSATs: Far-Out Communications for Remote Sites," *Telecommunications,* September 1990, p. 37. Tariq Khan, " 'Third-Generation' Technology Fuels VSAT Growth," *Telecommunications,* September 1990, p. 29.

Systems is planning to provide leased WAN service to businesses from a shared hub facility.[69]

Switching and Other Networking Technologies

The value of information and communication technologies is greatly enhanced to the extent that they can be networked together, allowing information to be efficiently routed from place to place. A number of technologies support networking by performing interconnection, switching, routing, and signaling functions. Included among these, for example, are, switches,[70] bridges and routers,[71] local area networks (LANs), signaling systems,[72] and intelligent peripherals.

Network technologies have advanced greatly over the past several years as a result of digital processing. The first computer-controlled switching systems were deployed 20 years ago. In the 1970s, when advances in integrated-_circuit technology permitted the creation of a solidstate exchange, telecommunications providers began to deploy all digital switches. Today, approximately 98 percent of all AT&T switches are digital.[73] With respect to the regional Bell operating companies (RBOCs), approximately 55 percent of Ameritech's central offices are digital, 66 percent of Bell Atlantic's, 62 percent of Bell South's, 47 percent of Nynex's, 43 percent of Pacific Telesis', 27 percent of Southwestern Bell's, and 32 percent of US West's.[74] For the RBOCs' projected deployment of SSI and ISDN see figure 3-2.

With the deployment of even more powerful microprocessors, faster computing speeds, and larger memories, it is possible to locate intelligence not just in the central office switch, but also at nodes throughout the network. Because these "intelligent" nodes can communicate in real time with one

69 Paul J. Nichoison, 'The Hughes Network Systems Shared Hub Facility at Spring Creek, NY," *Telecommunications,* September 1990, pp. 69-70.

70 A switch can be defined as "means of allocating resources—space, bandwidth, or time-to people or machines that use the resource to communicate at a distance." As quoted in Ivan T. Frisch, "Imcal Area Networks versus Private Branch Exchanges," *Telecommunications,* November 1988, p. 24.

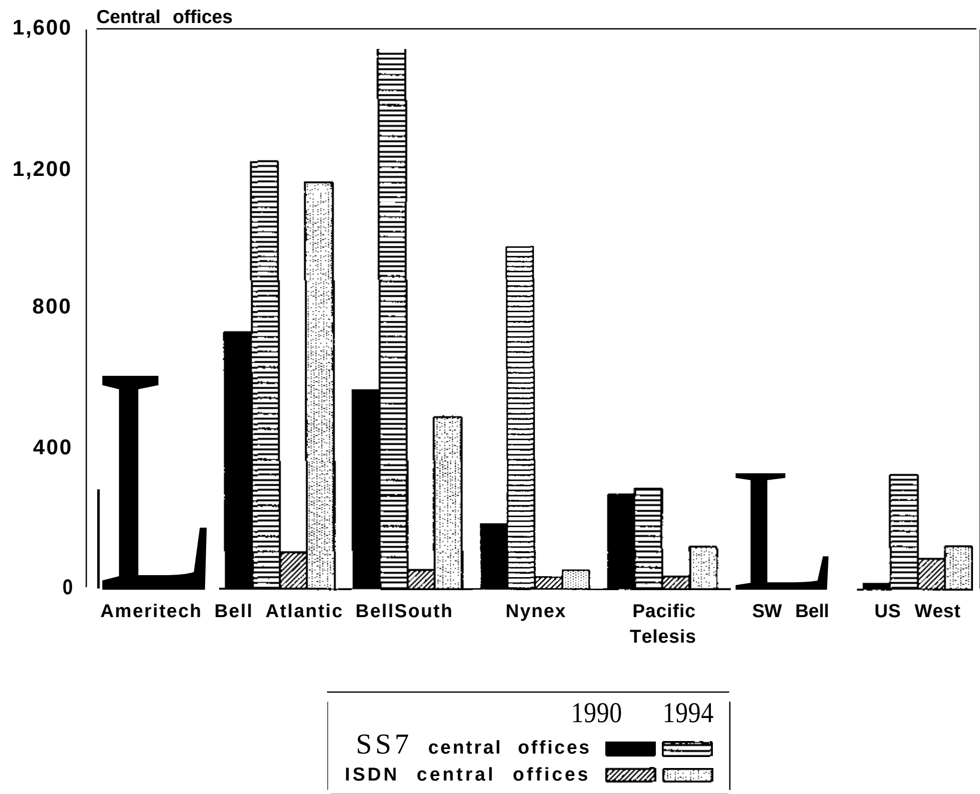
71 Bridges and routers are devices to interconnect networks. See for a discussion William Stallings, "Internetworking: A Guide for the Perplexed," *Telecommunications,* September 1989, pp. 25-30.

72 Signaling systems perform Supervisory functions, adressing functions, as well as information support functions. In previous systems, signaling information was passed together on the same channel as a message (called in-band signaling). This method was less efficient. It used up capacity and precluded the modification of calls, once in progress. However, with Signaling System 7, it is now possible to provide out-of-band signaling, which allows for a much more flexible and intelligent network. Abdi R. Modarressi and Ronald A. Skoob, "Signaling System No. 7: A Tutorial," *IEEE Communications Magazine,* July 1990, pp. 19-35.

73 Ian M. Ross, Keynote Address for Publication in the Conference Proceedings of the 1988 Bicentennial Engineering Conference, Sydney, Australia, Feb. 23, 1988, p. 12.

74 According to the companies' filings with the FCC in late 1989 for rate-of-return reproscription. Personal communication with Stan Williams, Bellcore, Feb. 13, 1981.

Figure 3-2—Regional Bell Operating Companies' Central Offices: Present and Projected



SOURCE: Carol Wilson and Czatdana Inan, "LECs Flatten Spending, Feast on Fiber,"Telephony, vol. 219, No. 26, Dec. 17, 1990, p. 42.

another, as well as with other networks, communication based on this kind of architecture offers greatly enhanced flexibility-they can respond quickly to network problems and to changes in user demand, optimize network capacity, and ensure greater system and service reliability .75

Fast packet-switching is an important development in this regard, and it will provide the basis for shared networking. Like conventional packet-switching, fast packet-switching makes optimal use of a transmission channel, but it does so with even greater speed and flexibility. Whereas conventional packet-switching is suitable for data only, fast packet technology can be used to switch voice, data, and images in an integrated fashion. Also, fast packet-switching can transmit hundreds of thousands or millions of packets per second, while conventional ones operate at a rate of only a few thousand packets per second (see figure 3-3).[76]

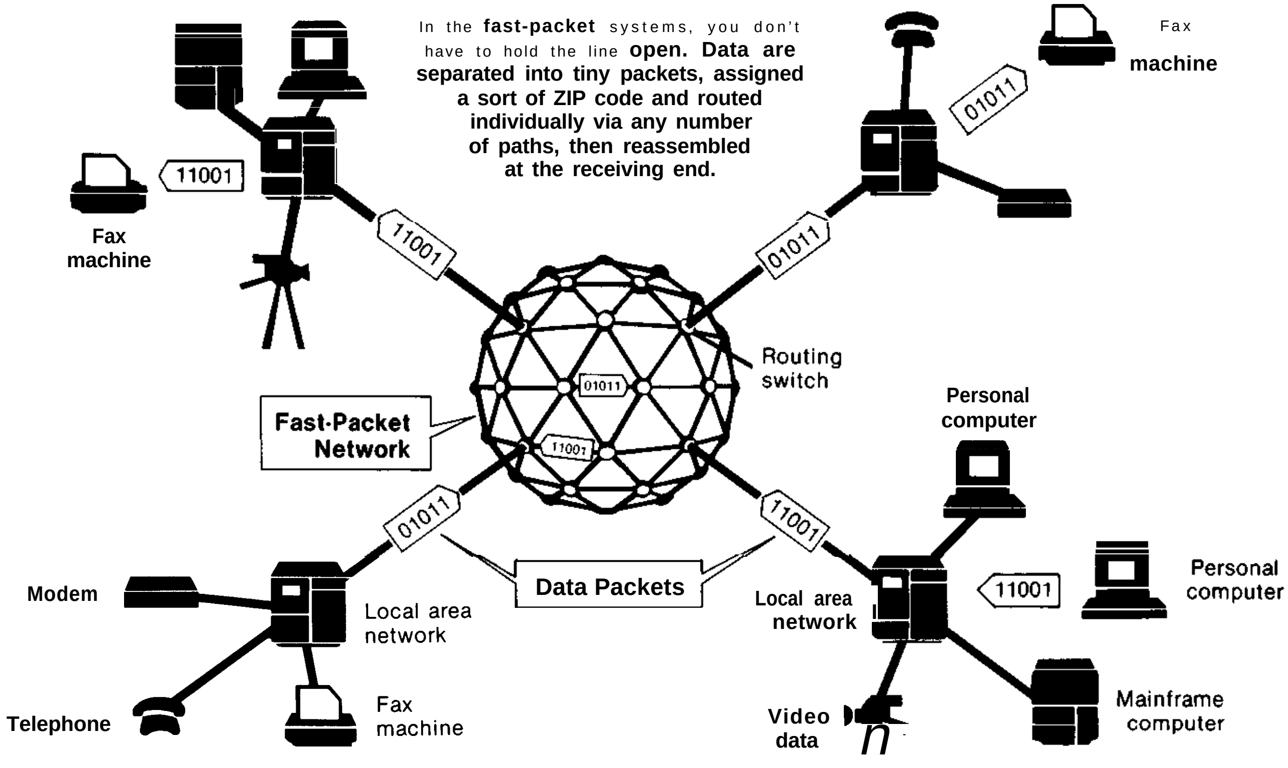
This dispersal of intelligence throughout communication systems is well illustrated in the intelligent network.[77] Using intelligent switches and databases,

[75]See, John O. Boese and Richard B. Robock, "Service Control Point: The Brains Behind the Intelligent Network," *Bellcore Exchange*, November/December 1987, p. 13.

[76]See for discussions, David P. Helfrich, "Fast Packet Switching: An Overview," *Telecommunications*, Novemeber 1988, p. 68; and James Brackett, "Fast Packet Switching: A Tutorial," *Telecommunications, November* 1988, pp. 65,67-68,7072, and 76.

[77]The idea of developing an intelligent network is not new. It was first conceived by AT&T before divestiture as a means of providing nationwide database services and private virtual networks. Since divestiture, both AT&T and Bell Communications Research (Bellcore), with the cooperation of other vendors, have been conducting research and development in this area. However, the development of the intelligent network has been much slower than was originally anticipated. Initially, Bellcore planned to develop the intelligent network in stages-Intelligent Network/1(N/1), which was intended for completion in 1991 and the Intelligent Network/2 (N/2), which was cast as the network of the 1990s. Designed to be even more flexible than N/l, N/2 would allow services to be provided in a variety of physical network configurations under the control of many different entities. In January 1989, however, Bellcore adopted a revised, more staggered approach, and postponed the development of the Advanced Intelligent Network (equivalent to an enhanced version of N/l, often referred to as N/1+) until 1995, a delay of 4 years. See for a discussion, Robert Preston, "Bells 'Intelligent Network' Could Be Delayed Until 1995," *Communications Week*, Feb. 20, 1989.

Figure 3-3—Fast-Packet Switching (Hello Central)



SOURCE: Copyright © 1990 by The New York Times Co. Reprinted by permission.

together with common channel signaling, the intelligent network allows network control functions to be separated from network switching functions.[78] This capability permits the network to select the most appropriate services and optimal routes, and to introduce new value-added services via simplified and modularized software. Among the services that the intelligent network can provide are dynamic call routing, call forwarding, call queuing, credit card billing, reverse charging, control of calls based on data held in a central database, wide area Centrex, and virtual private networks.[79] A description of the basic components comprising the intelligent network, and a discussion of how they are joined to provide intelligent services, is provided in box 3-F.

Intelligent networking technologies are also being used to create a wide variety of special purpose communication networks. In the past, one telecommunication network existed to provide universal service to all users. This arrangement was quite suitable, as users' needs were very similar and the services that could be offered were relatively limited. Businesses, for example, used the telephone for voice communication in much the same way as households did.

Today, this is no longer the case.[80] For many businesses, transmitting data now represents a more significant cost item than transmitting voice, and their data traffic is growing at a rate of 40 percent or

[78] See for discussions, David G. Fisher and William Bauer, "Multiplexing With Intelligence,' *Telecommunications*, February 1988, pp. 73-74 and 79; see also Marcel E. Looson, "'he State of the Intelligent Network Art," *Telecommunications*, February 1988, pp. 47,52, and 57.

[79] Gilhooly, op. cit., footnote 37, p. C5.

[80] As Eli Noam has pointed out: "The emergence of technological and operational alternatives undercut the economies of scale and scope once offered by the centralized network. In the past, sharing a standardized solution was more acceptable to users because the consequential loss of choice was limited and outweighed by the benefits of the economies of scale gained. As the significance of telecommunications grew, however, the costs of nonoptimal standardized solutions began to outweigh the benefits of economies of scale, providing the incentivfor nonpublic solutions. Furthermore, someusers began to employ a differentiation of telecommunication services as a business strategy to provide an advantage in their customer's eye. Therefore they affirmatively sought a customized rather than a general communication solution.' Eli M. Noam, "The Future of the Public Network: From the Star to the Matrix,' *Telecommunications*, March 1988, pp. 58-59, 65, and 90.

Box 3-F—The Intelligent Network

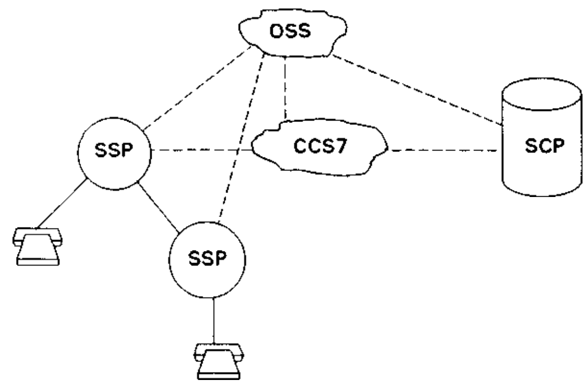
The intelligent network is comprised of four basic elements. These include:

- a *Service Control Point* (SCP), which consists of a centralized database that uses algorithms and customer instructions to route messages;
- a *Common Channel Signaling System (CCS7)* that provides out-of-band, packet-switched communications among network elements;
- a *Service Switching Point* (SSP) that consists of local and tandem-switching nodes designed to carry out low-level, high-volume fictions such as dial tone, announcements, and routing. The SSP performs functions as directed by the SCP; and
- an *Operations Support System (0SS)* that provides for network planning, engineering, provisioning, monitoring, maintenance, and repair.

How these elements relate to one another to provide service can be seen in the figure below.

To envision how this network operates, consider what happens with an 800 call. When an 800 number call is generated, it is sent to the SSP, which identifies its as an 800 call. At this point, the SSP sends the number, together with other information about the calling party, to the SCP via the CCS7 signaling network and asks for further instructions about how to treat the call. The SCP searches its database, translates the received 800 number into a standard telephone number, and returns this telephone number together with a routing instruction to the SSP, which then routes the call to its correct destination.

SOURCE: Paul Bloom and Patrick Miller, "Intelligent Network@, " *Telecommunications,* June 1987, p. 58.



SSP: Service Switching Point
CCS7: Common-Channel Signaling No. 7
SCP: Service Control Point
0SS: Operations-Support Systems

SOURCE: Art reproduced by permission of *Telecommunicstions* magazine.

more. In addition, different kinds of businesses increasingly have different kinds of business needs. Thus, businesses have been quick to take advantage of the unbundling of the communication infrastructure and the availability of a wide range of new, advanced products to develop their own customized communication systems. Banks and other financial institutions have developed specialized communication services such as the Society for Worldwide Interband Financial Telecommunications (SWIFT), while manufacturers have developed their own communication protocols, such as manufacturing automation protocol (MAP). Even 'system integrators are beginning to differentiate themselves by providing specialized networking services.[81]

Specialized networking has also proliferated within the scientific community. The first computer-based message system, ARPANET, was set up in 1968 in the Department of Defense by the Defense Advanced Research Project (DARPA) to provide communication between computer terminals and host computers (see figure 3-4).[82] Today, members of the education and scientific communities are pressing for the development of a more advanced communication network—the National Research Education Network (NREN). Designed to link supercomputer centers, this network would operate at very high speeds, in the gigabit range.[83]

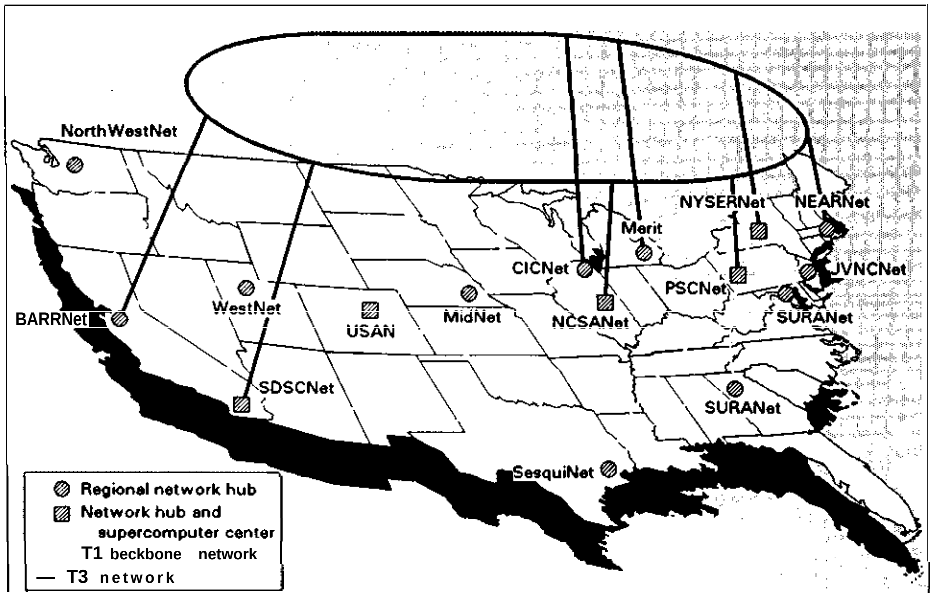
This kind of networking offers a number of benefits. At a minimum it can provide electronic

[81] Kelly Jackson, "The Diversification of System Integration," *Communication Week,* Aug. 28, 1989, pp. 22-24.

[82] Building on the Packet. switched network technology developed by DARPA, other agencies developed specialized networks for their research communities(ESNET, CSNET, and NSFNET). Meanwhile, other research-oriented networks, such as BITNET and USENET, were developed in parallel by academic and industry users who, not being grantees or contractors of Federal agencies, were not served by the agency-sponsored network. John S. Quarterman, *The Matrix: Computer Networks And Conferencing Systems Worldwide* (Bedford, MA: Digital Press, 1990).

[83] For a discussion of the public policy issues raised by NREN, see OTA forthcoming study, "Networking the Nation: The National Research and Education Network," expected publication date, summer 1991.

Figure 3-4--NSFNET



NSFNET is the National Science Foundation's high-speed network to connect mid-level regional computer networks that support scientific research facilities throughout the country. By the end of 1991, all of the backbone sites will be connected to the T3 network.

SOURCE: Merit Network, Inc.

mail and news services. Networks can also provide remote processing, allowing any computer in the network to access computer programs stored on any other host. Network users can also gain remote access to supercomputers to do advanced graphics, chip design (and remote fabrication), and scientific or economic computer simulation, and can access remote databases. In addition, they can use the network to collaborate with others or to participate in computer and/or video conferences. Perhaps the most important attribute of networks is that they can sort out people with similar interests and bring them together. Like the telephone and unlike the telegraph, they tend to reinforce community ties.

Local area networks (LANs), wide area networks (WANs), and-more recently-metropolitan area networks (MANs) are the building blocks of communication networks. LANs are relatively limited in their reach. They generally cover the premises of a building or a campus. Within the business community, the number of LANs deployed has recently grown by leaps and bounds. Predictions are that, in 1992, the number of LANs shipped will reach 5,228,945, and more than half of all PCs will be connected by LANs.

WANs provide long-haul connectivity among separate networks located in different geographic areas. Many businesses are using WANs to extend and restructure their operations on a national or worldwide basis, while at the same time gaining the economies of scale and scope that can be achieved by large-scale, shared networks.

WANs make use of a wide variety of transmission media, which can be provided on a leased or dial-up basis. WANs can also be privately owned. Recently, many businesses have chosen satellite networks, taking advantage of the development of relatively low-cost small aperture terminals to link their various offices to their headquarters facilities. General Motors is planning to build the largest network of this kind. Scheduled for operation in 1992, it will consist of 9,700 very small aperture terminals (VSATs) that will connect GM locations nationwide.

Still in the field testing stage, MANs provide switched data networking services at very high speeds (40 to 50 megabits per second) within a geographic area of at least 50 miles. MANs connect LANs to LANs as well as LANs to WANs. As designed by Bellcore, MANs will provide switched multimegabit data services (SMDS), which will allow users to set up a virtual (or logical) private network, and give them access to individual services on demand. These networks are optimally designed for shared usage (see figure 3-5).

To take advantage of advances in networking, rural areas will-at the very least—need digital switches.[84] Unlike loop technologies, the cost of switching facilities is shared, so digital switching is likely to be available in rural areas long before fiber technology. According to one estimate, the total cost of upgrading rural subscribers to digital central office switches is about $2.5 billion, or $250 per subscriber.[85] This is not beyond the financing capability of the average rural telephone company, even at existing subscriber rate levels. Current REA company total annual cash flow is over $1 billion, and construction spending is also estimated at about $1 billion.[86]

Figure 3-6 gives switching plant characteristics for REA companies. Interestingly, REA companies —while serving proportionately more of their subscribers with old step-by-step mechanical switching technologies—have a higher proportion of lines served with advanced digital technology (45 percent) compared to Bell companies (30 percent) and the 10 largest independents (61 percent). This has important implications for network upgrade decisions. On average, Step-by-Step switches are much older than the stored program control IAESS and cross-bar electromechanical switches that serve many Bell access lines and therefore closer to economic retirement. Thus, small companies may have an advantage over large telephone companies who must consider the financial effects of early retirements of their embedded base of electromechanical analog and electromechanical switching plant.

The per-subscriber costs of digital switching are also likely to fall as the technology advances and is used more efficiently. For example, the development of remote digital switching modules (called Transfer Switching Points in the context of the Intelligent Network Architecture) now permits carriers to use fewer expensive host switches to provide advanced intelligent services such as access to 800 number databases. The cost savings can be substantial. One host switch, such as the AT&T 5ESS, costs approximately $510 million, whereas a remote switching module will cost between $600,000 to $700,000.

Implications and Opportunities for Rural Areas

Technology Requirements and the Pace of Technology Deployment

In an information-based economy, communication needs are relative. In evaluating a rural community's technological requirements, therefore, it is necessary to look not only at a community's own economic activities, but also at its economic aspirations and, increasingly, at the activities of its competitors, whether they be businesses in urban areas or in other countries.

Rural areas will be unable to compete if the pace of technology deployment lags greatly behind that in other areas. All indicators suggest, however, that this will be the case. The history of the telephone, for one, points to such an outcome: first came major trunks linking Northeastern cities, followed by lines to smaller towns in their immediate hinterlands, then connections to major Midwestern cities, and so forth-a sequence of connecting ever lower order cities. Thus, although patented in 1876, it took 12 years for the telephone to reach Chicago, and transcontinental service was not inaugurated until

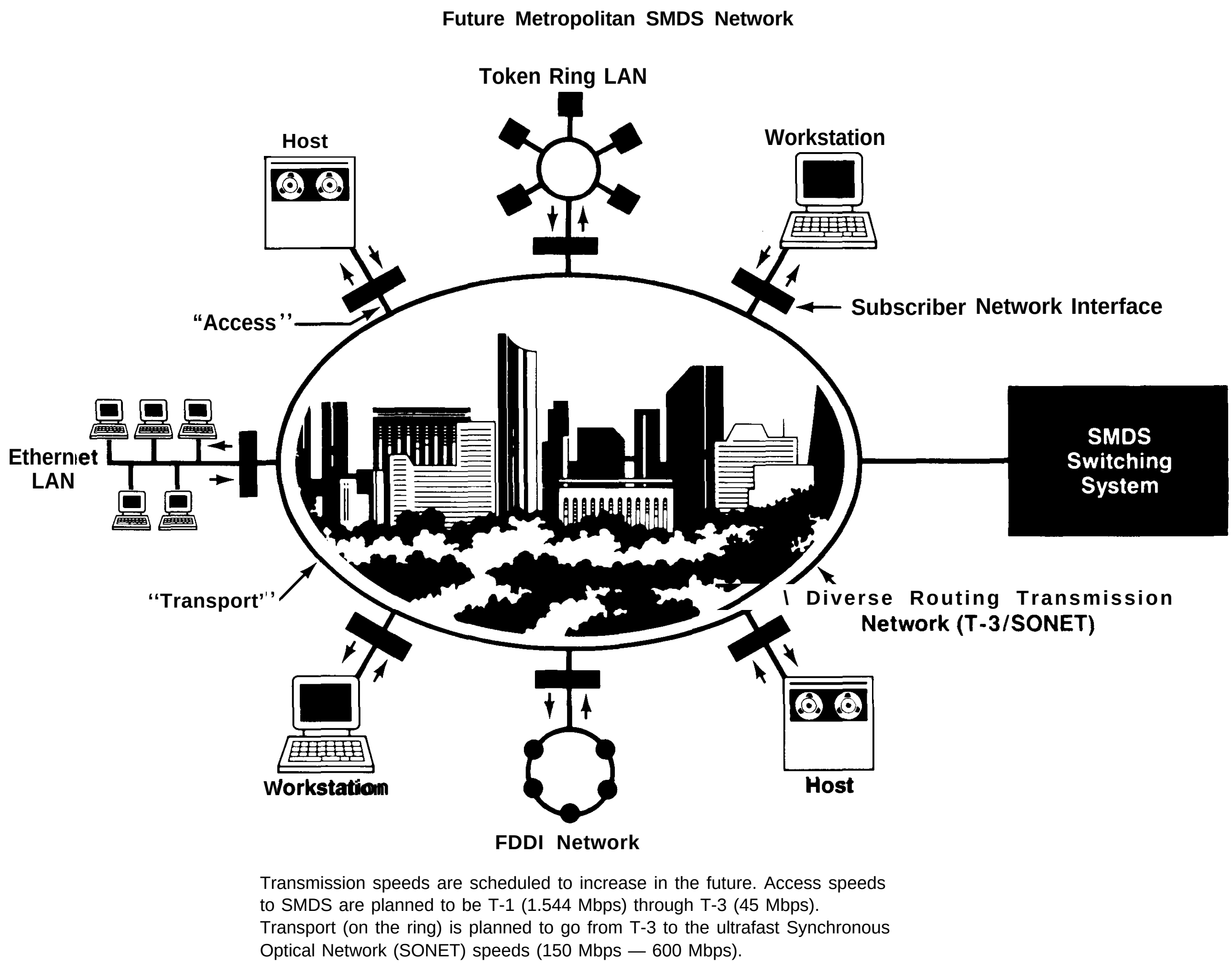
[84] Digital switches can provide users with an array Of call-management capabilities including call waiting, call forwarding, and three-way calling, as well as newer services including caller identification, call trace, distinctive ring, call block, call return, and preferred call forwarding. Analog switches can be upgraded to perform some, but not all, of the call management functions that are possible with digital switches.

It should be noted that both analog and digital switches can provide touch-tone service. Touch-tone service enables the caller to conduct telephone transactions with automated answering systems. These transactions range from banking to placing calls with a calling card, to obtaining prerecorded tax information from the Internal Revenue Service.

[85] Egan, op. cit., footnote 28. This estimate assumes 20 million rural subscribers with half already served by digital central office switches. A recent study of switching upgrade costs for rural loops for U.S. West estimated average per subscriber digital upgrades at $300 to $500 per subscriber in one State and $180 in another. This report also suggests that a reasonable near-term target is as low as $150 per subscriber. See Juli Molina and E. Reed Turnquist, "Rural Network Modernization in U.S. West," draft, July 25 1989.

[86] Egan, op. cit., footnote 28, pp. 40-41.

Figure 3-5-LANs and MANs



SOURCE: Courtesy of Southwestern Bell Telephone.

1915.[87] As a result, favorably situated businesses in the Northeast enjoyed a headstart of several decades in utilizing regional and interregional telephony.[88]

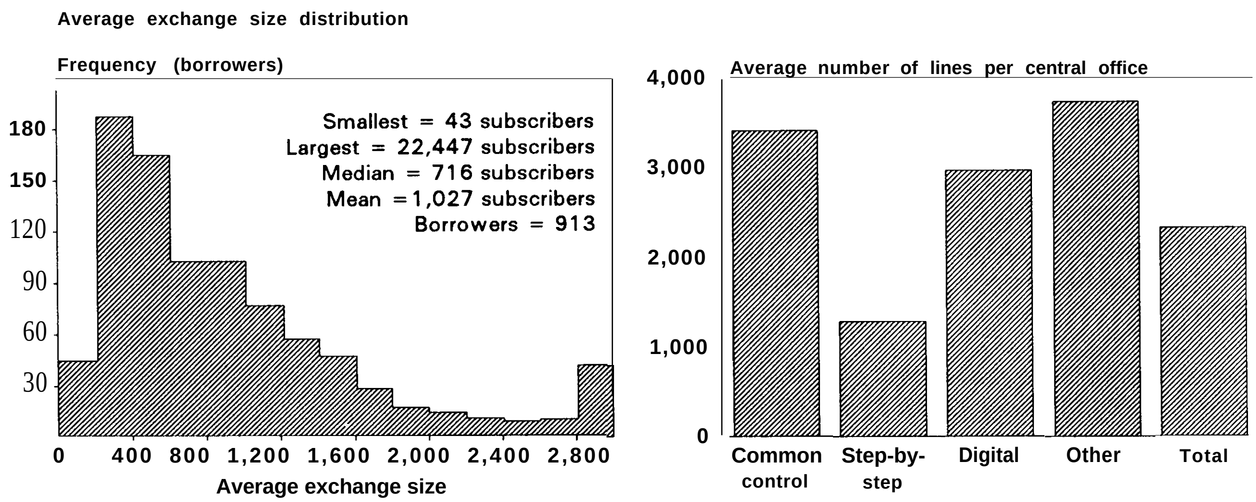
With deregulation and a highly competitive industry environment, it is unlikely that the deployment of new, information-age technologies will deviate greatly from this earlier pattern. One recent analysis suggests that, assuming a cost of $1,000 per subscriber, narrowband digital service can be delivered to rural areas within a 10- to 20-year timeframe. Broadband capabilities could be delivered to business subscribers within 2 to 10 years, at a cost of $5,000 per subscriber. It would take 10 to 20 years for residential users to receive broadband services, assuming the same per-subscriber costs.[89]

87 Kielbowicz, op. cit., footnote 2. Of course, many communities outside the Northeast developed their own local and regional systems, but for the most part they were not effectively integrated into the larger network.

88 In the case of the telegraph, it took 17 years to link both coasts. Richard DuBoff describes the problems of the small town user: "In concrete terms, telegraph users in smaller towns often found that the lines were tied up by heavy volumes of messages traveling between and within major cities. . . In 1848, an important business reply sent from Troy, New York, to Rochester took more than 24 hours to be transmitted to Roehester, 'solely because the [Troy] operator could not get his turn at the wires.' ..Incidents like this one appear to have been common, and they persisted into the era of improved instrument technology after 1870." DuBoff, op. cit., footnote 5, pp. 269-270.

89 Egan, op. Cit., footnote 28.

Figure 3-6-REA Central Office Switching Characteristics



The figure on the left shows the distribution of the exchange sizes of the 900 independent telephone companies that borrow from REA. Nearly one-third of these providers operates small exchanges, serving between 200 and 600 subscribers. The figure on the right shows the average number of lines that each type of central office supports for the REA borrowers.

SOURCE: Rural Electrification Administration.

There is considerable disagreement as to whether such a deployment schedule can meet the needs of rural areas. For example, many regulators and vendors do not view rural needs in relative terms. Instead, they look at needs in the present, evaluating them on an individual user, service-by-service basis. Accordingly, they contend that the needs of most rural businesses can be met given the evolutional deployment of technology. From their point of view, efforts to modernize the infrastructure should focus on immediate problems such as assuring that all parties have access to single-party lines, digital switching facilities, and touch-tone dialing.

There are others, however, who believe this assessment to be overly conservative. Citing the growing capacity requirements needed to support functions such as office automation with multifunction workstations, computer/aided design/computer aided manufacturing (CAD/CAM), and high-speed distributed data processing, they predict that rural businesses, if they are to be competitive, will need broadband capabilities within a much shorter timeframe.

This debate is not likely to be easily resolved. At present, there is not even a consensus about what capabilities large business users will need, and within what timeframe.[90] Trade-offs can be made between software capabilities and transmission capabilities. For example, with advances in compression technology less transmission capacity will be required. However, if new applications multiply faster than the advances in compression technologies (as might be the case, for example, with supercomputing and multimedia technologies) bandwidth requirements will be greater. Past estimates of future needs have been overly conservative, and vendors have been slow to anticipate future demand. Up until now at least, users have generally found ways to make full use of the bandwidth available to them.[91]

[90]For a discussion of the debate about broadband, see Martin C.J. Elton, "Integrated Broadband Networks: Balancing the Risks," Columbia University, Center for Telecommunications, 1989.

[91]As industry observer Tom Valovic has noted, "Current applications should not be used as a yardstick for future bandwidth requirements. Otherwise, it's another variation of the 'chicken/egg' question" the transmission people won't build the capacity unless the applications are thereto justify them, and the applications people won't develop new ones because the transmission capacity isn't available. The real truth of the so-called bandwidth argument lies in something called Deboever's Axiom: 'Data will expand to fill the bandwidth available'." Tom Valovic, "T1, T3, and the Never-Ending Bandwidth Argument," *Telecommunications*, December 1988, p. 6.

New Ways **of** Configuring Rural Networks

Together, the trends towards unbundling and decentralized intelligence will allow rural communities to have greater choice about, and control over, the configuration of their communication infrastructure. This is an important advantage since communication technologies define communities .92 By multiplying and intensifying contacts among people, some communication technologies tend to reinforce local, geographically based communities while others do not.[93]

Having more choice and control over their communication infrastructures is even more important as rural communities seek to use technology to compete more effectively with urban areas for businesses and jobs. It is not enough to improve the overall performance/cost ratio of communication technologies. Since it takes longer to deploy technology in rural than in urban areas, technological advances that affect everyone equally are likely to make rural areas worse off. What rural areas need to actually improve their situations are technologies or technical capabilities that can reduce the urban advantage. Thus, they will need to think about their communication systems less in terms of urban models and more with reference to the specific set of conditions found in rural areas.

One way of reducing the urban advantage is to deploy technologies, such as digital radio and satellite, where costs are relatively insensitive to distance. Another is to finding new ways to achieve economies of scale and scope. The trends towards the convergence of media and developments in networking provide rural communities a number of new opportunities in this regard.

The convergence of communication functions, media, and products and services will permit communication providers to spread their costs more widely, and thus to reduce the price that users must pay for service. With the deployment of advanced digital switches and fiber optics, for example, communication providers will be able to integrate services, transmitting two-way voice, data, and video on a joint basis. This prospect has particular relevance in rural areas, where the cost of providing any one of these services alone can be prohibitive.[%]

New economies can also be generated through networking. As noted above, networking allows like-minded people not only to communicate with one another, but also to share common resources. In so doing, they can benefit from significant economies of scale and scope. This kind of networking could be especially fruitful in rural settings, where people and facilities are few and far between.

Just as businesses are taking advantages of these developments to create their own customized networks, so too might rural communities. However, whereas many business networks are established along functional lines, Rural Area Networks (RANs) would be configured, instead, around the geographic boundaries and needs of an entire community. Designed on the basis of a ring, or campus type, architecture, a RAN would link up as many users within a community as possible-including among them businesses, educational institutions, health providers, and local government offices (see figure 3-7). Rural Area Networks could be linked statewide, perhaps by piggybacking on the State government and/or the State educational network.

Rural Area Networks have a number of advantages:

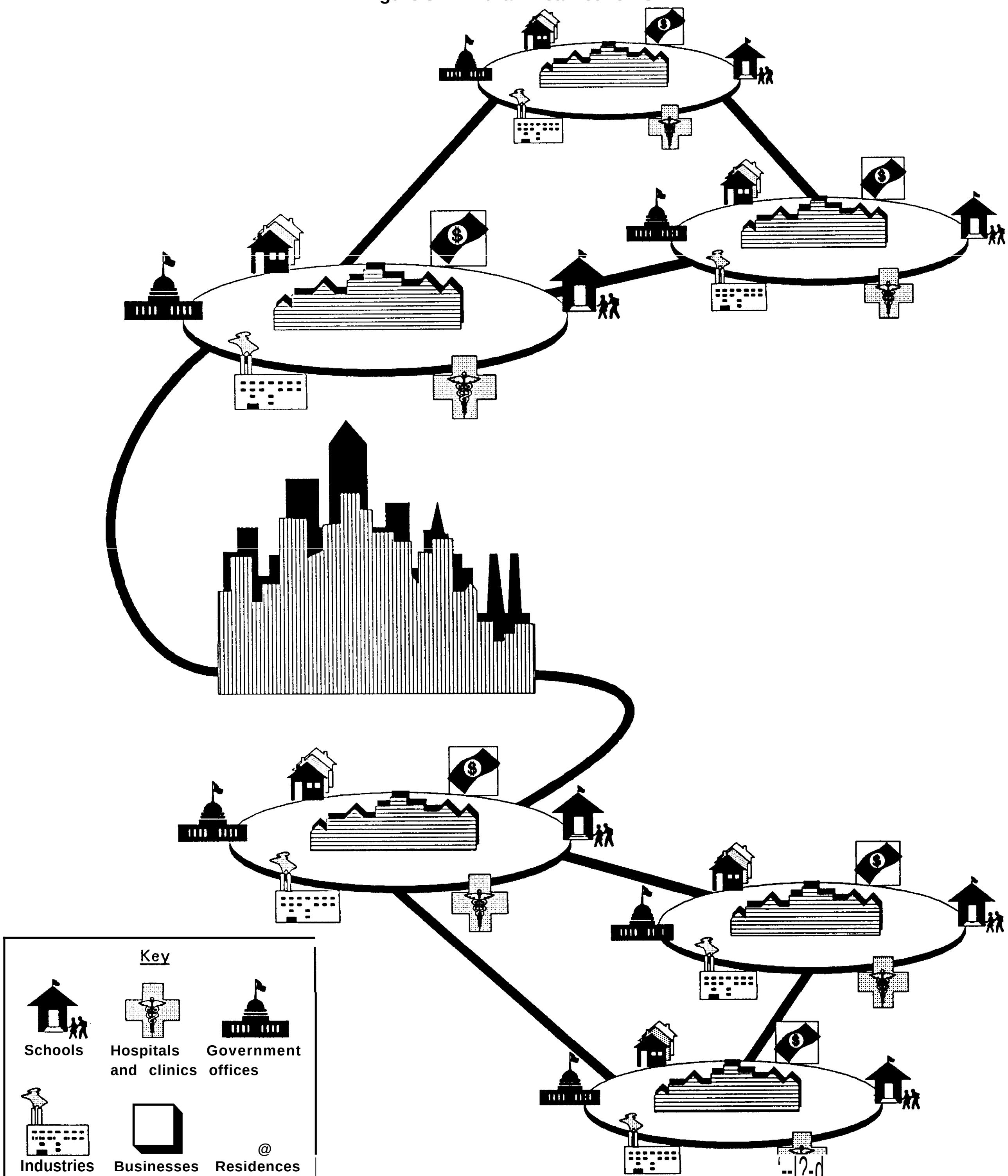
- RANs would foster the deployment of advanced technology to rural areas in an economically viable manner. By pooling diverse users, they would provide considerable economies of scale and scope.
- Built to meet shared needs, they could foster cooperation and community ties.

92As John Dewey has pointed out, communities are defined and reinforced by their communication systems According to Dewey, "Society not only continues to exist by transmission, but it may fairly be said to exist in communication. There is more than a verbal tie between the words common, community, and communication. Men live in a community by virtue of the things they have in common; and communication is the way in which they come to possess things in common. " John Dewey, *Democracy and Education (New* York, NY: Macmillan Co., 1915).

93For a discussion, see Kielbowicz, op. cit., footnote 2.

94Present rules and regulations limit the extent to which carriers and service providers can take advantage of this opportunity. To prevent regulated telephone companies from engaging in an anticompetitive behavior, the Modified Final Judgment, which gave rise to divestiture and the break up of the Bell System, forbids them from providing ".. any product or service that is not a natural monopoly service actually regulated by tariff." State regulations, which preclude intraLATA competition, also serve to constrain the extent to which communi cation providers can take advantage of new technologies to create additional economies of scale and scope. These regulatory issues are discussed in some detail below, in ch. 5.

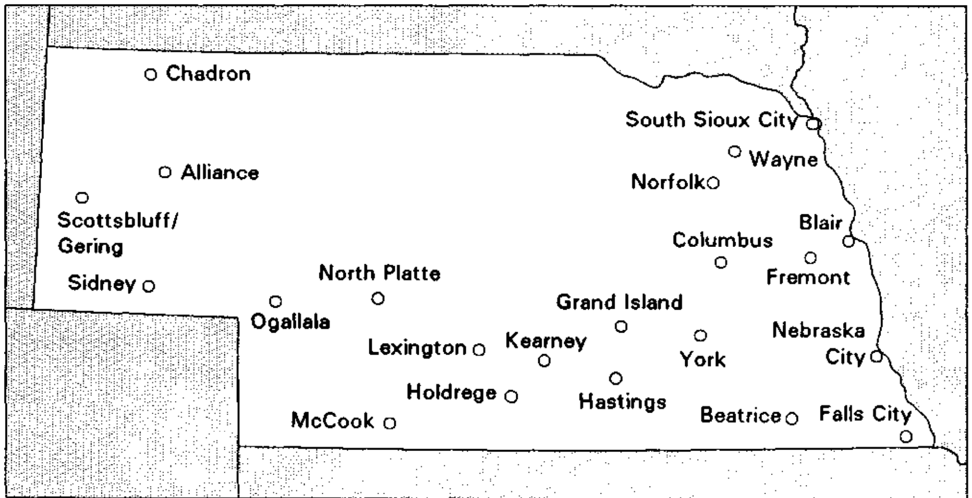
Figure 3-7—Rural Area Networks



A Rural Area Network would be designed to foster the deplovment of advanced technology to rural areas In an economically viable manner by pooling the communication needs of a community's many users—especially the businesses, educational institutions, health providers, and local government offices.

SOURCE: Office of Technology Assessment, 1991.

Figure 3-8-Nucleus City for Nebraska



It will be economically infeasible for many rural communities to keep pace with the modernization of telecommunications, and as a consequence many rural citizens will be further disadvantaged in securing fundamental services such as health and education. It will therefore be necessary to identify ways to give rural people and businesses access to these critical information highways and the services they will support and deliver. According to this model of nucleus townships, small rural communities will be most effectively served by concentrating on upgrading the telecommunications services of certain towns and small cities that will "function as hubs for the surrounding immunities."

SOURCE: Sufi Nazem, University of Nebraska, "Telecommunications and Economic Development in Rural America: A Case for Nebraska," contractor report prepared for the Office of Technology Assessment, December 1990.

- RANs would overcome the limitations of technological expertise in rural areas since they could be designed by one systems integrator.
- *RANs would induce* communication providers to be more responsive to the communication needs of rural communities. By joining forces, rural users will be able to exert greater leverage in the marketplace.

The ways of configuring rural networks are as diverse as rural America itself. Experimentation is in order. Sufi Nazem, for example, proposed the idea of creating nucleus cities, or hubs, throughout the State of Nebraska, each of which could serve communities within a 30- to 40-mile radius (see figure 3-8). As he points out, while "it is inconceivable that all small communities in Nebraska could be connected by the costly network any time soon, it is not. . . inconceivable to install a high technology network for approximately twenty-two townships. ' '[95]

The Maine Research and Productivity Center, in Presque Isle, already serves as such a hub for small businesses in the surrounding area.[96] Among the services that the Center provides are access to comprehensive information services as well as a shared CAD/CAM system. According to William Forbes, the Center's Executive Director, some small business owners and operators travel 50 miles to use the jointly owned CAD/CAM system, which would be much too costly to purchase on an individual basis. Because the Center is linked by a fiber network to the Canadian research facility in Fredericton, New Brunswick, it can also provide local businesses access to the services of this prestigious, multimillion-dollar institution.

Bloomsburg, a business center in rural Pennsylvania, has also taken a proactive role in assuring that its communication infrastructure can meet present-day business needs. Reassessing its communication

[95] Sufi M. Nazem, "Telecommunications Policy and Rural Economic Development," University of Nebraska at Omaha, International Center for Telecommunications Management, nd.

[96] The Maine Research and Productivity Center is a nonprofit corporation located on the campus of the University of Maine at Presque Isle. Separate from the University system, it is funded primarily by the Maine Science and Technology Commission. Its primary task is to provide technical assistance to Maine industry on a fee basis.

infrastructure in the light of its changing economy, the town concluded that "Bloomsburg is in the position of being a telecommunication 'island' without an effective bridge to the outside. "[97] Although businesses and institutions within Bloomsburg can obtain services such as local loop T1 circuits for high-speed data, voice, and compressed video applications, the town concluded that ''connections between Bloomsburg and the rest of the world are not economical. ' To address this problem, it developed-together with the Ben Franklin Partnership and Bloomsburg University-a plan to construct and operate a high-capacity, digital 'highway' to Harrisburg, the location of access points to all long distance telecommunication providers. This will be a 45 megabit per second digital microwave link with the capability of providing a broad range of telecommunication transmission services such as high-speed data, high-resolution graphics, compressed motion video, etc. Operated as a private carrier, it will resell capacity to users within Bloomsburg, providing them with gateway access for voice, video, and data communication services. The total cost of implementing the network including design and licensing, network construction, local infrastructure enhancements, and project administration) is estimated at $800,000. The town considers this price to be modest when weighed against the potential long-term economic benefits. Once in place, the network would provide a broad range of public as well as private communication services. For example, some capacity will be used to provide a two-way digital video and data link between Bloomsburg University and the Harrisburg University Center.

Creatively sharing communication and information systems and services can, of course, also be done in a smaller community, or on a much more modest scale. In many small rural Scandinavian towns, for example, a number of telecottages have been established to help local residents prepare for, and access the benefits of, the information age. Among the kind of services provided are:

- information services,
- data-processing services,
- information technology consultancy,
- distance working facilities,
- training and Education,
- telecommunication facilities, and
- village Hall facilities.[98]

In some locales, these telecottages-although they were originally set up using outside funds—operate on a self-sustaining basis. In other places and communities, they continue to be subsidized.

Where an adequate communication infrastructure already exists, it is sometimes possible to piggyback new services on it at very little cost. For example, when two professors at the University of Kentucky, Louisville, wanted to link the small private colleges in the Appalachian region of Kentucky up to the nationwide university research network, BITNET, an agreement was reached allowing these two faculty members to transmit BITNET via a portion of the television network's vertical blanking intervals. The costs to the university were minimal[99] (see figure 3-9—for other sharing schemes).

Changing User Requirements

While the unbundling of communication technologies and services now permits rural businesses and communities to design and deploy communication systems to meet their own particular situations and needs, it also places on them the burden of doing so. These are by no means easy tasks. Nor does the average rural businessperson have the requisite experience, skills, and resources to successfully undertake them.

Under the old Bell System, few were required, or even inclined, to explore their service options. Thus, today, many are unprepared to sort out the myriad of options available to them in an industry environment driven by rapid technological change. Taking the time out from routine business operations to come to terms with information age technologies is also difficult. Most rural businesses are quite small: job responsibilities are not specialized enough so that any one person could devote much time to becoming a communication expert. As one rural businessman reported to the OTA project staff:

> . . . I run my business on a shoestring. I supervise operations; keep the books; and even sweep the

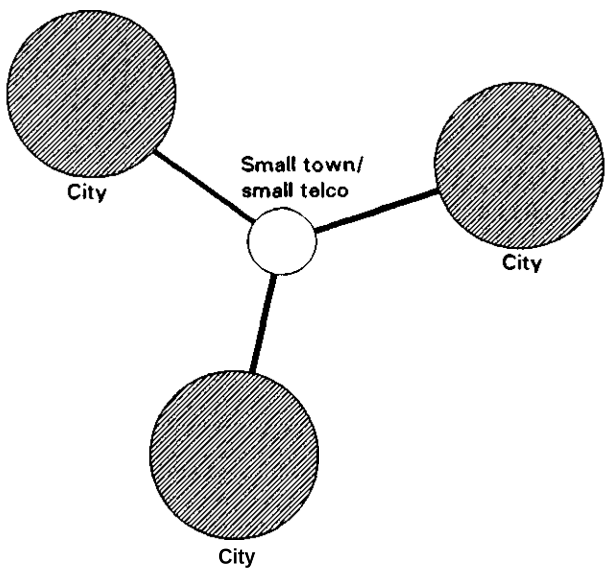
[97] See Dovetail Systems Corp., ''Telecommunications Opportunities for Bloomsburg,'' June 15, 1989.

[98] Lars Qvortrup, "The Nordic Telecottages: Community Teleservice Centers for Rural Regions," *Telecommunications Policy*, March 1989, pp. 59-68. See also, H. Albrechtsem, "The Telecottages in the Nordic Countries," *Telecommunications Journal*, vol. 55, pp. 298.

[99] Conversations with Professors Ken Kubota and Paul Eakin, Department of Computer Science, University of Kentucky.

Figure 3-9-Sharing Schemes

Centrality Strategy



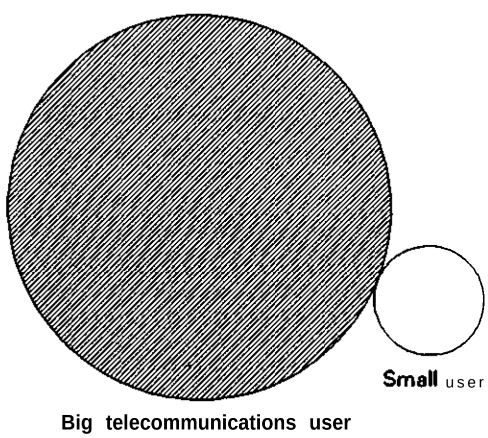
Centrality Strategy

ENMR Telephone Cooperative is an excellent example of how rural areas can capitalize on the flow of telecommunications between metropolitan areas by acting as a switching point.

Though serving a remote and sparsely populated region of eastern New Mexico, ENMR benefits from its location between major metropolitan areas. As an important switching point between these cities, ENMR is able to attain advanced technologies for its customers, such as Signaling System 7 capabilities.

According to ENMR's General Manager, the company's technological sophistication "has been aided by the fact that our inoperative serves as a 'golden highway,' routing calls among such cities as Denver, Albuquerque, Dallas, Lubbock, and Amarillo."

Piggyback Strategy



Piggyback Strategy

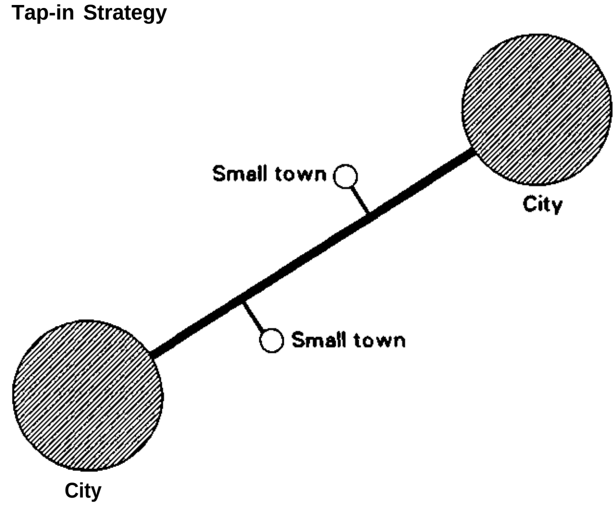
Because telecommmunications networks of many large corporations often extend to remote rural areas, one sharing strategy is to resell the excess capacity of the private networks to these rural communities, whose telecommunications needs are likely to be relatively small.

As an example of this strategy, EMRG, a software company in Kearney, NE, which depends heavily on telecommications, uses the excess capacity of the POP (point of presence, or telecommunications' equivalent to an on/off ramp) installed on the premises of Cabela's, the large sportswear retailer.

Tap-in Strategy

In the last few years, the competing long-distance carriers have rapidly modernized their networks and have installed high-capacity fiber optic lines connecting the major metropolitan areas. These lines by necessity crisscross "the land between the cities," and many rural regions of the United States are "hookable" into these networks with comparatively little cost.

Tap-in Strategy



SOURCE: Harmeet Sawhney, University of Texas at Austin, contractor material prepared for the Office of Technology Assessment, January 1991.

floor. When would I ever have time to learn about how to use communication strategically?

Nor are there many people to whom rural businesses can turn for help. In a competitive environment, many communication vendors are focusing their energies on the needs of the much more lucrative large business user. And among those who have typically supported rural businesses in the past-e. g., the agricultural extension agent, the economic development official, or the local chamber of commerce-few are even cognizant of the business opportunities that new technologies afford. Thus, it is not surprising that in most of the instances when a rural business, or a rural business community, has been successful in deploying new technology effectively, there has generally been a highly knowledgeable, energetic, and visionary individual involved.