PRIVATE NETWORKS PUBLIC OBJECTIVES
E. Noam and A. NíShúilleabháin (Editors)

History and Recent Developments

Private Telecommunications Networks: An Historical Perspective

David Gabel

1. INTRODUCTION

Joseph Schumpeter has argued that the life-span of monopolies were limited by the "creative destruction" forces of capitalism. For a period of time, a firm may be able to dominate an industry and earn monopoly profits. As other firms become aware of these profit opportunities, they are attracted to the industry. Through the process of innovation, the entrant may displace the first dominant firm and earn monopoly profits. In turn, the second dominant firm's high earnings will attract rivals to the industry.[1]

This mode of analysis has been used to explain the centrifugal forces operating in the telecommunications industry. In U.S. v. AT&T[2], the defendant argued that, due to the regulatory objectives of promoting universal service, the prices for some business communications services had been kept above the economic cost-of-service. High prices were set for business customers in order to provide a subsidy to residential customers.[3] According to AT&T, private telecommunications networks, as well as specialized common carriers, established service because of these regulatory distortions. If Bell had been free to establish subsidy-free rates, the firm believed that it could have continued to serve the entire telecommunications market at a lower cost than in its currently fragmented form.[4]

Eli Noam has argued that the same forces are currently pulling apart the network. In his paper on the "Tragedy of the Commons," he shows how subsidies can drive business customers off the common network. In order to avoid burdensome subsidies, large business customers have an incentive to establish private networks.[5] Noam's results are driven by the assumption of a U shaped cost curve and declining marginal utility.[6] Using this framework, Noam argues that because of subsidies, the initial customers of the network will eventually leave the network and form a second, or additional networks. They leave the first network because the marginal benefit of adding on marginal customers is less than the marginal cost. This results in a reduction of the welfare of the initial network customers and they are therefore better off establishing their own network. If not for the subsidies following from the initial customers to the customers who later join the network, there would be no need to establish this second network. The decision to establish a second network is "The Tragedy of the Common Network." If the network did not expand beyond the size where marginal private benefit equaled marginal private cost, there would be no incentive to form the second network. In his "Tragedy of the Commons" paper, Noam treats customers as a homogeneous body.[7] Noam has also addressed the development of private networks in a second paper, "The Public Telecommunications Network: A Concept in Transition."[8] In that paper he argued that it was the diverse demands of the service economy that made it impossible to

sustain a monopoly, public network. Private networks were formed because they provide the type of diversity that could not be provided through the traditional PTT complex.

The presentation made by Noam in the "Transition" paper was more compelling, and I argue below, more accurately reflects the forces that currently and historically have pulled apart the public network. The emergence of new networks has less to do with subsidies than it does with changes in the macro economy, the organizational structure of firms, and the ability of the incumbent telecommunications firms to install new technology that meets the needs of large users.

As the starting point for this paper, I review the formation of some of the nation's first alternative private networks. These networks were largely perceived by information intensive sectors of the economy as a superior means for transferring information between business units. The private networks provided a superior mode of communications for large businesses, and played a large role in the demise of Western Union. I show that the substitution of private networks for the public telegraph system of Western Union fits within Schumpeter's vision that an innovative entrant would constrain the long-term earning power of a monopolist, such as Western Union. In section three, I provide data on the size of the private line market prior to the divestiture of AT&T, as well as on the market shares of the competitive suppliers. In section four of the paper, I review some of the factors which led to the formation of private networks during the post-World War II era. Finally, in section five, I offer some propositions regarding the formation and demise of networks.

2. TELEGRAPH SERVICES AND THE EMERGENCE OF THE MULTI-UNIT FIRM

The expansive territorial span of the United States was an initial barrier to the development of large scale industrial enterprises in the United States. While the nation's population was growing rapidly during the first half of the nineteenth century, its dispersion over a wide territory limited the ability of firms to engage in large scale manufacturing. Costly transportation and communication technologies made it expensive for a firm to exploit the economies of scale available in existing manufacturing technologies. A necessary condition for the growth of large scale manufacturing was the development of technologies that lowered the cost of serving multiple markets.[9] In the two decades prior to the Civil War, three key technologies, canals, railroads and the telegraph, played a role in the take-off of the economy. The canals and railroads lowered transportation costs and increased the nation's access to coal, an inexpensive energy source.[10] Paralleling many of the nation's railroads was the nation's first high-speed information network, the telegraph. The telegraph improved the ability of firms to coordinate marketing and production activities in different localities, helped tie together the nation's banking and financial markets, and provided instant access to price information on the nation's commodity markets.[11]

In 1876 coordination of market activities was further enhanced by the invention of the telephone. Initially though, the impact on the nation was limited; business customers perceived few uses for Alexander Graham Bell's invention. The telephone was initially perceived as a poor substitute for the telegraph because it did not offer a written record for commercial transactions. Few saw how it could be used to coordinate market activities or for social purposes.[12] The lack of vision by the first managers and subscribers can be partly attributed to the limitations of the technology. Until the first switchboard was installed in 1878, telephony was conducted on a point to point basis (mesh network). Typically

customers ordered connections between their homes and businesses or between an office and a factory; it was hard to envision how universal coverage would be achieved.[13]

The development of the switchboard in 1878 radically changed the prospects of the industry. The deployment of the switchboard lowered the cost of service because the star topology reduced the amount of wire that was need for connecting subscribers and increased the possibility of sharing supporting structures, such as pole brackets. Furthermore, switchboards radically expanded the number of customers that could be reached. No longer were customers limited to calling customers with whom they had a direct connection. The increased calling area increased the value of service and this, in turn, stimulated demand.[14]

The public rapidly accepted the telephone. According to the Bureau of the Census, "By 1899 telephony...not only had surpassed telegraphy in physical and financial magnitude, but by its very growth had seriously restricted the expansion of" telegraphy.[15] The telephone gained almost complete control of the local telecommunications market. It was the preferred mode of communication within cities because it was more rapid, and less expensive. The telegraph operated at a cost disadvantage because of the need to use Morse telegraph operators on either end of the circuit. Telephony was less labor intensive, and consequently quickly became the dominant telecommunications technology for intra-city traffic.[16]

Telephony also quickly dominated the long-distance market. By 1902 there were 120,704,844 long-distance telephone messages, nearly thirty million more than the number of telegraph messages. Only when a written record was required, or a long-distance communication for which the cost of telephony exceeded that of telegraphy, did the older technology sustain a competitive edge.[17] The nation's leading long-distance telephone company, AT&T, did not limit its services to telephony. As early as 1879, Bell was marketing private line telegraph service, in competition with Western Union, to the nation's largest industrial, banking, and financial firms.[18] Before the invention of the telephone, large users of the telegraph network requested and obtained private line service.[19] Private line telegraph service was primarily used by four classes of customers: railroads, the press, industrial customers, and the financial community. The bankers and brokers were the largest customer group; in 1912 they accounted for 80 per cent of the private line business.[20] The private wire business was concentrated in the Northeast and Mid-West,[21] the regions of the nation with the greatest industrial and commercial development.

According to the Interstate Commerce Commission, the largest private network was leased to a banking and brokerage house. The system connected New York to important regional centers in both the United States and Canada:

> [The private-wire network] leased by a banking and brokerage house, operated four circuits from New York, N.Y. via four different routes to Chicago, Ill,, and one circuit thence through Salt Lake City, Utah, to San Francisco, Cal. At Salt Lake City there were connected a circuit running through Butte, Mont. and Seattle, Wash., to Vancouver, British Columbia. Another part of this same system extended from Chicago north St. Paul, Minn. to Winnipeg, Manitoba, and south through Memphis, Tenn., to New Orleans, La. There were numerous short wires connecting with the circuits above described, and a large number of terminal and intermediate drops.[22]

The bankers and brokers used the service primarily for exchange trading. When the wire was not being used for this purpose, market and other types of news was transmitted. Some private line networks were just used to transmit information. The familiar stock ticker and paper tape was used to widely distribute information on the volume of trading and the price of the transactions. One of the larger private networks was owned and operated by the New York Stock Exchange. The network had about one thousand ticker machines in operation, and according to the Bureau of Census, "[t]his system sent out over the tape nearly thirteen million separate impressions in 1901-2, and over seventy-five thousand on some days while it required about fifty tons of paper to keep the tickers supplied with reels of narrow tape."[23]

Industrial firms used the private lines mainly for coordinating activity between the different branches of the multi-unit firm.[24] As with the bankers, the industrialists believed that a private line provided benefits that were not available on the public network. Their networks provided extra privacy, something both parties desired in order to protect trade secrets. The Interstate Commerce Commission pointed out in 1918 that the superior quality of a private network was also of crucial importance to industrial firms:

> It is said that the matter transmitted over some industrial wires is of so technical a nature that the accuracy of service over the public wires can not be depended upon. Telegraphic discussions of chemical formulae and artistic designs are instances cited as possible over private wires, but impossible, at least in the view of the [industrialists], over public wires. Abolishment of private wires would make it necessary to conduct such discussion by mail, it is said.[25]

Other advantages of private wires included: higher quality and transmission speeds, as well as the carriers' commitment to restore service first on private lines on which there was an outage due to down lines. In order to obtain the best personnel, The lessees of private lines hired highly skilled telegraph operators. These operators received a premium which was up to fifty-percent higher than the wage paid to the less-skilled operators on the public telegraph network. It was because of the superior service, rather than cost savings, that most customers obtained the private line service.[26] Private lines were used by the "wire services" to distribute news stories and market quotations to the thousands of newspapers around the nation.[27] The railroads obtained private line service through the construction of stand-alone systems. The rail lines needed a network that could be used to coordinate the flow of traffic throughout the nation. Information was transferred along the lines to insure that trains were safely spaced apart, to convey arrival and departure times, and to coordinate the shipment of freight.

The telegraph companies found it costly to provide the high-grade of service needed in the railroad business. Postal Telegraph, the nation's second largest telegraph company, decided that because the service requirements of the railroads was "too exacting," to not serve them. The other large carrier, Western Union, did not operate lines in all of the rural areas covered by the rail system. Since the services available from the public telegraph companies was limited in quality and geographical coverage, the railroads decided to build their own private networks.[28]

While private line networks were used to provide both telephone and telegraph services, the latter service was far more common.[29] AT&T only marketed its private line telegraph

service to large users. Providing telegraph service to the public would have required the firm to hire workers for coding and decoding messages, as well as delivering messages. AT&T chose to only sell its telegraph service to customers with sufficiently large needs that they could afford to hire their own telegraph operators. While initially the market for this service was limited, the refinement of the telegraph printer around 1910 made the service more widely available.[30]

There were no technological barriers that hindered AT&T's provision of telegraph service. The same transmission lines used for switched message calls could be employed for telegraph service. Because of the similarity in transmission technologies, AT&T had some concern that Western Union would retaliate and enter the toll telephone business. Since, within city limits, the telegraph lines were not as ubiquitous as telephone lines, the threat would have been expensive to carry out. Absent the construction of its own telephone exchanges, Western Union would have had to ally itself with the Independent telephone companies that were competing with AT&T. While Western Union threatened to reciprocate and provide private line toll telephone service, the threat did not deter AT&T from expanding its offerings of private line telegraph services.[31] The competition between Western Union and AT&T for telegraph service illustrates three important concepts regarding private and public networks: the role of subsidies, technological innovation, and network design.

The first private networks were established to satisfy the customers desires for better service (speed, accuracy, privacy, and access to remote locations), rather than in response to regulatory distortions (the telegraph industry was not regulated during these years). It was inefficient for the public network to be designed to meet the more demanding needs of large users. The uses made of private networks by the financial community, newspapers, and manufacturers, illustrate that the rapid growth of private networks prior to the Great Depression was not a "Tragedy." Instead, private networks were an economically efficient response to the needs of the information intensive sectors of the economy.

Second, consistent with the Schumpeterian theory of transient dominance, new technologies eroded the power of the dominant firm, Western Union. The telephone company was able to exploit economies of scope between telephone and telegraph service, and this provided them with some cost advantages. As early as 1910, Bell was fond of pointing out that if telephone and telegraph communication was provided over the same trunk facilities, "one telephone circuit of two wires" could also be used to provide "at least four telegraph circuits." By user intercity facilities for both voice and messages, Bell believed that significant cost savings were realized.[32]

Third, AT&T was able to quickly capture the local message market because telephone facilities were more ubiquitous within a city. Western Union could not compete in AT&T's market until it changed the way its facilities were designed. Instead of locating operator facilities at one or only a few locations in a city, Western Union would have had to spread its operations throughout the town. This would have been an expensive course to pursue.

3. FACILITIES USED FOR PRIVATE NETWORKS

The relative importance of private line telegraph service varied accross firms. For the nation's two largest telephone companies, Western Union and Postal Telegraph and Cable, private line systems provided less than ten percent of their revenues. By as early as 1914, AT&T, which had somewhat of a cost advantage because of economies of scope with

telephone service, had captured a majority of the private wire telegraph business. Tables One and Two show the mileage and revenues controlled by the three largest suppliers of private Morse telegraph service.

Morse-service mileage: 1914[33]
Table One

	in private wire service	in public wire service	totals	percent private wire
Western Union	47,969	926,504	972,473	4.93%
Postal	17,283	245,695	262,978	6.57%
Bell Company	140,477	500,000	640,477	21.93%
total	205,729	1,672,199	1,877,928	10.96%

Sources: Federal Communications Commission, *The Investigation of the Telephone Industry*, 1939, p.129 and *Statistics of Communication's Common Carriers*, Federal Commission's annual report.

Morse-service annual revenues: 1914[34]
Table Two

	private wire service	public wire service	totals	percent private wire
Western Union	$1,084,837	38,640,009	39,724,847	2.73%
Postal	626,034	7,851,769	8,477,804	7.38%
Bell Company	2,218,638	9,411,423	11,630,061	19.08%
total	3,929,510	55,903,203	59,832,713	6.57%

Ten years earlier, Bell had only about twenty-eight percent of the business. Bell's expansion between 1904 and 1914 was partly at the expense of the telegraph companies; during the same ten years, the private line revenues of the telegraph companies declined. The business of providing private lines for telegraph operations remained an area of rapid growth for AT&T until the Great Depression. Fifteen years later, in 1929, the miles of Bell's private telegraph lines had increased to 1,200,000 miles. By that time though, the composition of the leases had changed. While in 1914 80% of leases were taken by bankers and brokers, in 1929, 33% of the mileage was rented by newspapers and press associations.

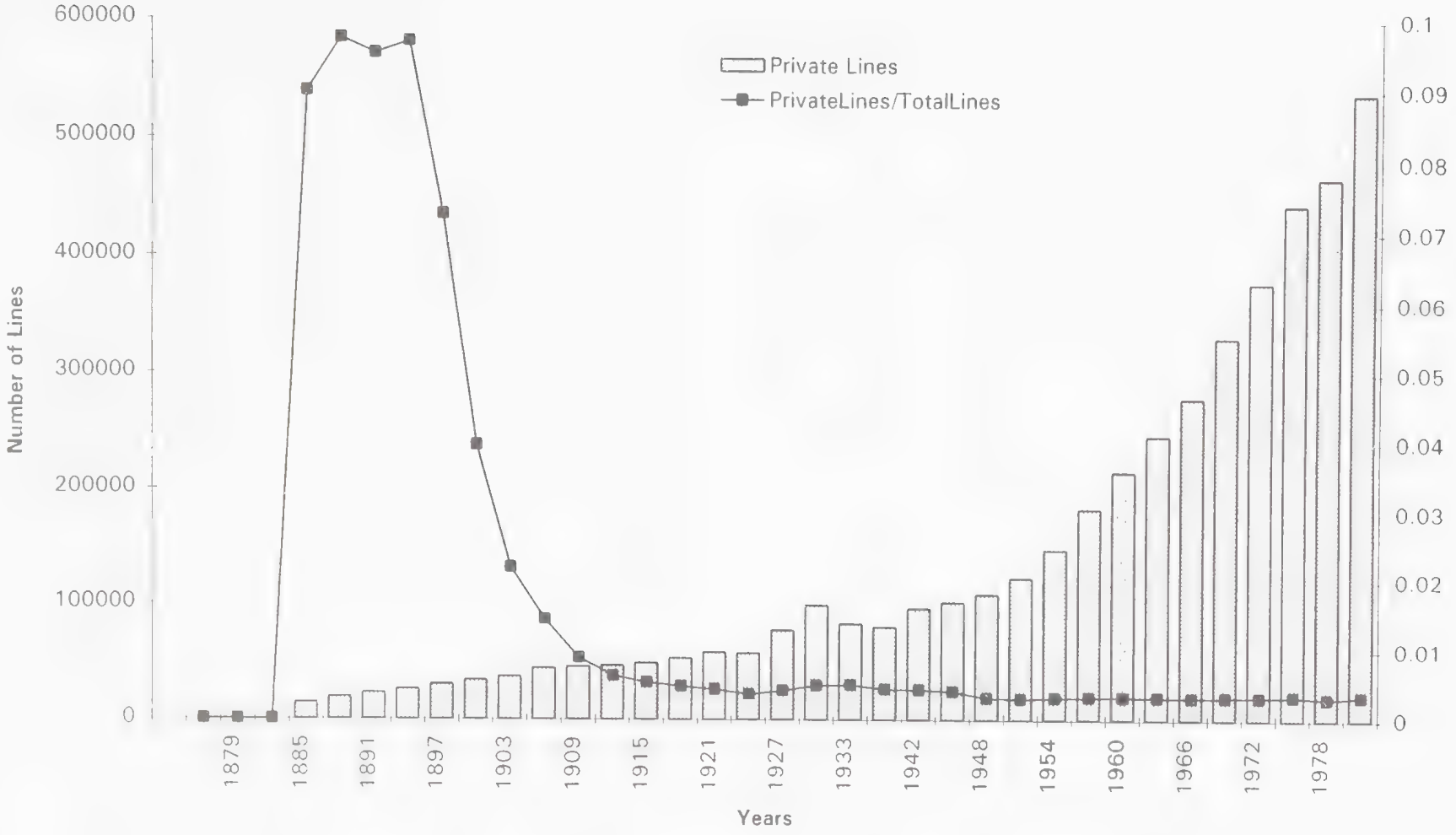

600000
500000
400000
300000
200000
100000
0
Number of Lines
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Private Lines
PrivateLines/TotalLines
1879
1885
1891
1897
1903
1909
1915
1921
1927
1933
1942
1948
1954
1960
1966
1972
1978
Years

Figure 1

The growth in importance of leased lines to presses is attributable in part to the introduction in 1925 of telephotograph service. This new service was used by newspapers and wire services to transmit photographs and facsimiles.[35]

Figure One shows the growth in the number of private line circuits between 1885 and 1981. The vertical axis on the left shows the number of private telephone lines as measured by the common carriers. The value likely excludes private lines that were not supplied by common carriers. Therefore, it would not include private lines on private networks. The right-side vertical axis shows the percentage of total common carrier lines that were accounted for by private line service. During the early years of telephony, private line service accounted for approximately ten percent of the installed lines. The ratio was high because telephony was marketed primarily to business customers, and switched service was in its infancy stage. While private line service was available from the beginning of AT&T's operations, switched service was not introduced until 1878. The large dip in the percentage of private line phones after 1897 is attributable to the growth of residential service. When AT&T's patents expired in 1894, rival telephone companies rapidly entered the market and targeted the neglected residential community. The competition led to a rapid growth in the number of residential subscribers, and a comparatiavely slow growth in the number of private lines.

The data series stops in 1981. After the divestiture of AT&T in January 1984, the Federal Communications Commission stopped reporting the number of private line loops. Private line service was made part of a larger reporting category, special access lines, and this new category included some switched services, such as interexchange carrier access.

4. FORMATION OF PRIVATE NETWORKS IN THE POST WORLD WAR II ERA

There has been a proliferation of private networks during the post-World War II era. In many ways the recently constructed private networks were established for the same reasons that were crucial during the first thirty years of telephony: security, the need for central management to coordinate and monitor activities in different units of the firm, the need to reach remote areas, and, more generally, the "failure" of the common carriers "to meet the new or specialized consumer demands in the market place."[36]

Immediately after World War II, a large part of the demand for new services was related to the growth of commercial television. AT&T was unable to provide the networks with ubiquitous or cost effective intercity transmission facilities. Since the facilities available through AT&T were unsatisfactory, the networks set up private, microwave systems.[37]

The other principle factor driving the demand for private line networks was the growth of the data processing industry. As the cost of processing dropped, operating systems that provided real-time solutions to problems became more common, and electronic mail communications took-off, the need for data communication lines increased.[38] The public switched network was not capable of providing the quality transmission lines that were needed for high speed data and video transmission.[39]

In the late 1950's, the shortcomings of the public switched network were discussed extensively in the FCC docket "Above 890."[40] A decade later, as the problems persisted, the data processing industry provided the common carriers with a list of ten ways in which service could be improved. The list included the speed of connection and disconnection, as well as the associated billing period; a greater variety of bandwidth and transmission speeds;

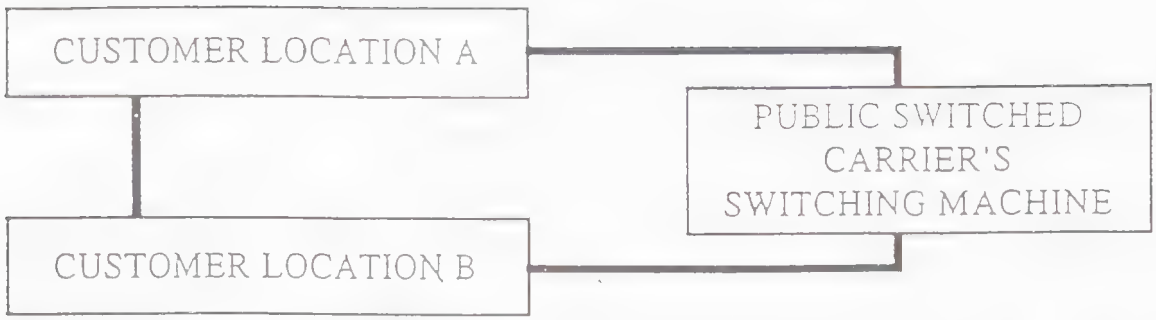
a reduction in the error rates; improved circuit testing procedures; and the deployment of a digital data transmission network.[41] Today, 30 years after "Above 890," large business customers have many of the same complaints about the public switched network. The users have established private networks, or obtained service from alternative local exchange carriers, because of quality-of-service and cost considerations.[42]

During the post-World War II era there has been a major change in the type of technology used in the public switched network. While manual switching systems were widely deployed in the 1940s, by 1990 the switching was largely completed by computer controlled equipment.[43] Similar modernization activity has occurred with interoffice facilities--coaxial, N and copper carrier systems have been replaced with T-carrier and fiber optics. With respect to the local loop, loaded lines were initially an impediment to the provision of high-speed data services. Loaded cables pairs have been largely eliminated from the loops located near large business customers.[44]

Despite these changes in facilities, large users still express their dissatisfaction with the service provided by the public switched telephone network. In part this is the result of the slow pace in which the public switched telephone network operators have deployed new technology. For example, during the 1970s the Bell Systems leading product in the PBX market was the analog, Dimension Private Branch Exchange (PBX). While the Dimension PBX was satisfactory for the majority of users, it was cumbersome for data transmission. Consequently many customers chose to buy digital PBXs from other suppliers. According to Temin, AT&T's decision to market the analog technology reflected the internal management style of the firm during the 1970s. The deployment of technology was determined by engineering criteria, rather than market objectives. The engineers controlled the operations of the Bell System, and they believed that digital consumer premise technology should not be deployed until the national network was converted from analog to digital technology.[45]

While more rapid deployment of digital technology would have allowed the Bell System to maintain its market share in the customer premise market, a more fundamental problem for the local exchange carriers (LECs) is the design of the exchange switching machines. The architecture of the switches limits the ability of the public switched telephone network operators to compete in the market for high-speed and video services. Data and video services have fundamentally different usage patterns that voice telephony. When only voice telephony was provided on the public switched network, engineers assumed that during the peak-demand period each customer placed one call that lasted for three to five minutes.[46] High-speed data services often involve short-bursts of information, perhaps 15 to 20 seconds in length. The number of per customer data connections during the system busy-hour is significantly larger than one. At the other extreme, some data transmissions, as well as video, will involve connections that last for the full system busy-hour.[47]

The switching network has been designed to satisfy the needs of voice telephony. The deployment of a switch that is used for voice, video and high-speed data transmission will increase the variance of usage patterns. In order to provide these three services through the same public switching nodes, there must be fundamental changes in the current design of the switching machines.[48] To date, the exchange public switched telephone network operators have not been able to obtain a switch that economically provides all three services. Consequently their current offerings of high-speed switched data services are offered through auxiliary machines, such as the Stromberg-Carlson Metropolitan Area Network or AT&T's Broadband Service 2000 Switch.[49]



The lack of a switching machine that can economically provide switched voice, high-speed data and video services explains in part why customers find it cost efficient to establish a private network. Due to the unavailability of a multi-purpose switch, public switched telephone network operators are unable to obtain a competitive advantage by exploiting economies-of-scope.[50] Since a local exchange carrier uses separate switching equipment for non-voice services, users may find it more economical to rely on private services. By constructing a private network, transmission costs may be reduced, as well as switching costs.

To transmit data between customer locations, the firm can either use a private, direct link (A to B), or use the public switched telephone network operator's switching machine. While the direct link involves a shorter distance, it may be cheaper to use the public switched telephone network operator's facilities. The cost of using the shared facilities could be less than the cost of constructing a private network. But when the public switched telephone network operator has to install special switching equipment for high-speed data services, there are few customers who will share the responsibility of recovering the fixed cost of the auxiliary switching equipment. This will raise the unit cost of obtaining high-speed data services from the public switched telephone network . Until the demand for high-speed data and video services broadens, agile niche suppliers may be able to provide non-voice services at a lower cost than public switched telephone network operators. While a local exchange company could also install direct facilities between locations A and B, the speed at which these large firms are able to respond to customers needs is notably slower than the entrants. But if the demand for these products broaden, the telephone companies marketing position will improve because of economies of scale.

4.1. Will We See A Repeat of Western Union's Demise?

In the preceding section I argued that a market developed for specialized carriers because of the technical limitations of today's switching technologies, and because it was costly to redesign the existing switched network to provide new services. The inability of the incumbent to rapidly adopt to technological changes raises the specter that today's telephone public switched telephone network will go through the same Schumpeterian destructive phase experienced by Western Union. Unable to obtain high speed data service over the public switched network, customers will obtain service from the new suppliers.

Private digital networks are capable of providing voice services. Currently, they are used to provide intracompany voice communications and to obtain access to long-distance carriers. The economics of telephony suggest that it is unlikely that private networks will expand into marketing voice services on a common carriage basis. While private carriers have access to customers where conduit is readily available, in less densely populated areas

providing duplicate loop facilities is difficult. In order to establish a second exchange network, the carrier would have to obtain a permit from the city for burying its cables. This is a formidable barrier-to-entry and is most likely to be overcome by cable companies since they already pass ninety percent of American households.

The ability of cable companies to introduce a rival telecommunications network is quite dependent on the pricing of interconnection. If a second exchange network is established, it lowers the percentage of customers who are served by a given switching machine. For example, if a city is initially served by one switch, all exchange calls originate and terminate on the same switch. If a new carrier enters the market, the percentage of exchange calls between switches will no longer be zero. The cost of these switching interoffice calls is, at the minimum, twice as expensive as the cost of an intra-office call.[51] If rates are established to reflect the cost of connecting competing exchange switches, customers will have an economic incentive to migrate to one firm. By relying on one firm, the cost penalty of additional interoffice calls is avoided. For example, after interconnection of competing telephone service was ordered in Lacrosse, Wisconsin in 1913, almost all customers moved onto one system in order to avoid the penalty associated with interoffice calls. The Wisconsin Railroad Commission had determined that the cost of an interoffice call was five cents and that cost should be recovered from the originating party. There was no charge for intra-office calls.[52]

In summary, just as the ubiquitous local telephone exchange gave AT&T a first-mover advantage over Western Union at the start of the twentieth century, the public switched telephone network operators continue to have an important advantage today. While specialized common carriers and private networks will be able to serve niche markets, the core voice market of the public switched telephone network is not contestable at this point in time.

5. CONCLUSION

As illustrated by the rivalry between AT&T and Western Union, new technology can lead to the rapid demise of a dominant firm. But the adoption of superior technology is not a sufficient condition for successful entry. Today's private data and voice networks may be based on technologically that is more advanced than the LECs' facilities, but the entrants are only a limited threat to the public switched telephone network's core, voice exchange services. The history of telecommunications networks in the United States suggests that regulation may have been a "boogy-man" used to explain the growth of private networks. While subsidies from business to residential customers, if they do exist, may have played a role in the growth of private networks, the origin is more based in the heterogeneity of user needs, and the inability of the incumbent firm to rapidly adjust its network to efficiently meet the demands of all customer groups. The problems faced by the LECs are conceptually similar to the challenge faced by Western Union prior to the advent of regulation. Once committed to a particular architecture and mode of doing business, it is cumbersome to modify the network so that the new technology may be rapidly deployed.

ENDNOTES

[1] See pp. 85-106, Joseph Schumpeter, *Capitalism, Socialism and Democracy* New York: Harper & Row, 1942.

[2] Civil Action No. 74-1698 (D.D.C.)

[3] American Telephone and Telegraph, "Defendants' Third Statement of Contentions and Proof," United States v. American Telephone and Telegraph, pp. 15, and 361-381, March 10, 1980.

[4] Ibid., pp. 35, 2097-2136.

[5] Eli Noam, "The Tragedy of the Common Network: Theory for the Formation and Breakdown of Public Telecommunications," in this volume, pp. 51-64. A private network is a set of telecommunication facilities which is not available for public use. Conversely, a public network, or common carriage, is "a public offering to provide for hire facilities...whereby all members of the public who choose to employ such facilities may communicate or transmit intelligence of their own design or choosing." National Association of Regulatory Utility Commissioners v. F.C.C. 525 F.2d 630, 641 (D.C. Cir.) cert. denied, 425 U.S. 999 (1976).

[6] Of course, the assumption of a U shaped cost curve is not crucial; all that matters is that at some point the marginal benefit of an additional network customer is less than the marginal cost.

[7] Noam does allow for a variation in the number of lines used by a subscriber, but otherwise treats them as homogeneous.

[8] Eli M. Noam, "The Public Telecommunications Network: A Concept in Transition," 37 *Journal of Communications* 30 1987.

[9] See pp. 49, 75, Alfred Chandler, *The Visible Hand: The Managerial Revolution in American Business*, Cambridge: Harvard University Press, 1977.

[10] Ibid.

[11] Ibid.

[12] See, p. 11, Robert W. Garnet, *The Telephone Enterprise: The Evolution of the Bell System's Horizontal Structure, 1876-1909*, John Hopkins University Press, 1985 and pp. 32-61, Claude S. Fischer, "Touch Someone: the Telephone Industry Discovers Sociability," *Technology and Culture*, v.29, 1988.

[13] Garnet, pp. 15-16, 20.

[14] Garnet, pp. 20-21.

[15] Department of Commerce and Labor, *Telephones and Telegraphs: 1902* Washington: Government Printing Office, 1902, p.3.

[16] Ibid., p.99.

[17] Ibid.

[18] See p.734, M.D. Fagan, ed., *History of Engineering and Science in the Bell System: The Early Years (1875-1925)*, Homdal, New Jersey: Bell Telephone Laboratories, 1975.

[19] Similar to today's software controlled private line services, the subscribers to private line services rarely had exclusive control over a wire between two points. Instead, the subscriber had exclusive access to the circuit for the hours negotiated in a contract. Subscribers to private line service could not use the dedicated line service during the system peak demand hours of 10 to 12 A.M. Interstate Commerce Commission, "Private Wire Contracts," 50 ICC (1918) 731, 734-736.

[20] The meat packing and steel industries accounted for the next largest block of business, approximately nine percent. The bankers and brokers accounted for a smaller proportion of the private telephone lines--27 per cent.
Ibid. p. 738. The difference was likely due to the need for a written record of the financial transactions.

[21] Ibid., p. 738.

[22] Ibid., pp. 738-39.

[23] See p. 104, Department of Commerce and Labor, Bureau of the Census, *Telephones and Telegraphs: 1902*, Washington: Government Printing Office, 1906.

[24] Interstate Commerce Commission, "Private Wire Contracts," 50 ICC (1918) 731, 740-1.

[25] Ibid., p. 742. The larger private industrial networks typically connected the firm's headquarters with its manufacturing plans and distributing stations. Smaller private industrial networks were used primarily to connect headquarters with a factory. Ibid., p. 740. The industrial firms considered only about five percent of this intracompany traffic to be of sufficiency urgency that they would have used public wires if private systems were not available. For the remaining 95%, if private wires were not available, the firms would have substituted the mail. Ibid., p. 741.

[26] Ibid., 742-3, 749.

[27] Green to Stockton, February 25, 1888, Box 1217, AT&TCA.

[28] AT&T, "Third Statement," pp.540-1; and N.A., quoting Postal Company, December 1909, in "Western Union Telegraph Company--Statistics--1912," ATT, box 20.

Even though the railroad companies found public telegraph service to be of unacceptable quality, they did recognize the advantages of sharing some facilities. The railroads allowed the telegraph companies to use their right-of-way for the stringing of poles. In 1902, 72.4% of the telegraph companies' wires were strung alongside of railroad tracks. See p. 104, Department of Commerce and Labor, Bureau of the Census, *Telephones and Telegraphs: 1902*, Washington: Government Printing Office, 1906.

[29] Interstate Commerce Commission, "Private Wire Contracts," 50 ICC (1918) 731, 736.

[30] See pp. 738-39, 743-44, Fagan, *Engineering and Science in the Bell System.*

[31] H. Stone/J. Hudson, March 28, 1995, "Private Line Rates in Chicago," box 1284, ATT.

[32] N.A., December 1909, in "Western Union Telegraph Company--Statistics--1912," ATT, box 20.

There is some evidence to suggest that similar economies-of-scope can be achieved today in the telephone and entertainment industries. James Cornford and Andrew Gillespie have estimated that in the United Kingdom, the addition of cable telephony to an entertainment network raises capital costs by 28% but increases revenues around 91%, p.594 "Cable Systems, Telephony and Local Economic Development in the UK," *Telecommunications Policy*, November 1993.

[33] Interstate Commerce Commission, "Private Wire Contracts," 50 ICC (1918) 731, 735. The Commission noted that the Bell value of 500,000 was composed of "250,000 miles of telephone circuits, each of two wire, making 500,000 miles available for superimposed Morse service, although not so used at present time."

[34] Ibid. The Bell revenue is from the long-distance portion of AT&T and does not include any revenue obtained from the local, Bell operating companies. The $9,411,423 in Bell revenue was "[n]ot Morse service, but included for purposes of comparison." Ibid.

[35] See pp. 9-10, James M. Herring and Gerald C. Gross, *Telecommunications: Economics and Regulation*, New York: McGraw-Hill, 1936. While the data presented in Table One excluded data for the Bell Operating Companies, it is not clear if Herring and Gross's data excludes or includes these operations.

[36] See, for example, Plaintiff's Third Statement of Contentions and Proof, in United States v. American Telephone and Telegraph, 74-1698 (D.D.C), p. 86 (quote); "Comments of Microwave Communications, Inc." in "Regulatory and Policy Problems Presented by the Interdependence of Computer and Communication Services and Facilities," FCC Docket No. 16979 (hereafter "Computer I,"), March 5, 1968, p. 26-28; Federal Communications Commission, "In the Matter of Allocation of Frequencies in the Bands Above 890 Mc," 27 FCC 359, 377-9 (1959); and Stanford Research Institute, "Policy Issues Presented by the Interdependence of Computer and Communications Services," Report No. 7379B-1 (1969), pp. 25-29.

[37] Plaintiff's Third Statement of Contentions and Proof, January 10, 1980, pp. 90-110.

[38] MCI, "Comments," p.1; "Response of U.S. Department of Justice," Computer I, March 5, 1968, p.2; Stanford Research Institute, "Decision Analysis of the FCC Computer Inquiry Responses," Report No. 7379B-3 (1969), p.13 and "Analysis of Policy Issues in the Responses to the FCC Computer Inquiry," Report No. 7379B-2, p. 115-6.

[39] MCI, "Comments," p.27.

[40] FCC, "Allocation of Microwave Frequencies Above 890 Mc.," pp. 364-379. For example, the Electronics Industries Association stated that potential uses of private microwave systems included firms "which require highly specialized communications circuits which are not readily or economically obtainable over wire communications systems..." Ibid., p. 378.

[41] Stanford Research Institute, "Analysis of Policy Issues," p.47.

[42] See, Eli M. Noam, "The Public Telecommunications Network: A Concept in Transition," 37 *Journal of Communications*, 30, 1987; p. 2137, John M. Griffiths, "ISDN Network Terminating Equipment," 30 *IEEE Transactions on Communications* 1982; p. 43, Roger G. Noll, "The Future of Telecommunications Regulation," in *Telecommunications Regulation Today and Tomorrow*, ed. Eli M. Noam 1983; Re Pacific Bell, 69 PUR4th 225, 236 1985; and Jane L. Racster, Michael D. Wong, and Jean-Michael Guldmann, "The Bypass Issue: An Emerging Form of Competition in the Telephone Industry," National Regulatory Research Institute, 84-17 1984.

[43] See table 25, Federal Communications Commission, *Statistics of the Communications Industry in the United States*, Washington: Government Printing Office, 1949.

[44] Byrne, Coburn, Mazzoni, Aughenbaugh, and Duffany, "Positioning the Subscriber Loop Network for Digital Services," 30 *IEEE Transactions on Communications* 2006 1982.

[45] See p.150, Peter Temin with Louis Galambos, *The Fall of the Bell System: A Study in Prices and Politics*, Cambridge: Cambridge University Press, 1987.

MCI believed that its original success in the transmission market would derive from its ability to quickly respond to customer needs in niche markets. As a new firm, they would not have to give "consideration to the preservation of other forms of types of service." MCI, "Comments of MCI," p.8.

[46] Peak-hour usage is one of the primary criteria used to determine the amount of switching equipment needed to serve customers.

[47] Kenneth F. Giesken, "ISDN Features Require New Capabilities in Digital Switching Systems," 3 *IEEE Journal of Telecommunications Networks* 19-28 1984.

[48] Ibid., p. 20.

[49] See p. 4, 96, "Bell Atlantic Set to Rollout Offerings Similar to SMDS," *Network World*, October 14, 1991 and p. 35, "PacBell Gives SMDS Thumbs-Up," *Communications Week*, October 14, 1991.

[50] Economies of scope exist if

$$C(Q_1,0) + C(0,Q_2) > C(Q_1,Q_2) \qquad (50.1)$$

where Q_1 – the output of product one; Q_2 = the output of product two. The equation merely states that it is cheaper to have product one and two produced by a single firm $[C(Q_1,Q_2)]$, than by having separate firms produce product one and two $[C(Q_1,0) + C(0,Q_2)]$.

[51] Switching costs will double, at a minimum, because of the use of two machines. The available cost data suggests that the cost penalty is much higher. See p. 53, David Gabel, "Deregulation: Should the Local
Telephone Market be Next?," *New England Law Review* 24 1989.

[52] Ibid., p.55.