A Case Study in the Deployment of Digital Access Technologies: DSL vs. Cable Modems

by

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Abstract

From its start in the early 1900's, the communications business has been a regulated industry with little or no competition. The economic incentives to deploy new technological innovations were often overshadowed by the regulatory environment and a lack of competitive pressures. The 1982 divestiture of AT&T successfully created competition in the long distance market, however the local access market continued to operate as regulated monopoly. As the primary access point between users and the telecommunications network, the local access providers have extracted significant value from the telecommunications market. The Telecommunications Act of 1996 (TA96) was designed to open up the local access market to competition. The incumbent suppliers were required to enable competition by making their assets available to competitors. At the same time, Internet data transport was becoming the dominant telecommunications revenue source and new technologies that offered high-speed Internet access were becoming available.

This thesis demonstrates that the three types of competitors defined by TA96 have evolved different strategies for maximizing the value that they can capture from the telecommunications market. By applying a case study for Cable Modems and Digital Subscriber Line (DSL) modems, it is shown that the economic incentives to deploy new technologies are not necessarily aligned with the needs of the telecommunications consumer.

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Chapter 1:
Introduction

From its start in the early 1900's, the communications business has been a regulated industry with little or no competition. The founders of AT&T successfully created a legal monopoly that practically guaranteed a fixed return on its assets and an environment with no competition. The return-driven business model encouraged AT&T to build a network that was made up long-lived, capital-intensive assets. In order to prevent the pre-mature obsolescence of sunk investments, AT&T often delayed deployment of new technological innovations.

A major milestone in the evolution of the industry was the 1982 divestiture that separated AT&T into seven independent local exchange carriers (LECs) and one independent long distance carrier. The primary intent of the breakup was to enable competition in the long distance market. Several new entrants started to compete with AT&T and the increased competition forced a decline in long distance rates. The LECs continued to operate as regulated monopolies in an environment with high entry barriers and favorable regulatory control. As the primary access point between users and the telecommunications network, the LECs started to extract significant value from the telecommunications market.

In 1996, the US Congress passed the Telecommunications Act of 1996 (TA96) which was designed to open up the local access market to competition. The LECs were now required to lower competitive entry barriers by leasing their assets to competitors. At the same time, the communications market was evolving into a very different business. The growth of the Internet and the increased usage of distributed computing resulted in an increase in the amount of data traffic carried by the telephone networks.

When TA96 was passed, it was also clear that several new technologies were becoming available. Digital Subscriber Line (DSL) technology offered consumers the ability to access the Internet over a high-speed connections instead of low-speed analog modems. The Cable TV (CATV) plant was undergoing a transformation from a "broadcast-only" medium to a new architecture that could be used for voice communication and high speed Internet access.

TA96 fundamentally changed the nature of competition in the telecommunications industry. Competitive Local Exchange Carriers (CLECs) were permitted to compete with the Incumbent Local Exchange Carriers (ILECs), the ILECs were required to open up their networks to enable competition and the Cable Television providers (CATV) could challenge the LECs by offering voice and Internet access services.

This thesis demonstrates that the three competitors have evolved different strategies for maximizing the value that they can capture from the telecommunications market. The ILECs are the incumbent providers with the largest share of value. They have a statutory obligation to cooperate with their new competitors. However, encouraging the implementation of TA96 will enable a new competitive environment that will likely reduce the ILECs revenues and profits. To counter this threat, the ILECs strategy is to delay the impact of TA96 while simultaneously expanding their product mix so that they will become the dominant provider when local access competition does become a reality.

The CLECs have started operations at a competitive disadvantage. They are fully dependent on the ILECs for access to the local loop and thus are dependent on their largest competitor for developing broad market penetration. Even if the CLECs could obtain unlimited access to the local loop, they still face substantial entry barriers from the ILECs. Instead of competing directly with the ILFCs, a number of CLECs started to target customers whose communications needs are not satisfied by the incumbent carriers. They are offering products such as high-speed Internet access and data transport solutions for business or consumers. In order to provide these services, the CLECs are partnering with local Internet Service providers and are investing heavily in network infrastructure.

Neither the ILECs nor the CLECs are a direct threat to the CATV firms. However, new entrants such as satellite TV providers and the desire to increase revenues have encouraged the CATV providers to upgrade their networks to support enhanced video services. The incremental costs to add cable modems and voice telephony to the CATV infrastructure are relatively small. The CATV firms are already building the infrastructure to challenge the LECs and the demand for high speed Internet access represents an opportunity to increase value capture.

This thesis concludes with an analysis of the market for high-speed consumer Internet access. While consumer usage of the Internet has grown rapidly, most consumers continue to use low speed analog modems as their principal connection to the Internet. More advanced technologies such as DSL and Cable Modems have not yet become dominant in the market. Although there has been much activity among the service providers, less than 100,000 DSL modems have been deployed and less than one million cable modems are in service. Some of the delay is due to technology issues, however the primary limiting factor is the economic environment either limits deployment rates or encourage investment in other areas. All three types of competitors are acting in a manner that is consistent with the economic environment and the incentives they face.

The ILECs have historically extracted value by controlling the local loop, which is the principal access point for most communication services. The value drivers are a mix of local telephone services paid for by the consumer, network access fees paid by the long distance carriers and other products such as leased line services. By deploying high-speed technologies such as DSL, the ILECs run the risk of cannibalizing existing revenue sources and converting their circuit switched infrastructure into stranded assets. At the same time, they can obtain a better return by investing in lower cost network infrastructure and adding enhanced service offerings such as long distance services.

Despite what appears to be limited economic incentives, the ILECs claim to be aggressively deploying DSL. While there are a number of explanations for the discrepancy between the ILECs statements and actual deployment, the evidence suggests that the ILECs are modifying their infrastructure to support DSL, but they are not investing in the network equipment.

The CLECs have had some early success supplying DSL service to customers. They claim to have developed the capability to service several million subscribers, but less than 50,000 customers are actually using the service. The CLECs have sited technical problems with DSL, the complexities of obtaining collocation facilities and local loop access as the principle limits to growth.

The CATV providers have been the most successful in making high-speed Internet access available to their customers. The total number of subscribers is over 800,000 and the cable companies are adding about 2000 customers per day. Although CATV has not had any significant deployments of Cable Telephony services, AT&T has been aggressively acquiring Cable companies with the intention of competing directly with the ILECs.

Like most firms, telecommunications companies will try to maximize the value that can be captured from the markets that they serve. While one's intuition suggests that companies will rush to fill products desired by consumers, the incentives for deploying new telecommunications technology is a function of many other factors including the regulatory environment, the robustness of the underlying technology, the effectiveness of competitive forces and the economic incentives for investment. This thesis concludes that deploying the technology that is most valued by customers does not necessarily maximize the value captured by the service providers.

Chapter 2

The Evolution of the US Telecommunications Market

In order to understand the technological deployment decision process in the telecommunications industry, we must first understand the evolution of the technological and competitive environment. The history of the industry can be meaningfully separated into three distinct time periods: 1) Pre AT&T Divestiture, 2) Post AT&T Divestiture and 3) Post Telecommunications act of 1996. Each is considered in turn.

Pre AT&T Divestiture

Prior to the breakup of AT&T in 1982, all of the elements of the US Telephone network were controlled by AT&T and its subsidiaries, collectively known as the Bell System. Although the Bell System carries the namesake of Alexander Graham Bell, inventor of the telephone, most of AT&T's early growth was attributed to Theodore Vail who managed the company from 1907 through 1920.

The rise of AT&T as a regulated monopoly

During the early 1900's, there were literally hundreds of independent phone companies competing to supply local telephone service. AT&T was the largest competitor although its market share had started to decline once the original Bell patents started to expire. In order to protect the business, Vail made use of the burgeoning "long distance" market as a means to force out competition.

At this time, telephone technology was only able to transport voice short distances (i.e. a few miles). AT&T controlled several patents related to "long distance" telephone service and was the only company capable of providing long distance voice communications. This technology allowed AT&T to connect calls between any two points in the country. To force out a local competitor, Vail would setup his own telephone company to compete with the local competitor. Vail's new entrant would offer both local and long distance telephone services while the incumbent, who did not have access to a long distance network, could only offer local service. Since most customers preferred the ability to make long distance calls, the incumbent player would gradually lose market share to AT&T. Unable to compete, the independents were either acquired by AT&T or forced out of business.[1]

As AT&T became the monopoly provider of telephone service, the company also became the target of anti-trust regulators. In an effort to block government action, Vail embarked on a three-part strategy of:

- Cooperating with the regulatory authorities in exchange for being allowed to operate as a regulated monopoly.
- Providing "universal service" to all customers
- Insuring that AT&T owned the technology necessary for its success.

The first element of Vail's strategy was to accommodate the demands of the public sector. He agreed to cooperate with regulators on matters of pricing, service quality and rate-of-return. The government agreed that competitors would not allowed to enter the market. AT&T would be permitted to operate as a regulated monopoly supplying an "end-to-end" service. Competitors were also barred from the equipment market and only AT&T supplied telephones and switching equipment could be connected to its network.

The concept of "Universal Service" was a social goal articulated by Vail and the second element of his strategy. It was intended to insure universal availability of reliable, affordable telephone service. Since a telephone network that interconnected the entire population would be more useful than multiple networks that did not inter-operate, it was logical to conclude that Universal Service would best be achieved by building a single network with no competition. The "One Policy, One System" concept appealed to customers, regulators and AT&T executives. Note that while the concept of Universal Service is socially attractive, Vail used the concept primarily to justify the existence of AT&T as a monopoly and to close off entry by other firms.

The last element of Vail's strategy was to establish Bell Labs to insure that AT&T would have access or control over all technologies that might threaten its market position. Overall, Vail's strategy insured that AT&T could operate in an environment where the company was protected from competition, had no dependence on external suppliers, and through its advocacy of Universal Service, was positioned as a protector of the public good.

Cross-subsidization.

Since the late 1800's, AT&T and its subsidiary companies have been subject to various forms or state and federal regulation. Due to a variety of constitutional issues, regulation of intra-state telecommunication services was regulated through State Public Utility Commissions (PUC) while the Federal Communication Commissions (FCC) regulated inter-state communications. As shown in Figure 1, AT&T provided inter-state long distance services through a separate company called AT&T Long Lines while the Bell Operating Companies were separate companies setup to provide local services.

Figure 2 shows a simplified diagram of the interaction between the various Bell System companies. An inter-state call was relatively simple to tariff. The call was delivered through the local Telephone Company's equipment and the toll charge was regulated by the state PUC. An

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[1] Faulhaber, Telecommunications in Turmoil, Ballinger 1987 Chapter 1 for a more detailed history of AT&T.

inter-state long distance call was more complicated to tariff because it required the use of equipment from two local telephone companies as well as AT&T Long Lines. While the FCC regulated charges for long distance rates, the local companies were regulated by their respective state PUCs. In effect, three separate government agencies regulated the cost of an inter-state long distance call.

During the 1950's, the FCC and the Justice Department wanted to reduce AT&T Long Line's profits and force a reduction in local telephone charges. Through a series of consent decrees and court decisions, the concept of "cross-subsidization" was developed. Cross-subsidization was designed to reduce the cost of local telephone service by transferring revenues from AT&T Long Lines to the local operating companies.

While the intent of the FCC was well-intentioned, the net effect of cross-subsidization was to introduce an arbitrary pricing model whereby interstate services subject to FCC regulation would, in effect, be subsidizing services beyond the FCC's jurisdiction. It is important to note that cross-subsidization was intended solely as a method to prevent excessive profits. The concepts of Cross-Subsidization and Universal Service evolved independent from each other.[2]

Investment in Telecommunications Infrastructure

The pre-divestiture AT&T operated in an environment that encouraged the development of capital intensive infrastructure that was highly reliable and could be depreciated over many years. The innovation process was primarily "process" driven or focused on reducing operating costs. At the same time, product innovations such as the introduction of new products and services received much less investment. The regulatory environment was a primary driver of this structure.

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[2] Peter Temin, The Fall of the Bell System Cambridge University Press, 1987

To understand the drivers of telecom innovation, it will be helpful to first show how AT&T controlled the innovations process. As part of its agreement with the regulators, AT&T had complete control over the equipment that would be used in its network. Vail strongly believed that controlling the telephony technology was key to maintaining his control over the market.[3] Bell Labs was created as a telephony research center and Western Electric was developed as AT&T's manufacturing arm. AT&T's preference for buying equipment from itself left little economic incentive for other firms to enter the market.

Although AT&T had its own development facilities, it could not afford to pursue every new technology. It still needed access to new innovations in the areas of wireless, vacuum tubes and a variety of other developments. In 1920, AT&T signed a cross-licensing agreement with General Electric, Westinghouse, RCA and several other technology competitors. The agreement gave Bell Labs access to new technologies. Bell Labs agreed not to compete in emerging technologies such as radio broadcasting in exchange for agreement that the other companies would not compete in wired telephony.[4]

The cross-licensing agreement insured that AT&T would have access to most new technologies and further insured that AT&T would be the sole player in the telecommunications equipment market. As a result of these two events, Bell Labs soon become the only research center for telephony and the sole source of new telecommunications technology. AT&T controlled the only source of innovation in the area of telecommunications.

By the early 1920s, every state had set-up a Public Utilities Commission (PUC) to regulate the local AT&T telephone subsidiary. As illustrated in Figure 3, telephone regulation was designed such that the revenues earned represented a fixed return on the company's asset base plus some incremental revenue to cover operating expenses. The Telephone Company could maximize its revenues by maximizing the value and life of its assets. This policy encouraged the installation of capital intensive, long life assets that could be depreciated over many years.

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[3] Temin, Peter, The Fall of the Bell System, Cambridge University Press, 1987
[4] Faulhaber, Telecommunications in Turmoil, Ballinger 1987

Bell Labs had become the only source of telecom innovations and AT&T had become its only customer. Bell Labs obediently served its customer by developing products that would maximize the profits of AT&T and its local operating companies. Bell Labs and Western Electric developed products that had high reliability and last for many years. Incorporating new innovations that lowered the capital cost was not encouraged because it would only reduce AT&T's revenues. The preference for long-lived equipment with long depreciation periods also created the need to protect the company against unanticipated innovations. An unexpected innovation would destroy the value of the asset base prematurely by forcing a reduction in the operating company's asset base. Through its control of Bell Labs, AT&T would delay or cancel new products that might accelerate the depreciation of its asset base.

Evidence supporting the "regulation theory"

The hypothesis that AT&T focused on reducing operating costs while suppressing new innovations can be supported through a comparison to the innovation rates in the computer industry. The computer industry has always been highly competitive and technological innovations have always been rapidly incorporated into new products. Communications and computers share many elements of underlying technology and there is widespread belief that these two areas will converge into a single industry.

Under competitive conditions, we would expect that the innovation rate in the two industries to be similar. However, the evidence suggests that the innovation rate in communications is much slower, suggesting that other factors are limiting the innovation rate.

Innovation in computers

The cost of computer technology has followed a downward trend since it first became available. According to one study, the cost of a mainframe computer for a given capacity dropped by 28% in the 1950s, 25% in the 1960s and 20% during the 1970s.[5]

Most of this cost reduction is consistent in improvement of the price/performance ratio of the various computer sub-systems such as processor bandwidth, memory, disk drives and the cost of peripherals such as printers and terminals. These subsystems are similar to those used in telecommunication networks and it follows that similar cost reductions should have been observed in the cost of communication networks.

Innovation in Communications

Developing a comparison between the cost of computing power and the cost of telecommunications capacity is difficult. Until the early 80's, there was no public market for telecommunications equipment (recall that AT&T controlled Bell Labs) and thus there is only indirect evidence to quantify the actual cost of equipment. One study looked at the cost for data communication on a 300-mile private line. The cost per data bit dropped by about 20% per year between 1955 and 1975. This data is similar to the decrease in computing costs mentioned earlier. However, most of the cost reduction was due to an increase in the capacity utilization of the line. Measuring the cost of transferring data at a constant rate shows a decrease of about 3% per year over the same period.[6] The latter measure suggests that the cost of the capital equipment necessary for this service did not benefit from innovations developed during this period.

An alternative comparison is to look at the introduction of the underlying technologies that are incorporated in both computers and communications. Since these elements are common, it follows that an innovation introduced in the computer industry should also be introduced in the communications industry at roughly the same time.

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[5] Crandall, Flamm, Changing the Rules: Technological Change, International Competition and Regulation in Communications. Brookings Institution, 1989

[6] Crandall, Flamm, Changing the Rules: Technological Change, International Competition and Regulation in

In fact, the introduction of new innovations into telecommunication systems appears to lag the computer industry by at least a decade. Core memory technologies were introduced into AT&Ts switches in 1971, about 10 years after the technology was introduced into the computer industry. Similar lags have been identified for the transition from vacuum tubes to transistors, transistors to integrated circuits and the introduction of microprocessors and high level programming languages. The delayed introduction of transistors is especially interesting since Bell Labs invented this particular technology.[7]

A third indication of the slow deployment rate of new communications technology can be found by looking at the longevity of product life cycles. The Bell Labs original Number 5 switch was introduced in 1948. This equipment was based on relays and other mechanical technologies that were considered state-of-the-art during that time. Between 1948 and the mid-1970's, the three generations of technology were developed. Vacuum tubes replaced relays, transistors replaced vacuum tubes and integrated circuits gradually replaced transistors. While the computer industry was quick to incorporate each technology, AT&T manufactured and deployed Number 5 switches until 1976! The existing equipment continued to remain in service even though the old analog equipment was no longer manufactured. Bell Atlantic retired the last of its mechanical based equipment in 1998![8]

Post AT&T Divestiture

In 1984, AT&T was broken up into an inter-state long distance supplier and 7 Regional Bell Operating Companies (RBOCs) also known as Local Exchange providers (LECs). (Note: to avoid acronym confusion later on, the regional operating companies will be referred to as LECs). Divestiture was the culmination of many years of regulatory battles between AT&T and the FCC.

The primary intent of the breakup was to enable competition in the long distance market. Inter-state telephone service was opened to competition and a number of new entrants immediately

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[7] ibid

started to compete in the long distance market. AT&T and new competitors such as Sprint and MCI quickly transformed the long distance market into a competitive market. Prices dropped and the quality of long distance service followed a path of continuous improvement.[9]

The LECs continued to operate as a regulated monopoly but they were constrained to operate within their geographic region. The LECs provided "local access" by switching calls within their operating region and connecting inter-state long distance calls to networks operated by the long distance suppliers. The LECs were specifically prohibited from providing long distance services

The divestiture agreement, which involved the US Justice Department, the FCC and the tacit approval of congress, recognized that LECs would lose substantial revenues from the lose of cross-subsidization payments that began thirty years prior. Partly to address this issue, the LECs were allowed to charge the long distance carriers "access fees" for interconnecting with the LEC's network. The LECs would also continue to be treated as a regulated monopoly and the PUCs would set rates that guaranteed a certain return on the LECs asset base.

While the new inter-state long distance companies (AT&T, Sprint and MCI) found themselves in a fierce battle for customers, the LECs found themselves in an environment with no competition. Market data suggests that the LECs were able to extract significant value by being the sole suppliers of local access services. Since 1990, AT&T averaged less than 5% return on assets while Bell Atlantic averaged a greater than 10% return.[10] The implication of the ILECs improved return is that the access fees and other efforts to support the ILECs far outweigh the loss of cross-subsidization revenues.

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[8] Bell Atlantic Press Release Bell Atlantic Completes Digital Network For Customers Across New York October 28, 1998

[9] Faulhaber, Gerald, Telecommunications in Turmoil, Balinger Publishing, Cambridge MA, 1987

[10] 1998 AT&T, Bell Atlantic Annual Reports

Discussion of Network Capabilities

In order to understand why the LECs were successful, we should first understand the telephone network. This synopsis is presented as a basis for discussion of network economics. It is a simplified description of the telephone network and its capabilities around 1990.

A block diagram of the telephone network is shown in Figure 4. The consumer, represented by the "customer premise", has the option of using one phone line that he switches between standard phone service (POTS) and a computer modem. Alternatively, many consumers have chosen to install a second line (data line) that is dedicated for use with a computer modem or fax machine. The Local Exchange Carrier (LEC) serves the customer by connecting wires between the customer premise and the Telephone Company's Central Office (CO). The connection between the subscriber and the CO is called the "local loop".

The CO is usually located within a few miles of the customer. It contains switching equipment capable of switching calls locally or to long-distance carriers. The CO can also aggregate traffic from many users and transport the traffic to other COs via high bandwidth connections. The "telephone network cloud" represents the intra-CO connections. If the call is a long distance call, it is routed to a long distance carrier such as AT&T, Sprint or MCI. If the user is accessing the Internet, the Telephone Company routes the call to an Internet Service Provider (ISP). The ISP is typically a separate company who acts as a gateway between the user and the Internet.

The Local Loop was typically an analog circuit while the intra-CO connections typically carried information on digital circuits. Analog circuit technology was developed in the early 20th century with the phone network. Its primary advantage was that it could be constructed with the technology available at the time. Digital circuits converted voice traffic to a digital format using a technique call Pulse Code Modulation (PCM). The advantages of digital circuits were that multiple conversations could be multiplexed onto a single wire and that it was easier to switch the traffic.

In the early 1990s, most traffic carried over the telephone network was voice traffic and the telephone network was optimized to carry voice. It turns out that the switched telephone network is most efficient when it carries large volumes of data traffic. In the figure, data traffic enters the network through a device called a modem. Most modems are analog modems that convert digital data to an analog signal suitable for the local loop. As shown in Figure 6, digital data from a computer must be converted at least four times before it reaches its destination. The data rate on a standard analog line has a theoretical limitation of 64Kbits/second and practical modems max out at 56Kbits/second.

In addition to the analog voice circuits illustrated in Figure 4, the telephone companies also provided "leased lines" for transporting data between two sites on the network. Companies that had multiple computer facilities would have used leased lines to interconnect the sites. These connections required special hardware and were generally fixed between two sites. A table of the most common services is shown in Figure 5. For the most part, these services were only available to business users.

Porter Analysis

Michael Porter's "Five Forces" Model[11] can be used to explain the locus of rents in the local access market, the markets served by the LECs. Porter's model evaluates a firm's competitive position by analyzing the intensity of industry competition, presence of substitute products, buyer power, supplier power and barriers to entry for new competitors. The influence of government is added as an important sixth force. By 1990, the effects of the divestiture had settled and the competitive environment was relatively stable. Figure 7 shows the competitive forces acting on the ILECs in 1990 and the competitive environment is evaluated as it existed around this time.

Intensity of Competition

A discussion of competition in the local telephone market is a moot point; the LECs had no competitors. In 1990, a potential competitor wishing to bypass the incumbent's infrastructure would have encountered regulatory opposition from the state Public Utility Commissions (PUCs). Further, potential competitors would have found that the cost of installing their own loop wires would not have yielded a sufficient return.

Presence of Substitute Products

Although there were early indication that Cellular Phones, satellite technology and Cable TV technology could be used to bypass the local loop, none of these technologies were considered commercially feasible in 1990.

Buyer Power

In the case of the local Telephone Company, there are a large number of customers and none are responsible for large purchases. Buyer power was very low.

Power of Suppliers

Telecom industry suppliers had moderate power in their dealings with the LECs. The 1984 divestiture separated Western Electric and Bell Labs from the LECs and they were free to purchase equipment from any company. Largely due to the complexity of telecom equipment, in 1990 the number of telecom suppliers was still somewhat limited. The largest suppliers were companies such as AT&T (now Lucent), Northern Telecom, Alcatel, Fujitsu and NEC.

The service providers typically entered into long term procurement contracts with their vendors. Once a provider committed to a supplier, the provider must continually invest resources in training, network operations support and provisioning. The effort required to replace a supplier's equipment would require extensive retraining of staff as well as changes to the network architecture. Thus the switching costs associated with moving to a new supplier were substantial.

Barriers to Entry

At the time of divestiture it was viewed as too costly for a competitor to install an alternative to the local loop. In fact, the concept of cross-subsidization was so prevalent that many regulators openly questioned the LECs survival. As part of the divestiture settlements, the LECs argued

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[11] S. Oster, Modern Competitive Analysis, Oxford Press, 1994

that they could not survive without cross-subsidization revenues. In response, the courts mandated special access fees for the long distance carriers.[12]

The cost to a new entrant for installing new wires between the central office and many customers would have been extremely prohibitive. At the same time, the revenue per customer was low and it would have taken many years to generate a positive net present value.[13]

Government Regulation

As the sole provider of local access services, the LECs continued to derive considerable value from the concepts of cross-subsidization and universal service. In order to fund these initiatives, the FCC and PUCs have mandated various access charges that funnel revenues to the LECs. Although early figures were not available, an examination of access fees today indicates that these revenues have proven to be quite substantial. By 1997, Bell Atlantic was deriving $7.3 Billion of revenue or 27% of its Telecom Sector revenue from "Network Access Services"[14]. AT&T claims that the total amount of access charges paid by consumers and the long distance company totals about $20 billion.[15]

The consent decree that created the LECs also gave them control over the assignment of new telephone numbers as well as directory services such as Yellow Pages and Operator Directory service. Like the access fees, these products have also grown into a substantial revenue source for the LECS. In 1997, Bell Atlantic derived $2.3 Billion or 9% of its Telecom Sector revenue from "Directory and Information Services"[16].

These two examples illustrate an interesting difference between the perceptions of the government regulators and the LECs. When the divestiture was first announced, it was believed that the LECs would not be viable companies if they lost the revenues from Cross-Subsidization.

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[12] Gerald Faulhaber, Telecommunications in Turmoil, Ballinger 1987

[13] Bell Atlantic's Gross Domestic PP&E is about $77 Billion for about 47 million lines. Suggesting a book value of well over $1500 per line. The cost of installing a completely new infrastructure would be at least this amount.

[14] 1997 Investor' Reference Guide, Bell Atlantic

[15] http://www.att.com/publicpolicy/univserv.html

[16] 1997 Investors Reference Guide, Bell Atlantic

In an effort to head off this problem, the government granted the LECs several additional revenue sources including the access fees and directory services. What has actually happened is that the LECs have prospered since divestiture and they have used the additional revenues to fund expansion and their own capital structure. A new entrant would not be able to access either of these revenue sources and would thus be deprived of over a third of the revenues available to incumbent competitors.

Post Telecom Act of 1996

By 1996, three main forces were changing the nature of telecommunications. First, the growth of business applications based on distributed computing was contributing to an increase in the amount of data traffic carried over the telephone network. Likewise, the widespread growth of the Internet was causing a dramatic increase in the volume of data traffic. This trend has continued to accelerate. According to the U.S. Commerce Department, data traffic on the public network is doubling every 100 days (or 1000% per year) as compared with voice traffic, which grows at a steady 8-10% per year. By the year 2002, data traffic is expected to comprise over 95% of the total traffic carried by the network.[17]

The second force was the desire by the LECs and the long distance carriers to compete in the others market. Both of these market segments were widely considered to be lucrative opportunities and expansion from one market to another was a natural growth opportunity for the both types of competitors.

Technological innovation was the third driving force. It had become technically feasible to deliver television programming over the telephone lines, and to deliver voice and data services over the cable TV network. The switching infrastructure for providing long distance services had become the same as the infrastructure for local services. The separation between the two segments had become a historical artifact left over from the early days of telecommunications.

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[17] BT Alex Brown, Convergence of the Public Network, Research Report, October 1, 1998

The LECs and the long distance carriers believe that they can offer lower costs if they can bundle local and long distance services into a single product.

On February 1, 1996, after months of negotiations and political wrangling, the US Congress overwhelming passed the Telecommunications Act of 1996 (TA96). TA96 was the first comprehensive rewrite of the Communications Act of 1934. It dramatically changed the rules for competition and regulation in virtually all sectors of the communications industry including local and long-distance telephone services, cable television, broadcasting and equipment manufacturing. It also created important new obligations for state regulatory commissions on a variety of issues related to local exchange competition, and it spawned a large number of proceedings at the state level to implement the Act's provisions.

TA96 defined several new acronyms to represent various competitors. The Incumbent Local Exchange (ILEC) providers are the firms that provided local access connectivity prior to TA96. In most cases these firms were the LECs (also known as RBOCs or Baby Bells) created by the 1984 divestiture. Competitive Local Exchange (CLEC) providers are firms that are trying to compete with the ILECs in the local access market.

The goal of TA96 was to create competition in the local access market. According to an FCC representative, "...[TA96] will make it possible for consumers to choose their local telephone company the same way they choose their long distance company or cellular company today. [Consumers] can expect to see lower rates and more "one stop shopping" for local, long distance, video and wireless services."[18]

In broad terms, TA96 mandates that the ILECs must:

- Unbundle the local loops into sections (Unbundled Network Elements – UNEs) and lease either the UNEs or the complete loop to competitors.
- Offer local-access services on a "wholesale" basis to competitors.

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[18] Susan Ness, The New Telecommunications Marketplace: Radical Changes and Golden Opportunities, Remarks as part of the Public Policy Forum Series, The Wharton School of the University of Pennsylvania, February 22, 1996

- Offer competitors interconnection rights at all feasible points in the ILECs network.
- Allow "number portability" enabling customers to switch providers without changing their phone numbers.
- Create collocation facilities where a portion of the ILEC's Central Office is leased to a competitor. Through collocation, a competitor can obtain direct access to the local loops. Collocation is illustrated in Figure 8.

In addition to the new ILEC restrictions, TA96 allowed the telephone companies to compete with the Cable Television firms by providing video programming over their phone lines. The FCC was also given broader powers to regulate the local telephone market.

Discussion of Network Capabilities

As shown previously, the LECs exercised complete control over the local loop. In order to understand how the competitive environment has changed, we should first understand how the telephone network has evolved. As noted earlier, this synopsis is a simplified description of the network and is presented as a basis for discussion of network economics.

This second model represents the technical capabilities of the telephone network in 1996. High-speed data access is now important and schemes have been added for supplying this service. TA96 also contained substantial provisions for the Cable Television (CATV) industry. The model is first presented as a simplified network without CATV services.

An enhanced block diagram of the telephone network is shown in Figure 9. The consumer's phone lines have been replaced with a single phone line. The new line has been modified to support the simultaneous transmission of voice and data. There are several new elements that have been added to the network as well. At each end of the local loop, a special modem that supports both voice and data has been installed. The technology behind this modem is called Digital Subscriber Line (DSL). At the consumer end, a splitter is required to separate the voice and data traffic. In 1996, DSL had passed a number of trials and was considered technically feasible. However, the technology was not deployed and unavailable for general use.

In the Central Office, the DSL modems are incorporated into a piece of equipment called a Digital Subscriber Line Access Multiplexer (DSLAM). The DSLAM also incorporates a splitter that separates the voice traffic and routes it to the circuit switched telephone network "cloud". The data traffic is routed to the Internet cloud.

By 1996, two different schemes had evolved for transporting traffic over the network. The switching technology in the "telephone cloud" is different from that used in the "Internet cloud". The telephone network uses circuit switched technology that dedicates a physical connection between users. The circuit connection is "set-up" when a caller initiates a call and the circuit is "torn-down" when the call is completed. The circuit is dedicated to the users while the call is in progress and no other users can utilize those circuits until the call is completed. Circuit switched technology is optimized for voice traffic and is widely considered to be inefficient for data services.

In contrast, the data networks use Packet based technology. The user's data is parsed into small "packages" and then transported to its destination using a shared physical connection. This process is analogous to a package delivery service such as Federal Express. In the latter, users insert their documents into boxes that are then transported over a shared platform (i.e. an airplane).

There are two competing forms of packet technology. Asynchronous Transfer Mode (ATM) uses a fixed packet size of 53 bytes of information. (The "packets" are called Cells in ATM terminology). Although manufactures and service providers jointly developed ATM, the driving force behind its development was a desire by the LECs to efficiently carry voice, video and data services over the same network.

Internet Protocol (IP) was developed to interconnect computers. It uses a packet size that varies in length depending on the type of data switched. Most DSLAMS use the ATM protocol for transporting the data. IP is optimized for carrying data traffic. Users encounter technical problems when transporting voice or video traffic. These problems are likely to be overcome in the next few years.

The final consideration is the DSL modem itself. The acronym "DSL" refers to several different types of subscriber line technology. A summary of the different implementations is shown in Appendix A. In 1997, a new DSL standard called "Splitterless" ADSL or G.LITE was developed. This technology was designed for use in consumer households and is supposed to be cheaper to install and operate. DSL technology has been available since 1995 but the cost is only now becoming low enough to justify large-scale deployment. Only 39,000 DSL modems had been installed at the end of 1998.[19]

Voice and Data Services over Cable Television

The Telecommunications Act of 1996 (TA96) also permits direct competition between the Cable Television providers and the LECS. The act enabled the Cable Television (CATV) providers to provide both voice and data services to consumers while the telephone companies are now permitted to market video services delivered through the phone lines. Because CATV is operated through a separate wired network, CATV has the potential to be the first widely available alternative for wired communication services.

The introduction of voice and data over cable is conceptually straightforward. As shown in Figure 10, the cable is a second "wire" that bypasses the local loop. Consumers now have the choice of transporting voice and data over the cable "loop", the LEC's Local Loop, or some combination of both.

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[19] Telechoice.com, Resources: Deployment and Projections, http://www.xdsl.com February 26, 1999

While the concept of using CATV for other services may be appealing, there are several technical issues that must be addressed. CATV was conceptualized as a "broadcast" technology. The CATV network was designed to souıce a large volume of data (i.e. video) from one location and deliver it downstream to a large number of customers. It was not designed to deliver data on a customer by customer basis, nor was it designed to handle upstream communication. These latter two points are necessary for any sort of voice or non-video data services.

The solution to this dilemma is the Hybrid Fiber Coax (HFC) architecture shown in Figure 11, video traffic, voice traffic and data traffic are transported between the Cable Companies CO and a "Head-End" using a fiber-optic distribution network. The information arriving at the Head-End is broadcast to the consumer via the standard coaxial cable. Finally, the cable box in the consumer's premise filters out relevant data and delivers what is left to the consumer. Head End equipment is designed to support between 500 and 1000 households while an HFC network can be expanded as large as necessary. In addition to installing Head End equipment, the CATV cable between the head end and the subscriber's home may also require upgrading.

A home that is "passed" by the CATV infrastructure is a home that is located close to a cable distribution network. That is, the cable company can deliver its services simply by installing a cable between the subscribers home and a nearby utility pole or underground conduit. The CATV industry uses the "number of homes passed" to measure the total market size that can be serviced without any additional infrastructure investment (excluding the cable to the subscribers house).

The CATV infrastructure "passes" approximately 100 million homes in North America. At the beginning of 1999, between 500,000 and 600,000 subscribers were believed to be accessing the Internet over Cable. This number is expected to double by the end of 1999 and increase to 3M subscribers by the following year. [20]

The CATV companies provide the infrastructure for delivering cable modem services, while they partner with a separate company who provides content and access to the Internet. The largest cable Internet provider is @Home Networks. The @Home network and its partners currently pass an estimated 11 Million possible customer of which 330,000 have subscribed to Cable Modem data services. The second largest provider is a joint venture between Time Warner and Media One. This network passes 5 Million possible customers of which 170,000 have subscribed to Cable Modem services.

While the CATV alternative is considered attractive, there are several factors that may limit this technology's ability to compete with the existing local access infrastructure. First, only about one half of the market currently served by cable television has been upgraded to support Cable Modem service. Time Warner claims that half of its network is Cable Modem capable but that this number will be increased to 70% by the end of 1999.[21] TCI, which was recently acquired by AT&T stated that only 26 percent of its cable systems had been upgraded to support Cable Modems. The company expects to spend about $2 billion dollars by the year 2000 to upgrade its network.[22]

The CATV infrastructure servicing the remainder of the market will require an extensive upgrade before it can support data services. On the other hand, Cable Modem penetration is less than 2% of the serviceable market and not likely to be saturated for several years. Either way, at roughly $40/month for cable modem service, acquiring just 10% (10 million homes) of the local access market could generate up to $4.8 billion dollars of annual incremental revenue for the cable companies.[23]

A second potential problem with Cable Modem is operation of the network under heavy operating loads. In the HFC architecture, the connection between the head end and the users is a shared cable that all users depend on for their service. The cable network's capacity is lower than the total traffic that would be generated if all users accessed the network simultaneously. The Cable Company designs its network so that the cable can accommodate a statistically

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[20] Cable Modem Market Stats & Projections, http://cabledatacomnews.com June 1990
[21] Time Warner "Factbook", http://www.pathfinder.com
[22] Corey Grice, AT&T Faces @Home Subscriber Challenge, http://www.news.com April 14, 1999.

probable traffic volume. That is, the company estimates the number of users that are likely to access the network at any one time and designs the network to meet that load. In most networks, the actual capacity available to transport data is much lower than the capacity that would be necessary if all of the users simultaneously tried to access the network. The potential problem arises when demand for data bandwidth exceeds that available in the network.

The final concern with CATV as an alternative to the local loop is the ability to provide reliable voice service on par with the existing telephone network. The technology that is deployed today uses the HFC architecture described earlier. Voice traffic is separated at the head end and transported to a CATV owned circuit voice switch while data traffic is transported over an IP network. An example of this architecture is the Nortel Cornerstone products. The approach of using a separate circuit voice switch is expensive because it requires a complete circuit switched infrastructure on top of the packet network required for data. The CATV providers would prefer to use a voice-over-IP solution and only build one network. The standard, which will enable voice-over-IP is not expected to be available for at least two years.[24] (Cable modem standards are defined in more detail in Appendix B).

Other Alternatives to the Local Loop

In 1996, there were several alternative technologies that had the potential to replace the ILECs local loop. The first was generically called "Fixed Wireless". This technology was designed to replace the wire between the central office and the consumer with a fixed radio link. Major suppliers such as Motorola, Ericsson and Northern Telecom have been marketing Fixed Wireless systems since the early 1990s. These systems were somewhat successful in developing nations where the cost of installing copper wires was prohibitive. Northern Telecom was also successful selling its technology to a UK based startup company that was trying to compete with the British Telecom. [25] In the US market, this technology appears to have been too expensive to compete with the LECs.

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[23] http://www.timewarner.com
[24] 3Com, Arris and GI Modems Certified By CableLabs, http://cabledatacomnews.com May 1990
[25] http://www.ionica.co.uk

A second technology, loosely referred to a "Broadband Wireless" has also been evolving. In contrast to Fixed Wireless, which was designed for voice only, this technology is essentially a broadband wireless connection capable of supporting voice, video and Internet traffic. The Local Multi-Point Distribution System (LMDS) is designed to use local transmitters to connect between a central location and consumers. Last year the FCC auctioned off the necessary spectrum and two companies (WinStar and Teligent) have announced plans to deploy this service. This service is expected to be expensive with early installation costs being several thousand dollars per subscriber.[26]

There were a number of other technologies such as satellite, cellular and various radio protocols that were commercially available in 1996. While these offered remote or mobile users access to the telephone network, none were considered to be sufficiently reliable or cost effective for providing telephone service.

Porter Analysis

As shown in Figure 12, Porter's Five Forces model can be used to explain the impact of TA96 on the ILECs.

Intensity of Competition and Barriers to Entry

Competition in the local loop market is still low to moderate but will probably start to decrease over the next 2-3 years. The ILECs had previously operated in a relatively secure environment with limited competition in the local loop. TA96 was passed with the expressed intention to create a high level competition in the local loop. In fact, TA96 has created a unique competitive environment where the ILECs not only face competition, but they must enable the competition by leasing their assets to competitors.

The ILECs do not have an economic incentive to offer proprietary assets to competitors and thus will use whatever means are available to prevent or delay the CLECs from obtaining access to ILEC's facilities and loops. Early evidence exists to suggest that the ILECs are indeed limiting

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[26] Eugene Steckley, Broadband Wireless -- The Dawn of a New Era, America's Telecommunications, February 1998

access to their facilities. According to FCC survey data, effective September 30, 1998, Bell Atlantic/Massachusetts had leased about 100K lines out of a total of 4.5 million available lines. Only about four thousand of these lines were leased for residential use. Only Thirty-eight (14%) of Bell Atlantic's 283 Central Offices had an operational collocation arrangement. In New York, 268K lines out of 11.7 million lines available had been made available to other communication carriers. Seventy-three (14%) of Bell Atlantic's 522 Central Offices had an operational collocation arrangement. The FCC survey data was similar for ILECs operating in other regions as well.[27]

In contrast, Bell Atlantic executives claimed by February 1999, the company had employed 1,000 people to serve new entrants and that they had resold over 600,000 lines across their entire operating region (which includes most of the Northeast and Mid-Atlantic States)[28]. While the Bell Atlantic numbers are more aggressive than the FCC, they still represent less than 2% of the total number of lines that are available in the region.

It is important to note that the ILECs face multiple logistical and technical challenges that must be overcome before a large number of lines can be made available to the CLECs. These challenges include reconfiguring the CO to accommodate CLEC equipment, negotiating collocation agreements and establishing pricing that is acceptable to the ILECs, CLECs and the regulatory agencies. Since the implementation of TA96 is still in the early stages, the FCC survey results are not sufficient to conclude that the ILECs are not adhering to the statutory requirements of TA96. However, no CLEC has yet been able to acquire significant market share or create a competitive environment for the LECs customers.

Government Regulation

As described in chapter 1, the government has had an influence on US telecommunications market since the days of Theodore Vail. Although TA96 was supposed to "deregulate"

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[27] Responses to the third CCB Survey on the State of Local Competition, http://www.fcc.gov/ccb/local_competition/survey3/responses/

[28] J. Cullen, Speech delivered to Alliance for Public Technology, February 19, 1999. http://www.ba.com/speeches/1999/

telecommunications, it appears that the FCC and the PUCs continue to be very much involved in regulating this market.

The text of TA96 was embodied in about 15 pages. It included a fourteen-point checklist describing the ILECs obligation to open its markets. The ILECs would be allowed to provide long distance services once these conditions were satisfied. The FCC subsequently converted this checklist into some 600 pages of detailed requirements that effectively increased the complexity of the checklist and increased the regulatory burden on the LECs.

While telecommunications is still regulated, it appears that the nature of the regulation has shifted. Prior to TA96, the regulatory agencies were primarily concerned with setting rates and insuring that service levels were acceptable. After TA96, The regulatory agencies have continued to set prices based for legacy services such as plain old telephone service, leased lines and complementary services such as directory assistance. The formulas for these prices are still based on the underlying asset base although depreciation rates have been accelerated. The local PUCs have also started to set rates Unbundled Network Elements (UNEs) that the ILECs must lease to competitors. Many PUCs have also established arbitration and dispute resolution procedures.

Presence of Substitute Products

Perhaps the biggest threat to the ILECs is the emergence of CATV as a viable alternative to the local loop. Although the number of CATV Telephony users is less than 200,000[29] subscribers worldwide, this technology will eventually become the principle competitor to the ILECs in the consumer market. According to the CATV companies, the cost of installing customer premise equipment for both cable Internet and voice services is about $800 of capital investment per subscriber while the ILECs typically invest $1000-$1200 per subscriber for voice services only. The cable companies argue that this cost advantage will allow them to offer voice at 10% below ILEC rates for the first phone line and 50% below ILEC rates for a second phone line.[30]

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[29] Cable Modem Market Stats & Projections, http://cabledatacomnews.com June 1990
[30] Sam Masud, Cable Telephony: Say Hello to Your New Phone Company, America's Telecommunications, 12/98

Buyer Power

Consumers will continue to have limited buyer power until there is more than one company offering local telephone service.

Power of Suppliers

The power of suppliers is probably growing. Large companies such as Nortel, Lucent and Cisco are acquiring smaller rivals and offering equipment for all points in the network.

Conclusion

This chapter has provided a brief history of telecommunications in the US market. We have seen how AT&T embraced government regulation as a means to limit competition and control the market. The regulatory structure that evolved created a cost-based pricing structure and tended to discourage innovation.

The chapter highlighted two attempts to introduce competition in the telecommunications industry. The first was AT&T's divestiture of its local operating companies. AT&T continued to operate as a long distance carrier while the new Local Exchange Carriers (LECs) became regional suppliers of telecommunication services. The Long Distance market became very competitive while the LECs continued to operate as regulated monopolies.

The second attempt to introduce competition is the Telecommunications Act of 1996 (TA96). This broad legislation setup specific conditions that the LECs must meet in order to sell long distance services. At the same time, it legislated that the LECs must open up their local markets to competition by leasing their assets to new Competitive Local Exchange Carriers (CLECs).

The chapter also illustrated the evolution of telecommunications technology. Up until the 1990s, most of the traffic carried over the telecom network was voice traffic. With the explosion of the Internet and the widespread use of distributed computing architectures, the amount of data transported over the telephone network has expanded rapidly. Data traffic is doubling every 100 days and is expected to comprise 95% of all traffic by 2002.

Several new technologies have emerged as well. Digital Subscriber Line (DSL) technology offers the ability to have reliable Internet access that is up to 20 times faster than the older analog modems. In addition, the Cable TV (CATV) companies are also upgrading their networks to support voice, video and Internet access services. The CATV has become one of the principle platforms for competing with the LECs in the local access market.

Chapter 3

Creating and Capturing Value after TA96

While Porter's Five Forces model is useful for understanding the competitive forces acting on a firm, the model provides limited insight into how firms continue to capture value when new innovations alter the competitive environment. Teece[31] defined a three-element framework that seeks to explain how a firm can capture value from an innovation. While the framework is not directly applicable to the telecommunications industry, the elements of the framework are useful for suggesting strategies that telecommunication firms can use to expand their ability to capture value.

Teece's first element is the regime of appropriability, which measures the firm's ability to appropriate the economic rents created by an innovation. A firm that invests in an innovative product is not guaranteed to capture the value from the innovation. One way to insure appropriability is for the firm to use legal processes such as patent or copyright protection that prevents competitors from copying the innovation. While this technique works in certain industries, it is not difficult for competitors to find methods that circumvent the legal protection. The innovator may also discover that the cost of litigating against an infringing firm is greater than the economic rents that can be recovered.

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[31] David Teece, The Competitive Challenge, Ballinger Publishing, 1987

The second element of Teece's framework proposes that a firm can appropriate value from an innovation by the use of **complementary assets**. A complementary asset is some element of the firm's business process that is unique or difficult for a competitor to duplicate. The complementary asset helps a firm to appropriate value from an innovation while a competitor who has the same innovation may not be able to capture the value. For example, a design firm that develops a new widget may capture substantial revenue if it has a distribution channel that delivers the widgets to customers. A competitive firm with no distribution channel may develop the same product but not receive the revenue because it has to contract distribution to a third party. As the only link to customers, the third party will capture most of the rents from the innovation.

The third element of the Teece framework is the Dominant Design Paradigm. This paradigm refers to the innovation process during a product's life cycle. During the early stages of a product's development, competitors attempt to win market share by offering different versions, each having different features and product innovations. At some point, the industry settles on a dominant design, a particular mix of features that meet the needs of the consumers. Once the dominant design is established, vendors develop similar products and start to compete on price instead of product innovations.

The Teece framework is useful for analyzing how a firm can capture value from its innovations. In communications, the value is derived from the basic need to communicate rather than from a particular innovation. The service provider's objective to capture the value that is already available in the market. Teece's framework can be extended by first viewing the telecommunications market as a large "pie" and applying Teece's three elements to analyze the strategy of each competitor as they try to maximize their value capture from the pie.

The total size of the telecommunications pie has historically increased at an average rate of 5-7% per year. A rapidly expanding economy or a demographic shift may cause a sudden increase in the demand for telephone service. Likewise, the expansion of the Internet and the rapid introduction of client-server computer network architectures are two forces that are increasing the demand for data communication services.

Assuming that the telecommunication service providers are rational competitors, then each will follow a strategy that maximizes the value they can capture from the total "pie". One approach is to control assets that allow one supplier to maximize value capture. The ILECs control over the Local Loop or the CATV firms control over the local cable infrastructure are good examples.

An alternative method for capturing value is to influence government regulations so that a supplier becomes legally entitled to a portion of the pie. Theodore Vail successfully used this approach when he was building AT&T. Competitors can also increase value capture through the use traditional marketing techniques such as bundling products and services, versioning the product mix so that it appeals to multiple market segments or by simply providing good customer service that builds customer loyalty.

An third strategy for increasing value capture is for a competitor to develop new products that capture the value in an expanding market. As mentioned previously, demand for data traffic is doubling every 100 days while voice traffic is growing at a much slower 8-10% per year. A competitor focused on data traffic is likely to capture more of the "pie" than one who is trying to compete only in the voice area. In fact, the data segment is a significant opportunity because the dominant design for transporting data has yet to be established. Consumers today have a choice between analog modems, cable modems, xDSL modems and several others. None of these are considered to be clearly superior to the choices.

TA96 has created three different types of competitors seeking to capture value from the local access portion of the telecommunication pie. The ILECs are the incumbent providers. They have traditionally captured most of the value and it is reasonable to assume that they will work to protect their revenues. CLECs and CATV providers are essentially new entrants in the data/voice market. Their strategies are likely to focus on growing their revenues by capturing more of the total market. The strategy of each competitor is considered in turn.

ILECS

Prior to TA96, the ILECs' ability to extract value was derived from their control of the local loop. The total size of the local access market is roughly about $100 Billion and is clearly worth protecting[32]. In the previous chapter, the Porter Analysis showed that the local loop has allowed the ILECs to prevent competitors and new entrants from providing local telephone service.

The Local Loop can also be viewed as a "distribution channel" for voice communication services. By controlling Local Loop, the ILECs can extract most of the value available from voice services. In contrast, long distance carriers (i.e. AT&T, Sprint and MCI) do not have a direct consumer channel. They must pay access charges to the ILECs that are estimated to be six times that actual cost of supplying local access.[33] Although TA96 tries to reduce the ILECs control over the Local Loop, these factors suggest that maintaining control over the local loop will be a principle driver of the ILEC's business strategies.

A second driver of the ILECs strategy is to maintain their historical return on assets. Up until TA96, the ILECs have invested in their infrastructure under the business model prevalent since the early days of AT&T. That is, they structured their investments expecting a fixed return on capital that would be guaranteed through the PUCs. By introducing competition, which presumably will result in lower prices, TA96 implicitly limits the ILECs ability to get a fixed return. The ILEC's investments are in danger of becoming "stranded assets" that will be unable to generate their expected investment return.

Before proposing how the ILECs will defend their business, it will be helpful to understand the competitive threats that are surfacing. The local loop is under attack from three fronts. First, TA96 legislated that the ILECs must lease their loops and associated facilities to competitive carriers at "non-discriminatory" rates. The competitors can then resell local access services at a profit. The leasing rates are set by the local PUC and are supposed to be based on the cost of installing and maintaining the loop.

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[32] http://www.att.com

[33] AT&T Press Release, Plain Talk on the Future of Communications, September 29, 1998, http//www.att.com

To understand the impact of leasing the local loop, consider the situation faced by a consumer who would like to purchase high speed Internet access. Prior to TA96, the consumer was forced to use a POTS line supplied by the ILEC. The ILEC charged the consumer a rate that was regulated by the PUC but also achieved the ILECs return on investment goals. If the consumer was a small business or a wealthy individual, he could purchase a higher speed "leased line" from the ILEC. The leased line was more expensive but was also priced to meet the ILECs financial objectives. Either way, the charges were derived from the ILECs cost structure and the ILEC was guaranteed a revenue source that provided a fixed return on investment.

With the passage of TA96, a competitor can enter the market by leasing the local loop from the ILEC and install his own high-speed connection to the Internet. The competitor can market this connection to the consumer and charge whatever price the consumer is willing to pay. The revenue from the consumer is now split between the ILEC and the competitor. In fact, the revenue received by the ILEC is regulated by the PUC and is lower than the amount that the ILEC received prior to TA96. There is no reason why the ILEC cannot offer the same services as the new competitor, however the presence of two firms competing for the same customer is likely to result in a reduced total revenue as each firm lowers their prices in an attempt to grow their customer base.

The second attack on the local loop is from the CATV providers. As described earlier, CATV has the technology to bypass the local loop completely by providing voice, video and data services over the CATV infrastructure. If this technology becomes widely available, the ILECs will start losing customers if the cost of CATV alternative is lower.

The third consideration is that the primary source of value in the telecommunications network is transitioning from voice to data. As suggested previously, the dominant designs for delivering data services have not been established. If an alternative to the local loop becomes the preferred approach, then the ILECs will find themselves controlling a complementary asset that creates less value than it does today.

In addition to the competitive attacks, the regulatory environment of TA96 has forced the ILECs into a competitive "no-mans" land where some services such as voice telephony will continue to be regulated and new services such as high speed data will be unregulated. The competitive environment will be clouded further as the various competitors lobby government bodies for regulations that favor their respective organizations.

Faced with the threat to their critical complementary asset, the ILECs strategy can focus on one of three objectives. The first choice is to protect the loops and deny access to competitors. While this strategy would probably maximize the ILEC's value capture and continue to insure a fixed investment return, it is a direct contradiction of TA96. The second alternative is to encourage competitive access and attempt to compete directly with the new entrants. While this approach is in line with the intention of TA96, it was just shown that the ILECs would encounter a substantial reduction in revenues under this scenario. The final choice is to delay competitive access until the ILEC can establish a dominant market position in the new competitive environment. This approach seems the most acceptable in that it delays revenue loss for as long as possible and simultaneously allows the ILECs to position themselves in the new environment.

The new strategy leads the ILECs to pursue several strategies that delay new entrants and position the ILECs to capture the value in the new environment. These include enhancing the total value of ILECs product mix, developing relationships with suppliers and partners and managing the regulatory bodies to limit the market power of the CLECs. Each is considered in turn.

Growing the product mix.

In addition to the local loop, the ILECs control several other assets which will help them to continue to extract value from the transport of voice and data. These assets include infrastructure for customer service and billing, the capability to offer value-added services such as Caller-ID, voicemail and similar services, directory services including information assistance and Yellow Pages, and the engineering knowledge associated with building and maintaining a complex voice and data network. The ILECs also own a "brand" that presumably will be useful in retaining customers.

Perhaps the most critical service offering is the ability to bundle multiple services into "one-stop" shopping to the consumer. Several ILEC's have suggested that consumers would prefer to purchase telecommunication services from one carrier that provides local, long distance and data services as a single package.[34] Through the use of the capabilities just described, the ILECs can already provide one-stop voice and data services to most consumers with the exception of Long Distance (Inter-LATA) services. As a result, entry to the Long Distance market is a stated policy objective of all the ILECs.[35] Note that the ability to provide video services such as broadcast TV or video-on-demand is also lacking. Although it appears that the technical capability to supply video over the local loop is still not available, Bell Atlantic has started to co-market satellite TV as part of a bundled product offering.[36]

It is interesting to note that TA96 requires that many of these services be made available to competitive carriers. For instance, a competitive carrier can purchase network resources from an ILEC that includes the Unbundled Network Elements (UNEs) as well as the billing and directory assistance services, value added services and even expect the ILEC to maintain the network. The CLEC can bundle these services with long distance or Internet gateways and effectively establish a virtual phone company that offers a superior product but is based entirely on the ILEC facilities.

Partnering

The second area where the ILECs are attempting to enhance value retention is by developing relationships with companies that offer complementary services. Developing relationships that limit network investments becomes advantageous when one considers the source of economic rents. Prior to TA96, consumers utilized the ILECs networks to communicate with other

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[34] Refer to the "Executive Speeches" section of any of the ILECs web sites. A good example is the CEO of US West's speech to the Economic Strategy Institute, Is America Getting What Americans Deserve? http://www.USWest.com/about/speeches, February 3, 1999.
[35] ibid
[36] Press Release, Bell Atlantic Video Steps Up Marketing Efforts for Satellite Television Service, March 22, 1999

consumers. They paid only for the connection and the ILEC earned profit by providing the infrastructure necessary to deliver the connection.

Today, the consumer is looking for the service provider to offer a bundle of services that may include any of the products and services described in the previous paragraphs. The consumer is less likely to care how the service is provided and is more concerned that the services meet his or her needs. Likewise, as multiple competitors enter the market, the PUCs will be less inclined to allow the ILECs to earn a fixed return on investment. By outsourcing certain services, the ILECs will be able to bring products to market faster, reduce investment risk and develop a larger product mix to offer to consumers.

An example of where an ILEC benefits from a partnership is the infrastructure required for the transport of data traffic. As described in the first chapter, the ILEC's circuit-switched networks are no longer sufficient to carry the vast amount of data traffic being generated today. In other words, the Dominant Design for that has been established for voice traffic is no longer efficient when traffic volumes are dominated by data. In order to provide adequate data transport services, the ILECs must either invest heavily in building packet-based networks or they must outsource this capability to firms that already have packet-based networks in place. New carriers such as QWEST, Level 3 and Williams Communications are building packet-based networks that they intend to make available for this purpose.

Another benefit of partnering is that it creates new revenue opportunities for the ILECs. Today, the Internet is a growing channel for the distribution of products and information. Consumers typically pay vendors on a per transaction basis ("payment" in many cases is watching an advertisement) while the Internet Service Provider and the LEC receive a flat rate for giving the consumer unlimited network access. Since the ILEC controls the consumers access to the Internet, it may be possible for the ILEC to retain more of the value created by providing local access to the consumer. In other words, the ILEC will start demanding a fraction of revenues earned by Internet content providers.

In January 1999, Bell Atlantic and America OnLine (AOL) announced a strategic alliance to provide high-speed Digital Subscriber Line (DSL) access to AOL customers. AOL customers will be offered high-speed network access using DSL lines supplied by Bell Atlantic. AOL intends to offer the service for a premium of about twenty dollars over current rates. In return, Bell Atlantic will receive premium advertising space on the AOL web site and, in the future, a portion of the profits generated by additional services provided through the AOL portal.[37] AOL signed a similar agreement with SBC communications.

As suggested in the previous section, there is no insurmountable barrier that will prevent a competitive carrier from pursuing the same partnering strategy. The ILECs primary advantage is that they control the local loop and they can leverage economies of scale to offer a broad product mix.

Regulatory and Legal

The ILECs must cooperate with the FCC, the local PUCs and the new CLECs in order for TA96 to be successful. However, encouraging the implementation of TA96 will enable a new competitive environment where the ILECs will lose control over the local loop. It is logical to conclude that the ILECs will resist efforts to implement TA96.

Understanding how the ILECs might interact with the regulatory agencies is a complex topic. While the ILECs cannot legally refuse to abide by the terms of TA96, there are several areas where the ILECs are protecting their existing value capture capabilities.

The first area is to use bureaucratic tactics to delay a CLEC's access to ILEC facilities. As an example, TA96 specifies that the ILEC must allow collocation of CLEC equipment within the ILECs central offices. The ILEC is responsible for leasing the space, providing power, environmental controls and constructing a secure cage for the CLECs equipment. TA96 does not

[37] Bell Atlantic Press Release: America Online and Bell Atlantic Form Strategic Partnership to Provide High-Speed

specify the time or cost associated with providing this service. An ILEC wishing to delay a competitors market entry can delay the cage construction for up to six months for various reasons. [38]

A second method of delaying market entry of competitors is to use the legal system to delay the implementation of changes mandated by TA96. In 1997, SBC Communications, several other ILECs and several PUCs filed suit in the US Court of Appeals Eighth Circuit court challenging the FCCs authority to set rules for local competition. The court held in favor of the plaintiff and limited the FCC's ability to regulate local competition and instead shifted the authority back to the state PUCs.[39]

Although the US Supreme Court eventually overturned the decision, it did not give the FCC the broad powers originally granted in TA96. Instead, the courts found that the FCC's power would be judged on a "case-by-case" basis. This effectively allows the ILECs to delay any FCC ruling by challenging the FCC's authority on that particular issue.[40]

A third method for protecting against the CLECs is to increase their costs of leasing the local loops by citing additional cost burdens and adding complexity to the rate structure. For instance, an ILEC can argue that the tariffs on an unbundled local loops (i.e. loops that are leased to a competitor) are too low because the ILECs true costs include some burden for providing services to low-income users

In Washington State, a proposed rule change cited the fact that "...customers in many local telephone exchanges cannot call basic community services, such as schools, medical facilities, government offices and businesses, without paying toll charges." The proposed solution was to reduce toll charges while adding a surcharge of $0.25 per user to cover the revenue shortfall.[41]

Access for the AOL Service, 1/13/99

[38] Refer to the 10K disclosures of the major data CLECs such as Covad and Rhythms Communications.

[39] Blumenfeld & Cohen, Appellate Telecom Overview, http://www.technologylaw.com

[40] On Writs of Certiorari to the United States Court of Appeals for the Eighth Circuit, Supreme Court of the United States, January 25, 1999, Nos. 97—826, et al

[41] Washington Utilities & Transportation Commission, Docket: UT-970545, http://www.wutc.wa.gov,

While the merits of this proposed rule change are debatable, it clearly makes the task of understanding costs more difficult. Presumably, the surcharge would also be considered when setting rates for leasing local loops in the area as well.

The ILECs can also use tactics that make it difficult for consumers to switch to alternative carriers. In a complaint filed by a CLEC consortium, it was alleged that Bell Atlantic was using inappropriate business practices in its dealings with new competitors. The complaint included allegations of prematurely cutting off customers who have selected a CLEC before the alternative service was activated, missing directory listings for customers who have selected CLECs and limiting access to customer information.[42] These problems may be due to temporary service issues and do not prove that Bell Atlantic is actively discouraging customer defections through unfair business practices. However, the filing is an indication of the entry barriers that still exist for firms wishing to compete with the ILECs.

Competitive Local Exchange Providers

TA96 created a new class of telecommunications service providers called Competitive Local Exchange Providers (CLECs). The purpose of these firms is to compete directly with the ILECs in providing services over the local loop. Apparently there are many companies that believe they can be successful in capturing value from the local access market. Since the passage of TA96, over 100 CLECs have applied to operate in the State of Massachusetts.[43] Other states have recorded similar levels of interest.

At first glance, the market position of the CLECs does not appear attractive. Some of the CLECs are established companies such as AT&T or MCI while other competitors are new organizations formed specifically to take advantage of the market opportunity created by TA96. While the

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[42] Competitive Local Exchange Carriers Cite Continuing Serious Problems With Bell Atlantic in New York, Association for Local Telecommunications Services, April 22, 1999

[43] Department of Telecommunications and Energy, Commonwealth of Massachussetts. http://www.state.ma.us/dpu/telecom/index.htm

established competitors may have considerable network infrastructure in their other operations, none of the CLECs own the local loops that connect the customers to the central office. CLECs depend on the ILECs, their principle competitors, for access to local loops and customers. Given this limitation, what strategy can a CLEC use to capture value from the telecommunications market?

One approach would be for the CLECs to lease local loops at wholesale rates and then resell voice services to consumers. Several long distance companies have tried this model unsuccessfully. The cost differential between the wholesale and retail rates was not large enough to be profitable.[44]

In order to compete with the ILECs, the CLECs must offer products that are more valuable than the access services supplied by the incumbent provider. The most important element of this strategy is to offer products to customers whose communications needs are not satisfied by the incumbent carriers. The areas where the CLECs are most likely to be successful are the services that are not already controlled by an incumbent. Local telephony and video services are controlled by the ILECS and the CATV firms. The only remaining area is high-speed data access, demand for which is doubling every three months. It is logical to conclude that the CLECs strategy will be to focus on the delivery of data transport solutions to businesses and consumers.

In order to provide customers with advanced data communication services, the CLECs will have to invest in infrastructure as well as partner with other providers. According to press releases[45], the major CLECs that are focused on delivering data solutions (Covad, Rhythms, and Northpoint) have partnered with local Internet Service Providers (ISPs) to provide high-speed access services. The ISPs provide customer service and billing while the CLEC provides the DSL connection and the routing of the customer's data to the ISPs Internet gateway.

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[44] Price, Timothy, The Future of Broadband, February 3, 1999, MCI Website, http://www.wcom.com/about_the_company/public_policy
[45] Look at the press releases for the CLECs: http://www.covad.com, http://www.northpoint.com

The investment in infrastructure is also critical. Although the CLECs are leasing local loops from the incumbents, the CLECs need to develop other parts of their network that transport customer data from the CO to the Internet. The additional network elements include connections to long distance companies, Internet service providers and private networks. Software for supporting call routing, billing and customer service must also be developed. Although TA96 states that all of these functions can be purchased from the ILECs, it is difficult to see how a new entrant will be profitable by simply leasing these functions from the ILECs.

A recent FCC documents suggest that the CLECs are aggressively investing in new broadband technologies such as DSL. The CLECs have raised between $15 and $20 billion to invest largely in broadband. The FCC claims members of DSL Access Telecommunications Alliance (DATA) have raised over $1 billion in private markets for DSL ventures. Another competitive LEC, Intermedia, has raised $2.5 billion in the last eighteen months with which to build broadband facilities.[46]

Analyzing the financial reports of several CLECs indicates similar investment. Covad Communications lists on its 1998 YE Balance sheet net PP&E of $59M and cash of $64M. Subsequently, the company raised approximately $130M in an IPO and an additional $175M of debt. Total capital raised is approximately $400M. At the end of 1998, Rhythms Communications had raised about $230M through venture capital, debt and equity investments from MCI and Microsoft. Both Covad and Rhythms intend to provide high-speed data services using DSL technology.

Given the competitive limitations described above, is it reasonable to expect that the CLECs will establish themselves as viable competitors to the ILECs? The CLECs must generate substantial revenues before they break even on their capital investment. One strategy is to target business

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[46] Inquiry Concerning the Deployment of Advanced Telecommunications Capability, FCC Docket No. 98-146, February 2, 1999

customers who are generally more lucrative than consumers. In the US market, 87% of the DSL lines installed by CLECs are servicing business customers.[47]

CATV

Prior to TA96, the CATV companies operated in a quasi-regulated environment. The CATV firms delivered video programming over the Cable TV infrastructure. In most localities, there was only one CATV provider and their prices were subject to some form of government regulation. Although the cable companies control the principal distribution channel for video programming, the value of this channel is not as great as the local loop. CATV is different from voice communications in that most consumers can choose not to subscribe to the service. Consumers can choose to use traditional broadcast TV or they can simply choose not to own a television.

In recent years, CATV has come under attack from two fronts. The most obvious front is the satellite TV broadcasters. By October 1998, satellite TV had signed up about 3 million subscribers and were capturing about $900 million of annual revenue.[48] The second threat is from LECs who are planning to deliver video services over the telephone wires. Although TA96 specifically encouraged the LECs entry into the video market, there does not appear to be any company delivering this service.

The CATV firm's response to these threats has been to try and protect their existing business by enhancing the value of their core products. Unlike the ILECs, the CATV firms have never been guaranteed a fixed return on their assets. The CATV firms will not survive if they fail to offer product mixes that customers find valuable. As it turns out, the network upgrades that are required to offer improved programming also enable the provisioning of Cable Modem and Cable Telephony services. That is, once a CATV firm upgrades its programming capabilities, the marginal investment for supporting data and voice services is small.

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[47] Telechoice.com, Resources: Deployment and Projections, http://www.xdsl.com May, 1999

There are three areas where the CATV firms can increase the value that they provide to the consumer. The most obvious approach is to increase the value of their broadcast programming. Offering more programming channels, interactive services such as video-on-demand and improved customer service are some ways to increase consumer value.

As shown previously, the cable infrastructure was originally designed as a one way "broadcast" medium. The CATV firms must invest in their networks in order to provide the expanded services just described. According to documents available from the FCC, the investment in the cable infrastructure is substantial. Deployment of two-way broadband via high-speed cable modems in 1997 alone totaled $6 billion. Cable operator TCI has committed to spend $1.8 billion to upgrade its faclities, in part to provide broadband services. Another major cable operator, Comcast, has spent over $1.2 billion over the past three years to upgrade its cable systems.[49]

As expected, the cable companies are seeking to capture the value created through their infrastructure upgrades. Time Warner claims that its upgraded networks will offer "...improved picture and sound quality, enhanced programming services such as...multiplexed premium...and more local programming."[50] This statement suggests that improved programming is at least one of the company's objectives. Presumably, the cost to the consumer will increase as the perceived value of the programming increases.

The second opportunity to increase value is to capture the expanding portion of the telecommunications "pie". The dominant design for delivering data services to the consumer has yet to be established. Assuming that the LECs delay DSL deployment for the reasons indicated above, the CATV firms have a unique opportunity to establish cable as the preferred method for high-speed Internet access. The network upgrade required to offer improved video services also

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[48] USSB Press Release, U.S. Satellite Broadcasting Announces Continued Improvement In Its Third Quarter And Nine Month Results, October 22, 1998, http://www.ussb.com

[49] Inquiry Concerning the Deployment of Advanced Telecommunications Capability, FCC Docket No. 98-146, February 2, 1999

allows the CATV providers to offer Cable Modem services. In other words, once the network is upgraded, the marginal cost of supplying Cable Modems is much lower than the marginal revenue generated from subscribers.

The third opportunity is to capture economic rents from the incumbent LECs. Once the cable infrastructure has been upgraded to support enhanced video and data services, only a marginal investment is required to add voice capabilities. The CATV firms are now well positioned to bundle the three most important telecommunication products that are typically marketed to consumers.

Conclusion

This chapter has highlighted the economic incentives that are driving the three major types of telecommunication competitors. Assuming that the competitors are rational, then each will follow a strategy that maximizes the value that they can capture from the total market. One approach is to control assets that act as entry barriers to competitors, a second approach is to influence the regulatory bodies so that the competitor receives some legal advantage. Alternatively, firms can focus on capturing share as a market expands or they can capture market share from incumbent competitors.

The Incumbent Local Exchange Carriers (ILECs) have the most to lose from the competitive environment created by TA96. The legislation specifically requires them to open their market up to competition. At the same time, the CATV firms are introducing innovation that bypasses the LEC's principal entry barrier. Finally, the LECs are also faced with a changing dominant design paradigm as the majority of network traffic is going to be data. It was concluded that the best strategy for the LECs is to delay competition until they can better position themselves in the market.

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[50] Time Warner "Factbook", http://www.pathfinder.com

The Competitive Local Exchange Carriers (CLECs) are new companies setup specifically to capture value from the ILECs. These companies start with no market share and are dependent on a hostile competitor (the ILECs) for their network facilities. Given these limitations, the best way for the CLECs to grow is to offer innovative products and services that augment the ILECs offering. Consumers would be willing to pay a premium if they receive additional value for their money.

The final competitor is the Cable TV (CATV) companies. These firms are using their cable infrastructure to capture the expanding Internet access portion of the market. They are also planning to challenge the LECs for a portion of the voice market.

Chapter 4

Case Study: The Deployment Rate of High-Speed Internet Access.

"With consumers and businesses clamoring for faster access to the Internet, data is emerging as the dominant and most lucrative form of traffic on telecommunications networks, rendering traditional local and long-distance voice service less profitable."[51]

It is well known that the Internet is growing at a tremendous rate. In 1999, approximately 32 million households had some sort of Internet access. This number is expected to double by 2002.[52] Over 95% of households access the Internet through dial-up modems. It is widely believed that the bandwidth of analog modems is in adequate. A typical web page containing 1 Mbyte of data will take about 2.4 minutes to download with an analog modem operating at 56K bits/second. This rate is too slow for applications such as real time video, interactive games and downloading graphics and images.

We have already observed that high-speed access technologies such as DSL and Cable Modems, which offer access speeds up to 10 Mbits/second, are technologically feasible and currently being deployed. However, the actual penetration rates of these two technologies are very small. AOL,

[51] Nortel shares hop on Bell Atlantic deal, CBS MarketWatch April 8, 1999, http://cbs.marketwatch.com

which claims about 12.5 million subscribers, uses POTS lines and dial-up analog modems to service its customers.[53] Less than 1 million households or 3% of households with Internet access are utilizing non-dial up connections.

Despite the dramatic growth in Internet usage, consumers continue to use analog modems or higher speed leased lines that are only accessible in the work place. Given that there is market demand for high-speed Internet access, why have the telecommunication companies not rushed in to fill that demand? Is the delay due to a series of technology hurdles that must be overcome or is there some economic driver that is limiting the deployment rate?

As a case study for the framework developed in the previous chapter, I have studied the efforts by the ILECs, CLECs and CATV firms to provide high-speed Internet data access services to the consumer market segment. To meet the demand for higher speed Internet access, the ILECs and CLECs are deploying DSL modem technology while the CATV firms are deploying Cable Modem technology.

This analysis will focus specifically on the consumer market segment. This segment is best characterized by its large size (roughly 100 million possible customers). Consumers spend about $45 per month on local and long distance telephone service and about $25 per month for each additional telephone line. The average cost of Internet connectivity is about $18 per month. CATV costs $34 per month but only 67% of consumers actually subscribe to the service. Thus, consumers spend between $63 and $122 per month on voice, video and CATV services.[54]

In order to understand the prospects for DSL and Cable Modem deployment, it is helpful to first explain the current state of the two technologies and then to look at the current deployment levels. Data for this section was derived from a number of different sources. A complete list of contacts is presented in Appendix ??.

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[52] Forrester Research: Internet Access Winners, January 1999
[53] 1998 Form 10K America On-Line Incorporated, Securities and Exchange Commission
[54] Forrester Research, Do Consumers Want Bundling, August 1998

The State of Cable Modem Technology

When quantifying the "state" of a technology, there are many factors that should be considered. Some of the more obvious factors are the cost of equipment, cost of installation and the cost of operation. Other factors are the complexity of installing and managing the equipment, the service quality and the general availability of the technology.

Of the two technologies, anecdotal evidence suggests that Cable Modems are farther advanced than DSL. An informal survey of about 20 colleagues in the New York and Boston area suggested that Cable Modems were relatively easy to install and tended to perform as expected. Installation required a Cable Company technician to visit the customer site. The process was straightforward requiring the installation of a network card in the PC and connecting a modem box to the cable wire. The installation process took between one and three hours and there were only minor technical problems.

The CATV provider generally supplies the Cable Modem at an approximate cost of $300. The largest suppliers of Cable Modems are Nortel and Motorola. Companies such as Cisco, 3-Com, General Instruments and SONY are also expected to compete in this market.[55]

Although the users that I talked to considered the service quality to be acceptable, a recent article suggested that users located in densely populated areas were experiencing usage and service problems.[56] It was not clear if these problems are due to relatively minor technical issues or if there is a fundamental problem with the technology.

Cable Modem Deployment Rates

In chapter 2, it was suggested that the CATV firms would follow an aggressive strategy to defend their video franchise from telephone companies seeking to compete in the video domain. The

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[55] IBID

[56] Christopher Byron, Trying to call but no one's At Home, http://www.msnbc.com March 31, 1999

threat from the telephone companies has not yet materialized. Although several ILECs such as Bell Atlantic are marketing Satellite TV services, my research was unable to uncover any LEC that was supplying video services over the telephone lines. The reasons for this are debatable but are most likely related to the high cost of a DSL installation and a lack of infrastructure necessary for delivering video over DSL.

In chapter 2, it was suggested that the CATV firms would deploy Cable Modems as a means to increase their total share of the telecommunications pie. The CATV firms have been rolling out Cable Modems at a robust rate. As of April 1999, over 815,000 subscribers were believed to be accessing the Internet over Cable. This number is expected to reach 1 million subscribers by July 1999 and increase to 2M subscribers by the following year. [57] The companies with the largest potential user base are @Home Networks with an estimated 15 Million possible data customer and 460,000 data service subscribers. Road Runner is the second largest with 8 Million possible customers of which 250,000 have subscribed to the service. The two suppliers are added about 2000 customers per day. Note that these two companies supply the Internet access while the local cable companies supply infrastructure.

While the absolute number of active Cable Modem users is substantial, the total penetration rate still appears to be at the early stage of the demand curve. The Cable Television (CATV) infrastructure passes approximately 100 million homes in North America. Of these, approximately 26 million are capable of supporting Cable Modems and about 3.2% have actually subscribed to the service. Assuming the 2 million-subscriber mark is accurate, total penetration will be about 7.6% of the total market by the end of next year.

The revenue impact on the LECs is difficult to determine but most likely small. Assume that a customer who subscribes to a Cable Modem service simultaneously disconnects one phone line. If the LEC charges $25.00 per month, then the annual revenue impact is about $300 per subscriber or about $600M dollars. In contrast, Bell Atlantic's revenues are about $13 Billion and the total revenue for all LECs exceeds $100 Billion.

Cable Telephony Deployment Rates

I was unable to find any reliable figures indicating the current penetration rate of Cable Telephony. One article stated that Cox Communications had signed up 20% of its customers in Orange County, California and that MediaOne was offering the service to 35,000 customers in Los Angeles.[58] Given these numbers, it is reasonable to conclude that there are fewer than 100,000 subscribers currently using Cable Telephony.

While these figures are not very impressive, they are likely to change in the near future. AT&T apparently believes that Cable Telephony is the way past the local loop. The company has recently completed a merger with Telecommunications Inc, one of the largest cable companies in North America. To further demonstrate its commitment to the cable medium, AT&T signed contracts to purchase $900M of cable telephony equipment before the merger received full approval.[59] In April 1999, AT&T successfully bid to purchase MediaOne, another CATV firm.[60]

In February 1999, AT&T and Time Warner announced a joint venture to supply Cable Telephony to residential and small business customers. The venture, which includes several other cable companies, claims that it will bring Cable Telephony coverage to 40% of the United States. The target penetration rates are 5% in 1999 and 25% in five years. Time Warner claims that the capital investment is about $700 per subscriber and that this amount will drop to around $350 once Voice-over-IP becomes available.[61]

This joint venture is an ambitious technical undertaking and a complex business arrangement. While discussing the venture's success potential is beyond the scope of this paper, it is worthwhile to note that the target penetration rate is about 10% of the US population in 5 years. These subscribers are likely to be users who currently have multiple phone lines and are heavy

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[57] Cable Modem Market Stats & Projections, http://cabledatacomnews.com June 1990
[58] Sam Masud, Cable Telephony: Say Hello to Your New Phone Company, Americas Telecommunications, December 1998
[59] IBID
[60] Press Release: AT&T offers $62 billion in cash, stock and assumed debt and preferred equity for MediaOne, http://www.att.com April 22, 1999

users of Internet and data services. Assuming that the average customer replaces two phone lines (total $50/month), the revenue impact on the ILECs will be $600 per subscriber or $6 billion dollars per year!

State of DSL Technology

In contrast to Cable Modems, there is evidence to suggest that DSL technologies are facing a variety of technical problems. A survey of DSL chat boards[62] indicated that there were a variety of problems associated with DSL installations. Several users claimed that the DSL hardware was subject to interference and had reliability problems. While these problems are most likely due to technical issues, it is likely to take a year or longer before a user can install a modem without encountering problems.

In addition to the technical hurdles, most DSL installations require that a technician install a "splitter" on the customer premise. This process includes the modification of the customers phone wiring and often takes several days worth of labor. The combination of unanticipated technical problems and longer than expected installation times has resulted in an average installation costing about $1500 for labor and $1000 for the hardware.

Another indication that DSL is still not technically feasible is the state of G.LITE, a new standard that was expected to simplify the installation issues associated with DSL. This technology was designed to reduce installation costs through the use of new hardware that would be purchased directly by the consumer and installed without a service technician. A trial conducted by BellSouth and GTE found that G.LITE was still susceptible to various interference problems implying that DSL technologies are still not mature enough for large scale deployment.

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[61] Communications Joint Venture Between AT&T and Time Warner, Investment Community Briefing, http://www.pathfinder.com/corp/att_tw/attindex.html February 1, 1999,
[62] Check out the users group at: http://www.xdsl.com

DSL Deployment Rates

The deployment rates for DSL appear to be much slower than the Cable Modem rollout. Deployments in the US totaled about 73,000 users at the end of March 1999 up from about 39,000 users at the end of 1998. About 15% of the installations are CLEC based while the remaining 85% are owned by the ILECs. Approximately 70% of the installations are for residential customers. Assuming that the total market size is represented by the 32 million Internet users, then DSL penetration rates are less than a quarter per cent.[63]

This deployment rate appears to conflict with the public statements of the ILECs. Executives at Bell Atlantic corporation claims that, by the end of 1999, the company will have "equipped" 10 million lines in its service area. The company is focusing on major metropolitan areas where "...customer concentrations make deployment economic." DSL service is available in "...parts of the Pittsburgh, Philadelphia and the Washington, D.C., metropolitan areas, as well as in the Hudson River waterfront communities in New Jersey." [64,65] Bell Atlantic's PR office indicated that DSL would be available in Boston and New York within two months.

Bell Atlantic and SBC Communications have signed agreements with AOL to jointly market AOL's Internet services using DSL lines supplied by through the two companies. While these agreements were signed at the end of 1998, the service is still available to the mass market.[66] AOL claims that it has over 12 million subscribers.

These robust deployment statistics are not limited to the ILECs. Covad Communications (a CLEC) recently stated that it was capable of servicing a total of 6.0 million homes and business but had only installed a total of 3,900 DSL lines. Northpoint and Rhythms Communications also made similar claims.

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[63] Telechoice.com, Resources: Deployment and Projections, http://www.xdsl.com May, 1999
[64] April 8, 1999. Bell Atlantic Signs Network Technology Agreements with Nortel ... http://www.ba.com
[65] Cullen, James Speech Delivered to Alliance for Public Technology, February 19, 1999.
[66] Press Release: AOL and Bell Atlantic Sign Joint Agreement... http://www.bellatlantic.com

ILECs

As mentioned in chapter 2, the ILECs principle objective is to retain its control over the local loop and to maximize the value retained from this asset. Since the ILECs capture most of their value by controlling the local loop, it will be helpful to review the revenue drivers that create the value. Recall that the LECs provide all telephone services within their local operating areas.

The principle source of revenue is telephone line service whereby the LEC charges a residential or business customer use of a telephone line. The user is free to connect his telephone, fax machine, modem or any other device to the phone line. Regardless of what is connected to the phone line, the LEC transports the information over the local loop to a central-office where it is then transported over a "back-bone" network to its destination. The LEC charges the consumer a fixed monthly charge for the use of the line and an incremental "per-minute" charge for calls made outside the local calling area.

For the most part, these charges are regulated by the local PUCs and are based on the LECs investment in the network. The concept of cross-subsidization is still prevalent. Business users, who presumably can afford higher rates, are charged more than consumers for the same service. The LECs are also required to adhere to the universal service concept and is obligated to provide "affordable" telephone service to everyone.

If a caller initiates an inter-state long distance call, the LEC routes the call to a long distance carrier (i.e. AT&T, Sprint or MCI) who then connects the call to its destination. Although this type of call requires the use of the LECs local network, the LEC does not collect revenue directly from the consumer. Instead, the LEC charges the long distance carrier an "access charge". This charge is about 35% of the total revenue collected by the long distance carriers. In 1997, Bell Atlantic collected about 27% of its revenues from network access services.

While plain old telephone service is the largest source of revenue, the ILECs also derive revenue from many other sources. One major revenue source comes from supplying telephone lines that are dedicated to the transport of data. These services, usually called Leased Line or Frame Relay services, generally involve transporting data between the customer premise and a fixed destination. Many businesses use dedicated lines to connect to Internet Service Providers (ISPs) who in turn provide access to the Internet. Bell Atlantic claims that the market for connecting networks is worth over $5 billion.

The LEC also collects revenue from the consumer for access surcharges mandated by the FCC. These charges are justified by the need to fund services that cannot be funded directly. For example, 911 emergency services are usually funded by an access charge. Other sources of revenue include charges for directory assistance, yellow pages directories and value added services such as Caller-ID, electronic voice mail and so forth.

If the ILECs were to embark on a mass deployment of DSL services, there is potential to impact revenue in at least three ways:

- Many consumers who are heavy Internet users also purchase additional POTS lines for use with their computer modems and fax machines. The ILEC usually receives a monthly fee for this line of approximately $25/month or $300/year. It is difficult to determine how many consumers actually subscribe to a second phone line, however if 50% of the 32 million Internet users pay for a second phone line then the revenue totals about $4.8 billion. Usage of POTS lines for Internet access has been increasing steadily and the ILECs have been investing in additional circuit switching equipment to meet this demand.

  Bell Atlantic, SBC Communications and other ILECs are planning to sell DSL based Internet services to consumers for about $40/month. Assuming the consumer disconnects the second phone line, the ILEC receives an incremental revenue gain of $15/month or $180/year. However, the ILEC must also incur a capital expenditure of $1500 (the consumer will pay some of the installation costs) and may also have to write off some of its investment in the circuit switch equipment. Recall that DSL offers the capability to carry voice and data over the same wire. Thus, the revenue impact may be greater if some consumers disconnect both of their phone lines.[67]

- The introduction of DSL is likely to cannibalize revenues that the ILECs collect from leased lines, which are sold mainly to business. A high speed T1 line (a dedicated point-to-point connection that carries data at 1.5 Mbit/s) generates an average of $1000 in monthly revenue for an ILEC. In contrast, a DSL line costs a business user about $300 per month or 70% less than the T1 line. In 1998, total leased line revenue was about $13 billion. Using the 70% cost reduction as a proxy, the ILECS would lose about $9 billion of annual revenue should the entire business customer base switch to DSL. In addition, the ILECs would incur a capital cost of about $2,000 per line to install the DSL modems and they would have to write-off the existing leased line infrastructure.[68]

- Another potential impact of DSL deployment is an increase in the use of voice-over-IP as a replacement for long distance voice calls. Voice-over-IP is a technology that uses the Internet to carry voice traffic. Calls made via this method are about one cent/minute and are substantially cheaper than standard long distance calling charges currently at about 9 cents/minute. The ILECs currently charge the long distance carriers an access fee totaling about 3 cents/minute for a long distance call.

While the actual impact DSL deployment would have on the ILECs leased line business is debatable, it is clear that DSL will lower the value of the Local Loop and reduce the ILECs ability to maintain its historical return on asset ratios. Massive DSL deployment will have the opposite result of the ILEC's goals that were defined in Chapter 2. Given these business limitations, it is difficult to see how the ILECs will be economically incentivized to deploy DSL services.

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[67] Inquiry Concerning the Deployment of Advanced Telecommunications Capability, FCC Docket No. 98-146, February 2, 1999
[68] Alex Gove, Toeing the Line, Red Herring, May 1999

Despite what appears to be limited economic incentives, the ILECs claim to be deploying DSL capability. Although I was unable to find an accurate estimate of customers currently subscribing to Bell Atlantic's DSL services, the press releases referred to above suggest that the ILECs are aggressively rolling out the service.

Some of the confusion may be due simply to terminology. As shown in chapter 1, a DSL connection requires that the LEC install hardware in the Central Office as well as on the customer's premise. At the end of March 1999, a total of 1,855 Central Offices were DSL "equipped". Assuming that a Central Office services 25,000 customers, than LECs can theoretically support 46 million DSL connections.[69] Given that less than 100,000 DSL lines are in service, it is unlikely that the LECs have purchased equipment to support 46 million users. Instead, the LECs have most likely installed enough equipment to support a few users in each Central Office. It is more reasonable to conclude that the ILECs are capable of deploying DSL but have not purchased the equipment necessary to support a large number of installations.

An alternative explanation may simply be the logistics of installing a DSL line. As described earlier in this chapter, a DSL installation requires a service technician and several hours of labor at the customer's premise. At the same, the connection must be made between the DSLAM in the Central Office and the Internet Service Provider's network. A simple explanation could be that DSL lines are being installed at the maximum rate given a limited number of trained technicians.

An Alternate Explanation for the DSL Deployment Rate

While terminology and installation problems may account for some of the discrepancies in the number of DSL deployments, it is likely that there is some other issue as well. Recall that the ILEC's strategy is to protect their control of the local loop and maintain their return on assets. Massive deployment of DSL does not achieve either of these objectives and is likely to have a negative impact on the ILECs total revenue.

[69] Telechoice.com, Resources: Deployment and Projections, http://www.xdsl.com May, 1999

An alternative explanation may involve the relationships that exist between the PUCs and the ILECs. A recent interaction between Bell Atlantic and the Pennsylvania PUC provides some insight into this relationship. In 1994 and 1995, Bell Atlantic signed agreements with the Pennsylvania PUC that committed it to modernize its network and "protect" basic phone rates. During a recent debate regarding competition in the Pennsylvania local access market, Bell Atlantic cited these agreements and claimed that it has reduced rates by a cumulative total of $120 million (over 4 years) and is investing $18 million per week in its Pennsylvania network.[70] A counter claim stated that the "...advanced technology services deployed in Pennsylvania [are] largely unavailable to residential and small business customers"[71] implying that residential customers were not receiving the benefits of Bell Atlantic's investments.

Although these statements are likely to be somewhat biased; they do provide some insight into how the ILECs are seeking to maximize their value capture. First, if we accept the broad assumption that the cost curves for telephone service should be similar to the cost curves of computer technology, then the $120 million of cumulative savings is low compared to the $27 billion in revenues that the company collects each year. It is plausible to argue that the reduction in rates is much smaller than the reduction realized through the investment in new infrastructure. Second, if an ILEC is aggressively investing in lower cost switching equipment, then the PUCs would require that the cost savings be passed on to the customers. By claiming that the investments are for "broadband Services", then the ILEC effectively hides its real cost savings and simultaneously projects an image of aggressively deploying new technologies.

While collecting supporting evidence for this hypothesis is beyond the scope or this paper, it is worthwhile to note this strategy is consistent with the strategy proposed in chapter 2. The company is protecting its control of the Local Loop and simultaneously expanding its value capture by lowering its costs faster than it lowers its rates. At the same time, Bell Atlantic is

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[70] Press Release, Bell Atlantic Responds to Pennsylvania State Senate Committee Action on Telecommunications Bill, May 4, 1999

introducing "premium features" and broadband capabilities that potentially would be valuable in a future bundled service offering.

CLECs

As noted earlier that the CLECs were likely to have difficulty obtaining access to the ILECs local loop. The Financial Statements of various CLECs all suggest that difficulty in obtaining collocation agreements and loop access represents a significant risk to their business plans.

Bell Atlantic states that it has spent $1 billion to open its networks to competitors and that over 1,000 people staff its resale center. The number of collocation agreements signed so far suggests that the ILECs are allowing access to their facilities. Northpoint Communications claims that it has installed equipment in over 200 central offices, and Covad had 168 operational collocation facilities.

Unfortunately, the number of actual DSL lines in service is small. Rhythms Communications claims to have 650 lines in service and 9,000 lines under contract[72].

Conclusion

In chapter 2, it was suggested that the CATV companies had an economic incentive to invest in their infrastructure and expand their video programming and Internet access services. Based on the deployment rates just summarized, it appears that Cable Modems are being deployed rapidly. However, the total number of deployments is still relatively small. It is possible that the innovators and early adopters are the dominant customer in the subscriber base. As discussed above, DSL services are not yet available on the same scale as Cable Modem technology. Cable Modem deployment rates may slow down if DSL becomes available.

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[71] Press Release, President of Economics and Technology Says Bell Atlantic's Own Research Shows Company has Failed to Keep Promise to Provide "Broadband Service", April 28, 1999 Source: Pennsylvanians for Local Competition

[72] 1998 Form 10K Northpoint Communications Incorporated, Securities and Exchange Commission

The CLECs deployment rate of DSL is consistent with their business position outlined in chapter 2. They appear to have been encountered various delays in setting up DSL networks and their penetration has been mostly to business customers.

Finally, it is not clear what the ILECs are actually deploying. Their press releases suggest that they actively deploying the technology, but there is evidence to suggest that they are focused on expanding their value capture in other ways.

Chapter 5
Conclusions

Throughout its history, the communications business has been a regulated industry. AT&T successfully created a legal monopoly that operated in an environment that discouraged deployment of new technological innovations. The divestiture of AT&T successfully created competition in the long distance market, but allowed the local access market to continue operating as a regulated monopoly. As the primary access point between users and the telecommunications network, the local access providers extracted the most value from the telecommunications market. The Telecommunications Act of 1996 was designed to open up the local access market to competition. At the same time, the demand for communications was also evolving to a data-centric network and new technologies are enabling competition in the local loop.

This thesis demonstrated that the competitors have evolved different strategies for maximizing the value that they can capture from the telecommunications market. The ILECs will try to delay the effects of TA96 while positioning themselves as the dominant providers when local access competition does become a reality. The CLECs are fully dependent on the ILECs for access to the local loop and thus have targeted customers whose communications needs are not satisfied by the incumbent carriers. The CATV providers are upgrading their networks to support enhanced video services and the incremental costs to add Cable Modems and voice telephony are relatively small.

This thesis concluded with an analysis of the market for high-speed consumer Internet access. While consumer usage of the Internet has grown rapidly, few consumers have the option of using DSL of Cable Modems as their principal connection to the Internet. The primary limiting factor is that the economic drivers either limit deployment rates or encourage investment in other areas.

The ILECs run the risk of cannibalizing existing revenue sources and they can obtain a better return by investing in other parts of their business. The CLECs have sited the complexities of obtaining collocation facilities and local loop access as the principle limit to growth. The CATV providers have been the most successful in making high-speed Internet access available to their customers but penetration levels are still low.

This thesis has provided an introduction into the complexities of the telecommunications business. This industry still operates under a regulatory umbrella and the incentives to invest in new technologies may not align with a firms desire to maximize value and profits. It would be easy to conclude that the cable providers have incentives to deploy cable modems but they are limited by technology factors, the ILECs face incentives that discourage deployment of DSL and the CLECs DSL deployment rate is limited by the ILECs incentive structure. However, there are a number of events that could easily alter this scenario. The ILECs may discover that the CLECs can actually be valued partners. Perhaps the ILECs will start to use competitive carrier to more effectively address market segments that are too small for the ILECs. Alternatively, a new set of court rulings and FCC regulations may change the opportunities for capturing value.

The various scenarios suggest several possibilities for future study. Will the LECs continue to benefit from a regulatory environment that insures a constant return on their assets? Lastly, the relationships that exist between the PUCs and the FCC have been subject to various reviews by the US court system. Do these relationships encourage or discourage innovation? Would the innovation rate increase if a single entity such as the FCC regulated all of the communication companies?

As this thesis was being completed, AT&T agreed to by MediaOne, one of the largest independent cable operators. AOL and Hughes Networks started a joint effort that will deliver television and Internet access through Hughes satellites. These combinations have the potential to impact the competitive landscape by changing the distribution of the economic rents. There will clearly be more changes as the competitors seek to increase their value capture in the telecommunications industry.

Appendix A

Figures

Figure 1: Organization chart of AT&T, circa 1920

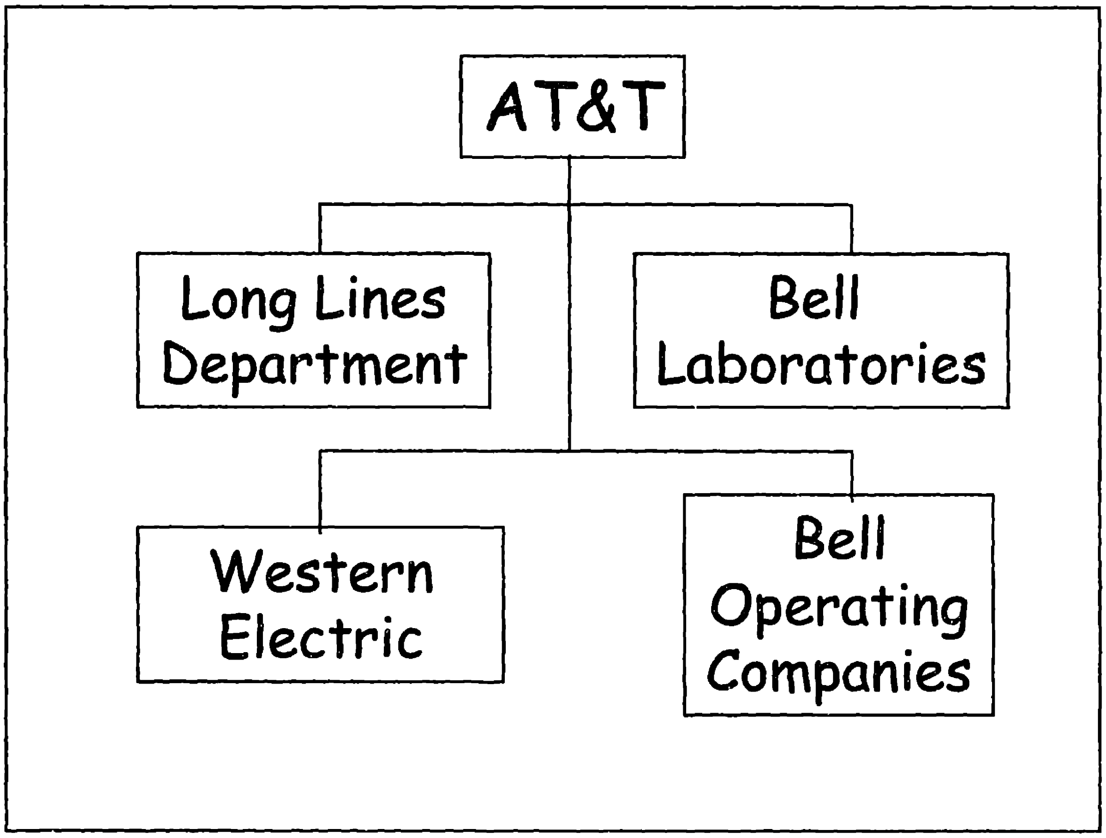


Figure 2: Long distance and local call processing

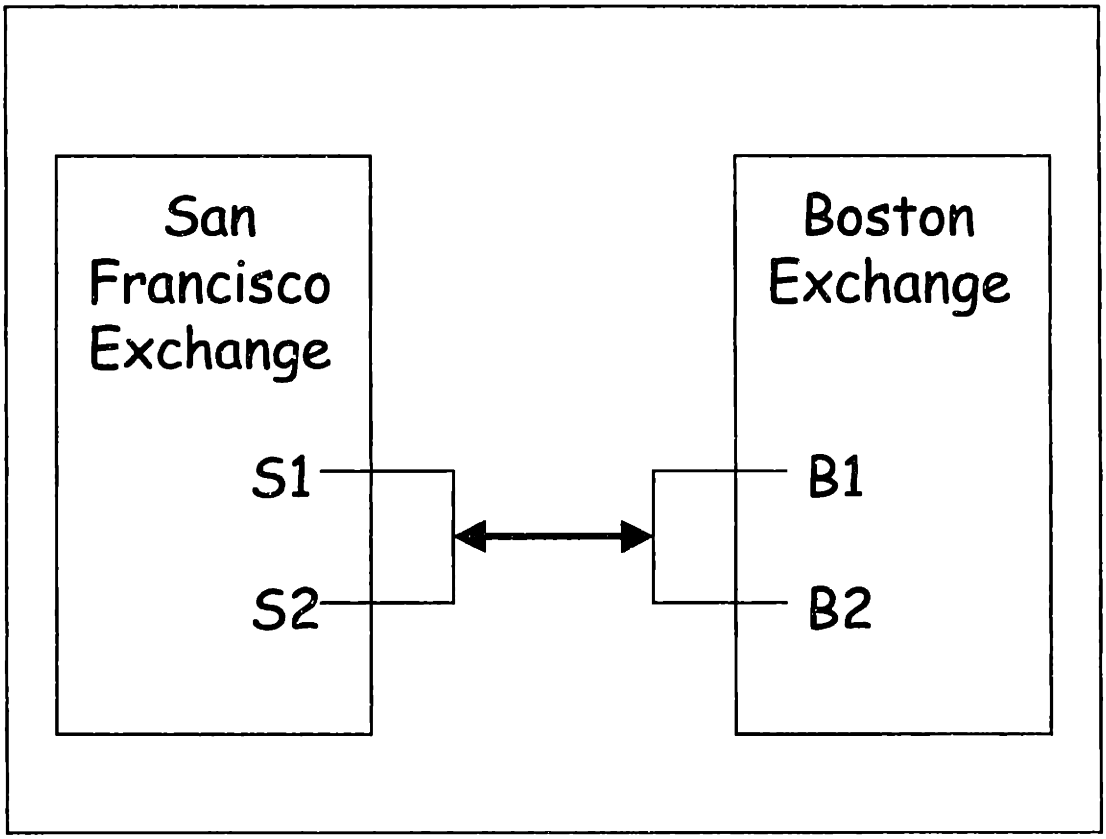


Figure 3: Telephone company revenue calculation

Depreciation and Innovation in Telecommunictions

R = Regulated Rate of Return
r = Telco's cost of capital

Period 0: Machine with Book Value Bo can either be replaced with new machine costing Eo. Maintenance cost on new machine is dEo, Accounting depreciation rate is s (s<d) and

$$Bo = a * Eo, a >= 1$$

If telco installs new machine, then a = 1

If Telco continues to operate old machine, book value will be greater than economic value and a > 1.

In Period 1, Book Value B1 =

$$B1 = Bo + dEo - sBo = Bo*(1-s) + dEo$$

In Period t, Book Value Bt =

$$Bt = [a * (1-s)^{t} + d * \Sigma (1 - s)^{i-1}] * Eo \quad ;Sum\ i = 1\ to\ t$$

The Present Value of the old machine is given by:

$$V^{o} = (\Sigma (1+r)^{-t} * [R * Bt^{o} - dEo] \quad ;Sum\ t = 1\ to\ inf$$

The Present Value of a new machine is given by:

$$V^{n} = (\Sigma (1+r)^{-t} * [R * Bt^{n} - dEo] - Eo + z*Bo^{o} \ ;Sum\ t = 1\ to\ inf$$

and $z*Bo^{o}$ is the real scrap value of the old machine. So...

V^{o} is always greater than V^{n} as long as the scrap value of the old machine is less than the cost of the new machine.

Conclusion: The Present Value of old equipment is always greater than the Present Value of a new replacement. This is always true if the book depreciation rate is less than the economic depreciation rate. The Telco earns greater revenues if the book value remains high

Figure 4: The US Telecommunications Network, 1990

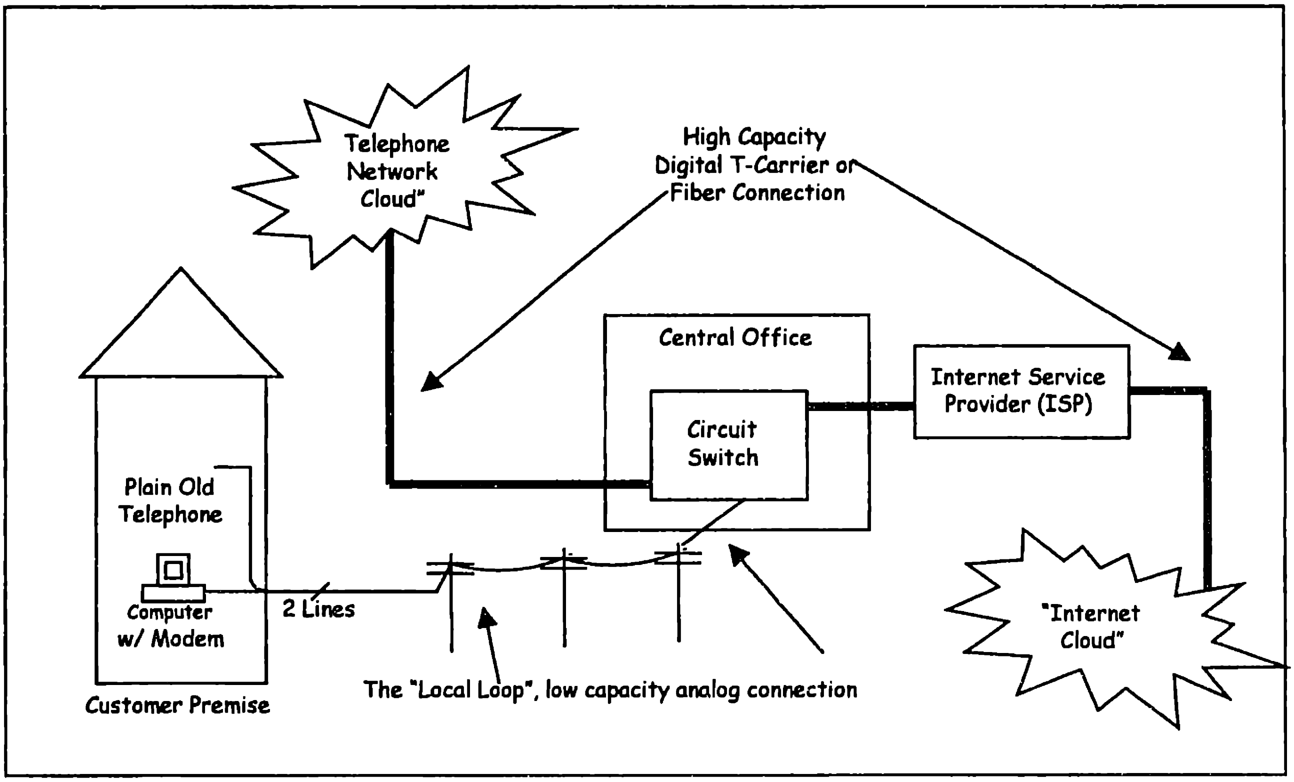


Figure 5: Digital "leased line" services provided by the LEC.

Circuit Type	Speed
"56K Line"	56 Kbits/second
ISDN	64-128 kbits/second
Fractional T1	64, 128, 256 or 384 Kbits/second
T1/DS-1	1.544 Mbit/second
T3/DS-3	45 Mbits/second

Figure 6: How an analog modem is connected to the telephone network.

All digital data is not the same. The figure illustrates how digital information is transmitted between two computers over the telephone network. The "Digital Data" that resides at the customer premise is converted to an "analog" format by the modem. The local loop then carries this data to a telephone central office that converts the data again to a digital format called "Pule Code Modulation" or "PCM".
The digital switch aggregates traffic from all the local loops entering the Central Office and transmits the information into the "cloud". The cloud is a euphemism for the high speed interconnections between telephone company Central Offices. The entire process is reversed at the destination central office and the customer premise site receiving the data.

Data transported over the telephone network must be undergo up to four format conversions. This process is inefficient resulting in slower transmission rates and increased likelihood of data corruption.

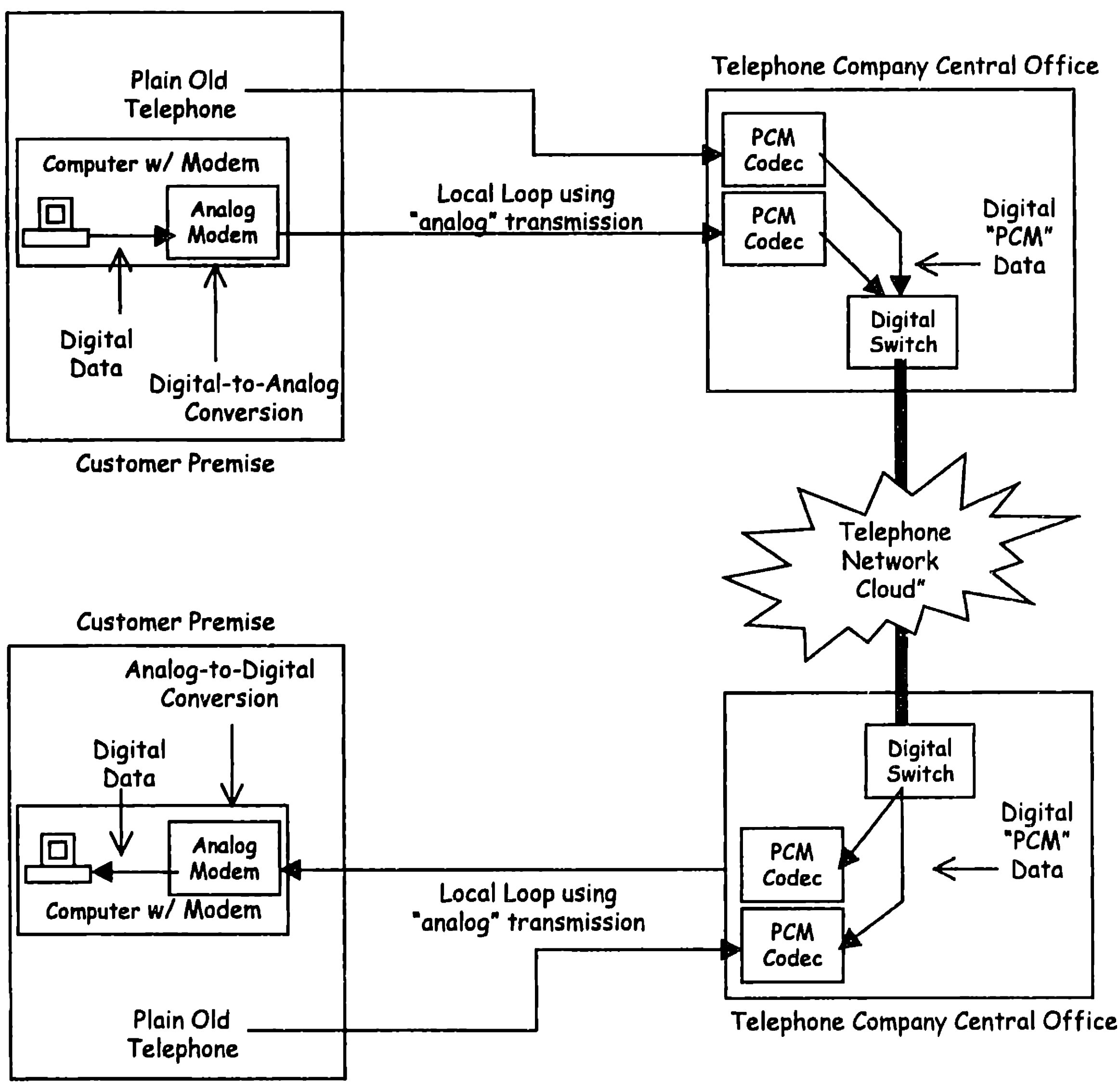


Figure 7: Porters Five Forces: Post AT&T Divestiture

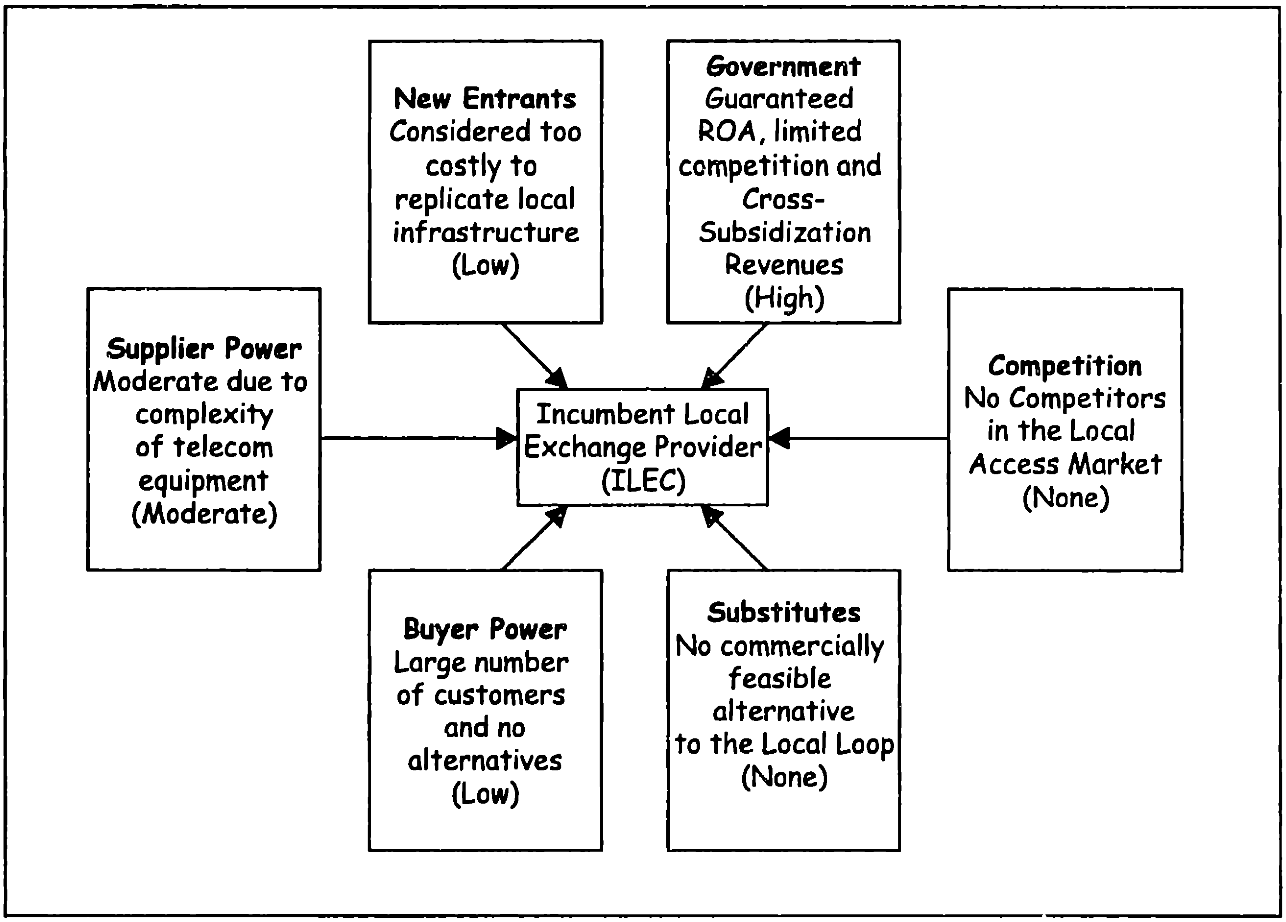


Figure 8: ILEC Central Office with collocated CLEC equipment

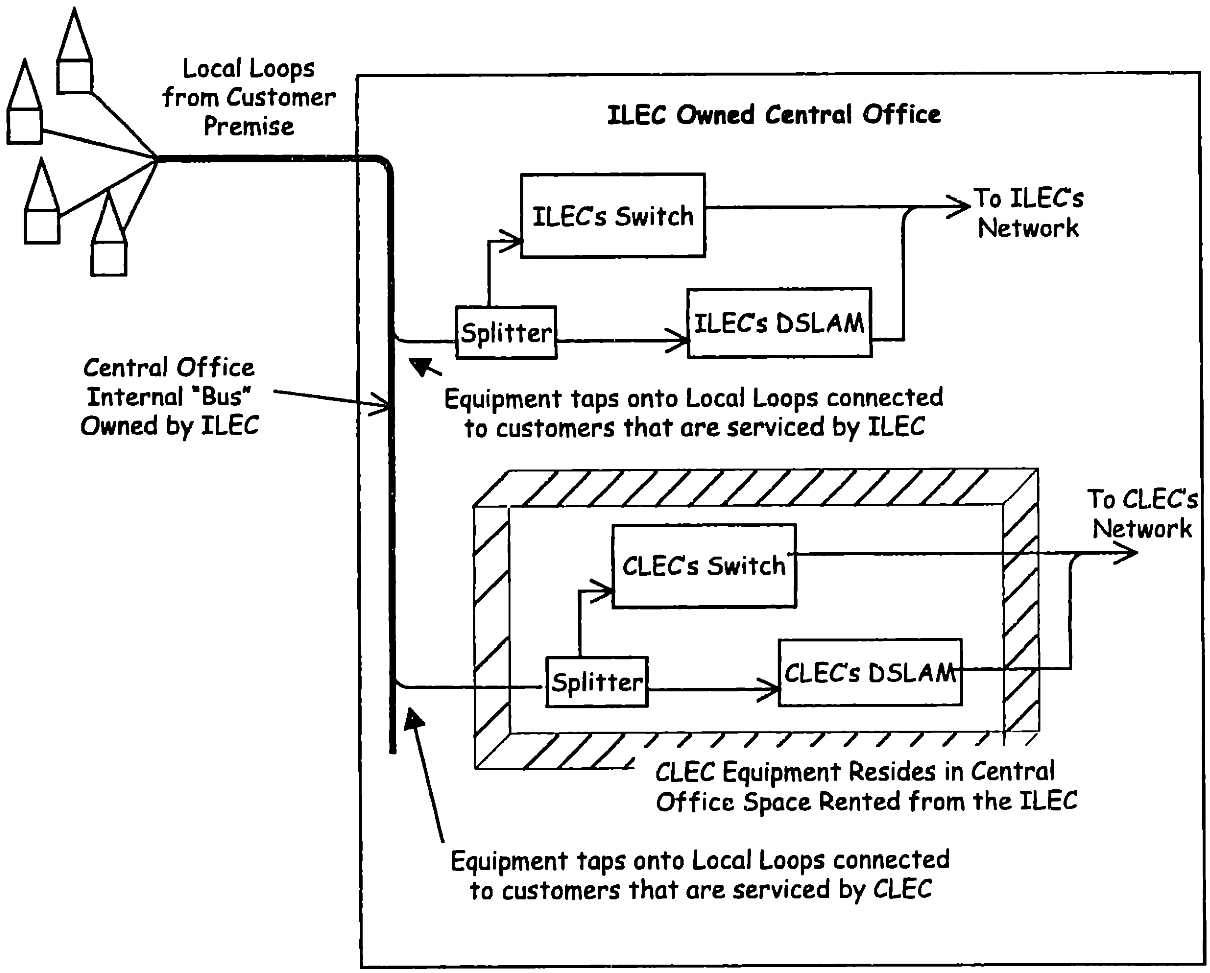


Figure 9: The US Telecommunications Network, 1996

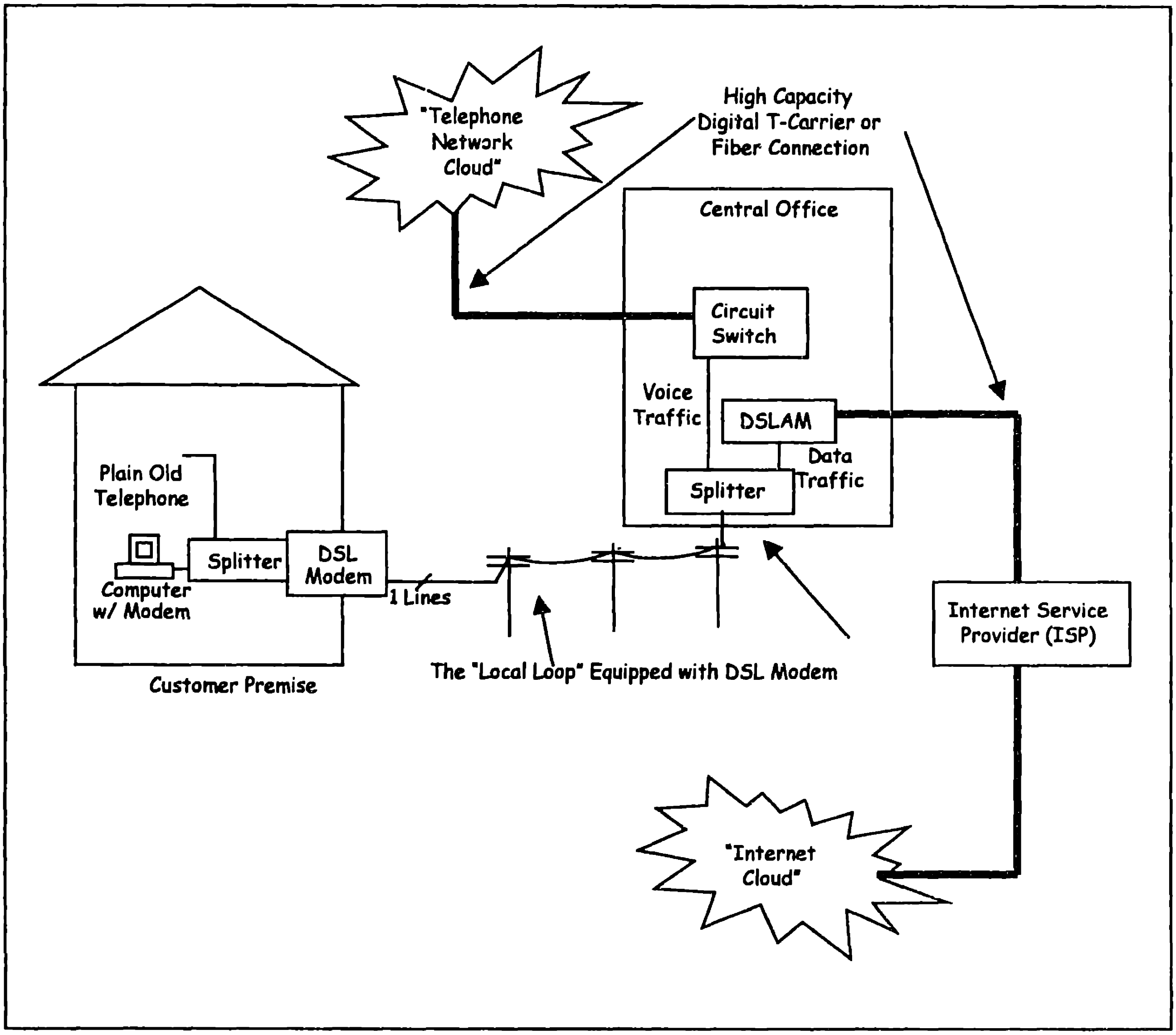


Figure 10: The US Telecommunications Network, 1996 w/ CATV

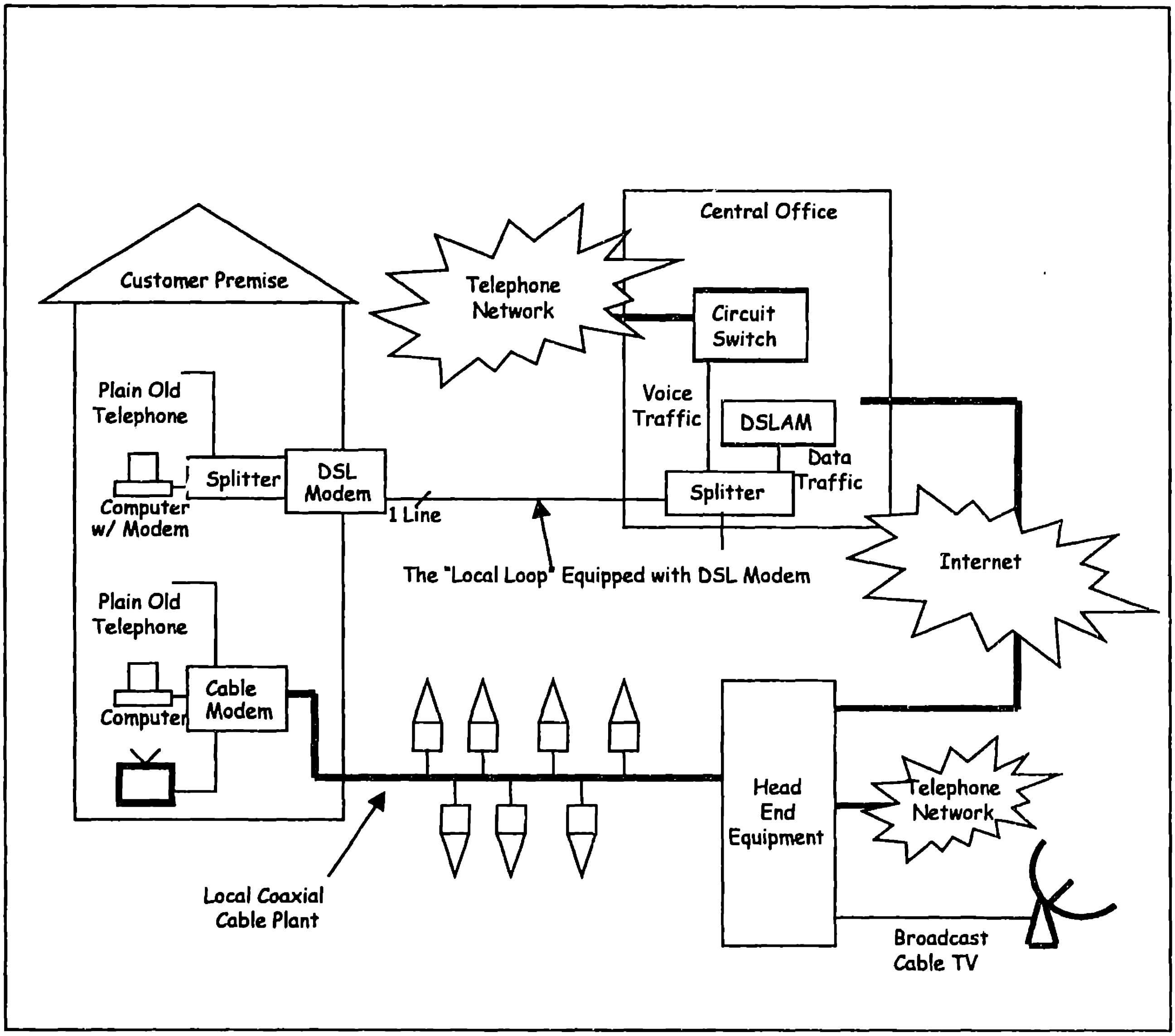


Figure 11: Hybrid Fiber Coax Architecture

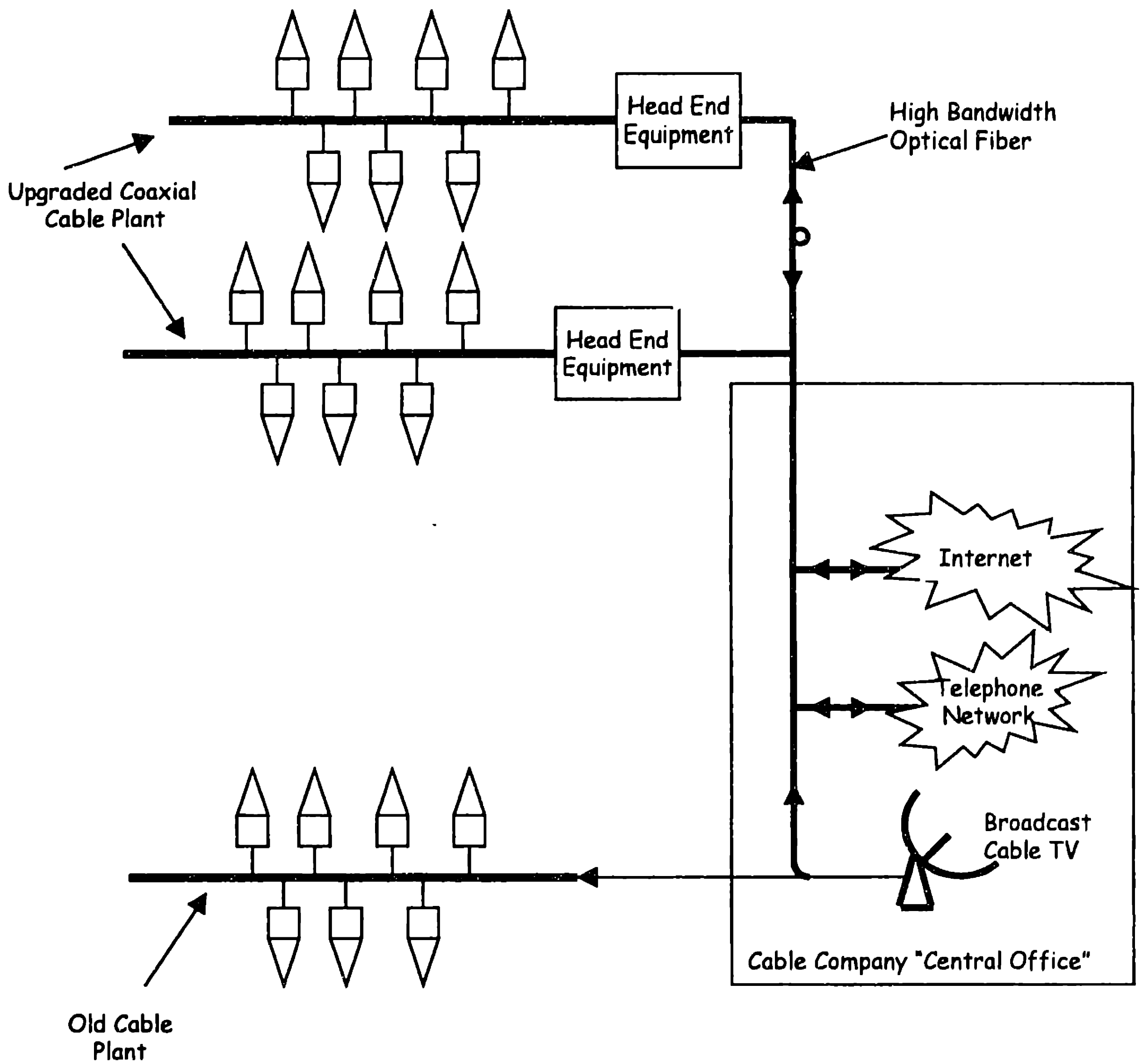
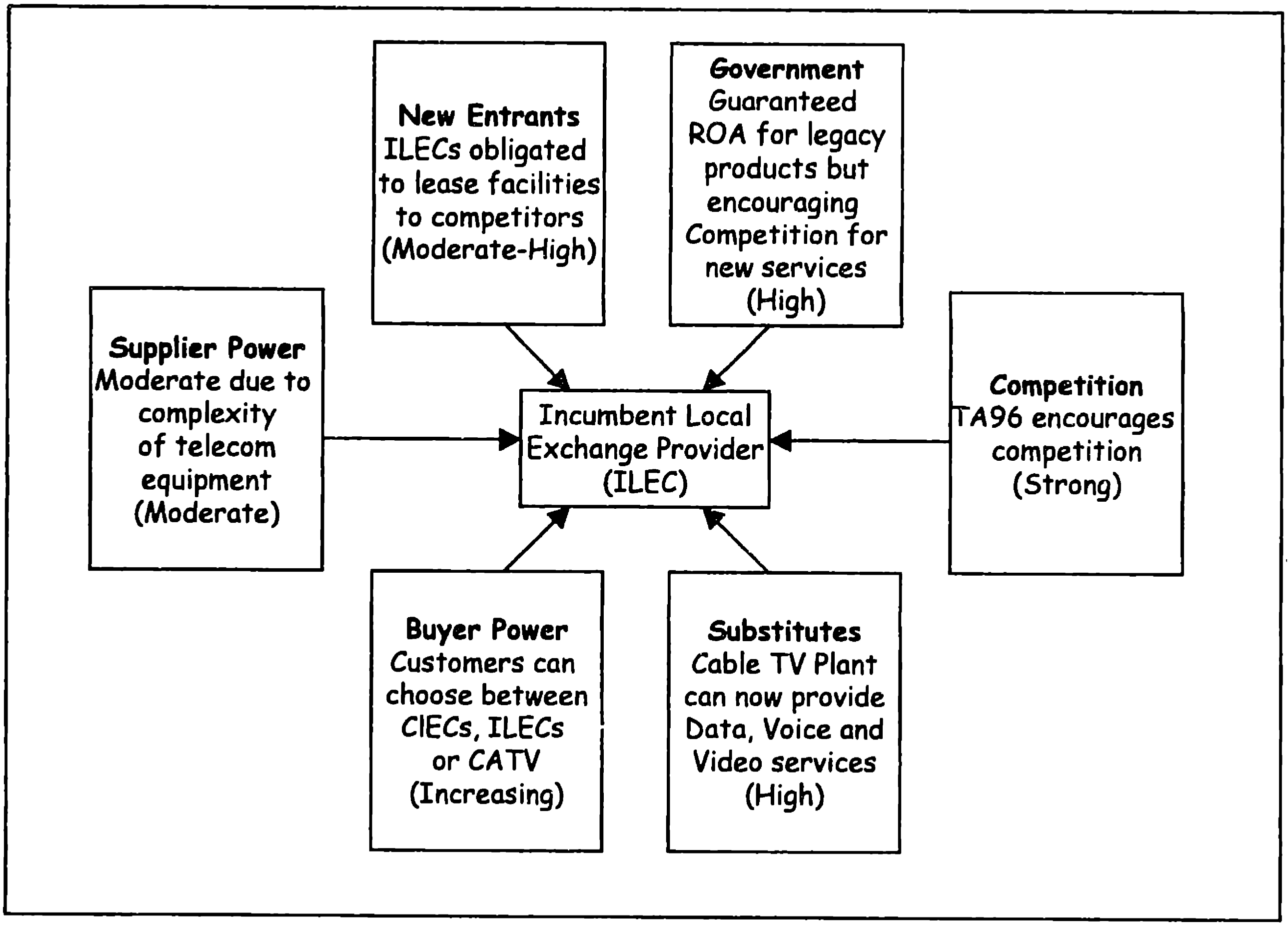


Figure 12: Porter Analysis: Post Telecommunications Act of 1996



Appendix B

The different Versions of DSL technology[73]

- **ADSL**. Asymmetric Digital Subscriber Line. A term for one-way T1 transmission of signals to the home over the plain old, single twisted-pair wiring already going to homes. ADSL modems attach to twisted pair copper wiring. ADSL is often provisioned with greater downstream than upstream rates (hence "asymmetric"). These rates are dependent on the distance between the user and the central office and vary from 9 Mbps to as low as 384 Kbps.
- **HDSL**. High bit-rate Digital Subscriber Line. The oldest of the DSL technologies, HDSL continues to be used by telephone companies deploying T1 lines at 1.5 Mbps.
- **IDSL**. ISDN Digital Subscriber Line. IDSL provides up to 144-Kbps transfer rates in each direction and can be provisioned on any ISDN capable phone line. Unlike ADSL and other DSL technologies, IDSL can be deployed regardless of the distance the user is from the central office.
- **RADSL**. Rate Adaptive Digital Subscriber Line. RADSL makes it possible for modems to automatically and dynamically to adjust their transmission speeds. This allows for improved data rates for customers residing greater distances from the CO.
- **SDSL**. Single-line Digital Subscriber Line or Symmetric Digital Subscriber Line. A modified HDSL software technology, SDSL is intended to provide 1.5 Mbps in both directions over a single twisted pair. The distance over which this can be achieved is less than 8,000 feet.
- **VDSL**. Very high-rate Digital Subscriber Line. The newest of the DSL technologies, VDSL can offer speeds up to 25 Mbps downstream and 3 Mbps upstream. Similar to SDSL, the gain in speed can be achieved only at short distances. These maximum speeds can be achieved only up to 1,000 feet. Sometimes also called broadband digital subscriber line (BDSL).
- **xDSL**. A generic term for the suite of digital subscriber line (DSL) services, where the "x" can be replaced with any of a number of letters.

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[73] http://www.covad.com/about/glossary

Appendix B

A brief tutorial on Cable Modem standards

Two standards have been developed to support Cable Data services. The Institute of Electronic and Electrical Engineers (IEEE) developed a standard that was completed in 1997. The standard specified the Asynchronous Transfer Mode (ATM) protocol between the head end and the cable modem. In March of 1997, a cable industry consortium developed a competing standard. The Data over Cable Service Interface Specification (DOCSIS) specifies the Internet Protocol (IP) between the head end and the cable modem. In both cases, a standard 10BaseT Ethernet link connects to the subscriber's computer.

Cable operators were initially focused on delivering high-speed Internet services to consumers. They believe that the ATM protocol added an unnecessary level of complexity and cost to cable modem systems. To date, more than 20 vendors have announced plans to build products based on the DOCSIS standard while none appear to have committed to the IEEE standard. Cable modems compliant with DOCSIS 1.0 were originally going to shipping ship in the third and fourth quarters of 1998, however only three vendors had passed qualification by the end of the first quarter of 1999.

The DOCSIS 1.0 standard was designed as a cheap consumer Web-surfing platform. It does not provide for all of the QoS and latency controls that are required to support toll-quality IP voice services. Release 1.1 of the DOCSIS standard includes technical enhancements to support Voice over IP and a complete multi-media platform[74]. Vendors do not expect DOCSIS 1.1 products to be available until sometime in 1999, the CATV companies must upgrade the head end router to interface to the PSTN. The rollout rate for IP Cable Telephone services is not yet clear.

[74] http://cabledatacomnews.com

Appendix C

Glossary of Terms

Local Exchange Carrier (LEC) is the term for a public telephone company in the U.S. that provides local service.

Local Access and Transport Area (LATA) is a term in the U.S. for a geographic area covered by one or more local telephone companies, which are legally referred to as local exchange carriers

Incumbent Local Exchange Carrier ILEC- is a telephone company in the U.S. that was providing local service when the Telecommunications Act of 1996 was enacted.

Competitive Local Exchange CLEC –Carrier is a company that competes with the already established local telephone business by providing its own network and switching. The term distinguishes new or potential competitors from established local exchange carriers

Central Office CO –is an office in a locality to which subscriber home and business lines are connected on what is called a local loop. The central office has switching equipment that can switch calls locally or to long-distance carrier phone offices.

Regional Bell Operating Company (RBOC) is a term describing one of the U.S. regional telephone companies (or their successors) that were created as a result of the breakup of AT&T

Telecom Act of 1996 (TA96) was enacted by the U.S. Congress on February 1, 1996, and signed into law by President Bill Clinton on February 8, 1996, provided major changes in laws affecting cable TV, telecommunications, and the Internet. The law's main purpose was to stimulate competition in telecommunication services.

Local Loop - is the wired connection from a telephone company's central office in a locality to its customers' telephones at homes and businesses.

Modem - A modem modulates outgoing digital signals from a computer or other digital device to analog signals for a conventional copper twisted-pair telephone line and demodulates the incoming analog signal and converts it to a digital signal for the digital device.

Plain Old Telephone Service (POTS) is a term sometimes used in discussion of new telephone technologies in which the question of whether and how existing voice transmission for ordinary phone communication can be accommodated.

Internet Service Provider (ISP) is a company that provides individuals and other companies access to the Internet and other related services such as Web site building and hosting.

T1 (T-Carrier) is the most commonly used digital line in the United States, Canada, and Japan. In these countries, it carries 24 pulse code modulation (PCM) signals using time-division multiplexing at an overall rate of 1.544 megabits per second.

Pulse Code Modulation (PCM) is a digital scheme for transmitting analog data.

Cable Television (CATV)

Digital Subscriber Line (DSL)is a technology for bringing high-bandwidth information to homes and small businesses over ordinary copper telephone lines.

Digital Subscriber Line Access Multiplexer (DSLAM) is a network device, usually at a telephone company central office, that receives signals from multiple customer Digital Subscriber Line (DSL) connections and puts the signals on a high-speed backbone line using multiplexing techniques.

Internet Protocol (IP) The Internet Protocol is the method or protocol by which data is sent from one computer to another on the Internet.

Asynchronous Transfer Mode (ATM) –is a dedicated-connection switching technology that organizes digital data into 53-byte cells or packets and transmits them over a medium using digital signal technology.

Appendix

List of people Interviewed

James Cullen, Chief Operating Officer, Bell Atlantic, March 5, 1999

Mark Heslop, Senior Product Manager, Nortel Networks, March 18, 1999

Tom Cooper, Chief Executive Officer, Virata Corporation, March 2, 1999

Glenn Bindley, Vice President, Access Products, PMC-Sierra, February 26, 1999

Michele Sweeney, Director East Coast Sales, PMC-Sierra, March 18, 1999

Bela Incze, Area Sales Manager, PMC-Sierra, Inc., March 24, 1999

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