UNITED STATES
TELEPHONE
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August 12, 1998

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Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
1919 M Street, NW
Room 222
Washington, DC 20554

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AUG 12 1998
FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

Re: Written Ex Parte Presentation
CC Docket Nos. 98-146, 98-147

Dear Ms. Salas:

The attached written ex parte presentation and attachment were provided to each of the Commissioners and indicated Commission staff on August 12, 1998. Pursuant to Commission rule 1.1206(b)(1), we are herewith providing to you copies of the ex parte presentation and attachment.

Please contact me if you have any questions.

Sincerely,

Lawrence E. Sarjeant

Lawrence E. Sarjeant
Vice President Regulatory Affairs & General Counsel

attachment

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UNITED STATES
TELEPHONE
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USTA 100 Years 1897-1997

EX PARTE PRESENTATION

August 12, 1998

The Honorable William E. Kennard
Chairman
Federal Communications Commission
1919 M Street, N.W., Room 814
Washington, D.C. 20554

The Honorable Harold Furchtgott-Roth
Commissioner
Federal Communications Commission
1919 M Street, N.W., Room 802
Washington, D.C. 20554

The Honorable Susan Ness
Commissioner
Federal Communications Commission
1919 M Street, N.W., Room 832
Washington, D.C. 20554

The Honorable Michael K. Powell
Commissioner
Federal Communications Commission
1919 M Street, N.W., Room 844
Washington, D.C. 20554

The Honorable Gloria Tristani
Commissioner
Federal Communications Commission
1919 M Street, N.W., Room 826
Washington, D.C. 20554

Re: Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans
Deployment of Wireline Services Offering Advanced Telecommunications Capability
CC Docket Nos. 98-146; 98-147

Dear Mr. Chairman and Commissioners:

Accompanying this letter please find a copy of a study, *Eliminating Barriers to DSL Service*, authored by Dr. Robert Crandall and Dr. Charles Jackson. The study was released on July 27, 1998, at the NARUC conference in Seattle. In the study, Drs. Crandall and Jackson analyze the economic viability of digital subscriber line services and "the potential impacts of regulation on the incentives of local exchange carriers (LECs) to invest in and deploy technologies associated with DSL." The Crandall-Jackson DSL study is an important work that, based on empirical data,

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offers compelling insights into the impacts of alternative regulatory approaches on LEC incentives to invest in advanced telecommunications technologies.

In the introduction to the Commission's recently released Advanced Services NOI, you acknowledge that the Commission's "regulatory system is uneven in its treatment of different technologies."[1] You further observe that "it may distort the performance of the market to have separate regimes of regulation for competitors in a converging market."[2] There is clearly a market for DSL services and ILECs are highly motivated to broadly serve those markets. You also state that you are committed to "ensuring that incumbent LECs make their decisions to invest in and deploy advanced telecommunications services based on the market and their business plans, rather than regulation."[3] Unfortunately, regulation stands to further dampen ILECs' motivation to provide Americans with the advanced telecommunications capability that they want and need. The Crandall-Jackson study provides compelling facts, data and analysis that can, and should, serve as a basis for a comprehensive deregulatory initiative by the Commission with respect to the deployment of advanced telecommunications services by ILECs.

USTA agrees with the Commission that it is not the Commission's role to "pick winners or losers, or select the 'best' technology to meet consumer demand, but rather to ensure that the marketplace is conducive to investment, innovation, and meeting the needs of consumers."[4] Such regulatory neutrality, though, must apply across the board. In an already competitive advanced telecommunications services market, ILECs should not be singled out for special regulatory treatment not imposed on other advanced telecommunications services providers. Disparate treatment for ILECs, such as that proposed in the Commission's Advanced Services NPRM, is inconsistent with the Commission's goal of creating and maintaining a robustly competitive market for advanced telecommunications services and will slow the rollout of those services to consumers -- many of whom have little hope of securing access to advanced telecommunications services unless their ILEC is able to provide the service.

---

[1] Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, Notice of Inquiry, CC Docket No. 98-146, FCC 98-187 (rel. Aug. 7, 1998) (Advanced Services NOI) at ¶ 4.

[2] Id.

[3] Deployment of Wireline Services Offering Advanced Telecommunications Capability, Notice of Proposed Rulemaking, CC Docket No. 98-147, FCC 98-188 (rel.Aug. 7, 1998) (Advanced Services NPRM) at ¶ 13.

[4] Id at ¶ 2.

Whether the focus is the NOI and the longer term future of advanced services or the NPRM and the more immediate prospects for the availability of advanced services, the Crandall-Jackson study is important to the Commission's deliberations. Accordingly, USTA is filing the study in the NOI and NPRM proceedings in order to allow you and the Commission staff the maximum opportunity to review and consider it. We look forward to the opportunity to have Drs. Crandall and Jackson visit with each of you and the Commission staff so that any questions concerning the study can be answered.

Sincerely,

Lawrence E. Sarjeant
Vice President Regulatory Affairs & General Counsel

Attachment

cc: Thomas Power
Kevin Martin
Kyle Dixon
Jim Casserly
Paul Gallant
Robert Pepper
Christopher Wright
Kathryn Brown
Larry Strickling
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Eliminating Barriers to DSL Service

by

Robert W. Crandall
Charles L. Jackson

July 1998

Eliminating Barriers to DSL Service

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About the cover

The various business logos on the cover illustrate the wide range of active competitors for Internet access.

@Home is the most prominent cable Internet venture. @Home is currently offered by Cox, Comcast, and TCI on some of these cable companies' cable systems.

AirBridge is a cellular-based Internet access service that uses the CDPD technology and is offered by Bell Atlantic in the northeastern United States. While the AirBridge service is slower than DSL services, it has the convenience of portability.

Covad is a Competitive Local Exchange Carrier (CLEC) providing services over existing local telephone lines as an alternative to the existing ILEC (Incumbent Local Exchange Carrier) service. Covad provides DSL services to several Internet service providers.

DirecPC is a high-speed satellite Internet access service provided by Hughes.

Ricochet is a packet radio Internet access service provided by Metricom. Like AirBridge's service, Ricochet service is not as fast as DSL service but has the advantage of portability.

About the Authors

Dr. Robert Crandall is a senior fellow in the Economic Studies program at the Brookings Institution. He is the author of several books on economic and policy issues in telecommunications.

Dr. Charles Jackson is an engineer who writes extensively on public policy issues in telecommunications.

This study was prepared for Keep America Connected! The opinions expressed are those of the authors, and do not necessarily represent the views of Keep America Connected!

Executive Summary

New high-speed digital subscriber line (DSL) services, offered by local telephone companies, will provide small businesses and residential users with access to the Internet that is comparable in speed to that enjoyed today by larger organizations. We have been asked to analyze the economic viability of these services and the potential impacts of regulation on the incentives of local exchange carriers (LECs) to invest in and deploy technologies associated with DSL. In this paper, we describe results derived from our models of the demand and cost of digital subscriber line services.

It is clear to us that these new DSL services will have to compete with other comparable services, including cable modems, wireless services, and services provided by competitive carriers and Internet service providers (ISPs) who use unbundled loops obtained from the LEC itself. This competition will limit regulators' ability to require LEC provision of DSL service in some markets at rates that are significantly above cost in order to cross-subsidize service in other markets. For example, the price of DSL service in urban areas cannot be raised to generate significant cross-subsidies to support DSL service in less dense neighborhoods. If regulators attempted to do so, the LEC would lose its urban subscribers to others.

Such competition is not merely a theoretical possibility. Several firms are already using local exchange carrier loops together with their own DSL gear to provide their own high-speed services to consumers. Such firms include Covad in San Francisco; Vitts in Manchester, New Hampshire; SourceNet in Reno, Nevada; HarvardNet in the Boston area; and many others.[1] Covad has announced plans to offer service in the Washington, D.C.; Boston; New York; Seattle; and Los Angeles areas reaching roughly 20% of the nation's population.

Competing technologies are evolving rapidly. We do not yet know how consumers value the mix of portability, speed, and cost. Wireless suppliers are working hard to develop technologies that support effective Internet access. Hughes is selling satellite-delivered Internet service to consumers. Cable companies are rolling out cable modems. Such rapid innovation and turbulent competition promises benefits for consumers but increases the risks for service vendors who must invest significant capital in a specific technology.

Our analysis also indicates that the threat of binding price regulation several years into the future is sufficient to change from positive to negative the net present value to a LEC of offering DSL service. Moreover, if regulators require geographic ubiquity of DSL service, the profitability of DSL service would plummet.

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[1] See http://www.covad.com, http://www.vitts.net/press.htm, http://www.source.net, or http://www.harvardnet.com.

The table below outlines the impacts we have identified.

FCC Chairman William Kennard has said:

> Like its appetite for ever-increasing computing power, I believe our nation will have an ever more voracious appetite for data transmission capacity, sometimes called "bandwidth." The key to satisfying this appetite will be to create real opportunities for companies to compete to deliver high bandwidth services over the "last mile" to consumers. Competition in our backbone networks today is driving backbone providers to keep increasing the capacity and speed of the backbones. We need to bring that competitive drive to expand capacity and improve service to the final links to consumers.

We agree. The FCC should, whenever possible, implement rules that reflect the competitive nature of DSL offerings and create the proper long-run incentives for DSL rollout by the LECs. .

Effects of Regulation on DSL Service		
Regulatory Scenario		
Price Regulation Strict rate-of-return	Incentives to invest would be greatly weakened.	Slower development of service, less competition, higher prices.
Price caps set in 2003 on forward-looking costs at that time	Incentives to invest would be greatly weakened because it is harder to justify investments with lower returns.	Slower development of service, less competition, higher prices.
Regulatory depreciation	Rapid technological change and the assurance of competition would increase the risks of using regulatory depreciation. In addition, regulating depreciation would require regulation of prices generally. Again, incentives to invest would be significantly weakened.	Weakens LEC incentives to invest. May also deter competitors from investing in early years.
Universal service requirements Requirement to provide DSL service to all households served by a DSL-capable central office	Such regulation would give the LECs the incentive to deploy DSL technologies only in central offices where the vast majority of loops could support DSL service.	Restriction of LEC supply of DSL services to urban areas and to those suburban areas with little use of digital loop carrier.
Requirement to provide DSL service at all central offices	Some smaller central offices, especially those with few loops capable of supporting DSL service, would be uneconomic. Consequently, the LECs' incentives to invest would be reduced.	May deter some LECs from initiating DSL service.
Requirement to provide DSL service to all LEC subscribers, if requested	Cost of providing DSL service would increase significantly. Under all reasonable scenarios, a LEC's ability to make a viable business is severely handicapped by ubiquitous deployment requirements.	Less competition, slower service rollout.
Unbundling requirements Loop unbundling	Three different impacts: 1. The ability of others to provide DSL over LEC loops would ensure competition based primarily on CLEC facilities (e.g., DSLAMs, routers). 2. Regulators would not be able use LEC urban DSL profits to support other services. 3. The ability of others to provide DSL over LEC facilities would create difficult problems in managing interference in the outside plant.	Would ensure that DSL will be a competitive service. Would ensure that LECs face DSL competitors with deaveraged costs. Managing interference would create some difficult, but not unsolvable, regulatory problems.
Unbundling applied to unique DSL facilities	Would raises costs for LEC networks.	Would raise costs to consumers and discourage deployment of DSL facilities.
Assurances that DSL costs and revenues will be treated as competitive • Requirement to offer conditioned unbundled loops without electronics • Available on non-discriminatory basis • Not subject to price caps • Nondominant treatment of service	The LECs would be able to consider the DSL market as would other firms. The LECs' incentives to pursue market quickly to gain partial first-mover advantage would be increased.	Would speed availability of DSL service.

The value proposition of ADSL service is compelling for the end user: for most applications it provides near-Ethernet performance for small or home offices. Multiple megabit-per-second bandwidth to the home or small office enables new applications in commerce, entertainment, education, and science.

Mark Huntzinger, 3Com, at TELECOM Interactive 97

1. Introduction and Overview

The rapid growth of the Internet has created new demands for communications capabilities. Many large organizations have high-speed access to the Internet using T1 lines connected to their organization's local area networks. Small businesses and residential users lack comparable access to the Internet.

In our study, we consider three aspects of a new digital subscriber line (DSL) service that local telephone companies are now preparing to offer to small businesses and residences:

- the value of this service to residential and small-business consumers,
- the likely competitive environment, and
- possible regulation of LEC provision of DSL service and its impacts.

This report offers recommendations regarding the public policies most likely to result in the rapid, robust rollout of high-speed digital subscriber line services (DSL) to consumers. We begin with a review of DSL services and technologies and of competitive offerings such as Hughes DirecPC service, cable modem service, and wireless services. The technology is here today, but there is substantial uncertainty about the effectiveness, capacity, and cost of competitive technologies. It is also clear that today's DSL services will only be a way station to even faster digital access services.

Next, we examine the recent historical performance of the markets for high-speed access. A key issue in analyzing the prospects for DSL services is the potential residential demand for high-speed access. We offer three different approaches to such an analysis. Section 4 presents an economic analysis of the problem of estimating future demand for these services with only

fragmentary information on current demand. Section 5 looks at the same problem from the point of view of a technologist considering the growth of complementary technologies.[2] Finally, Section 6 offers the views of a social scientist who conducted interviews with over a hundred residential users of high-speed cable modems.[3] While the details differ, all three approaches predict that high-speed residential access to the Internet will be strongly valued by a significant fraction of consumers and will deliver substantial value to the economy.

Having established that high-speed access to the Internet is valuable to consumers, Section 7 provides a brief description of a computer model that we developed to study the impact of regulatory decisions on the incentives of firms to invest in DSL technologies. A more complete description of the model is provided in Appendix C.

Finally, Section 8 provides simulation results of the likely profitability of DSL services offered by established LECs under a variety of assumptions. We conclude that DSL service could be profitable in the absence of regulation. If traditional regulation is applied to DSL services, it will significantly weaken LEC incentives to invest in this service. Rolling out DSL services requires significant initial outlays. Under many reasonable scenarios, cash flows turn positive in the third year but cumulative discounted cash flows are not positive until year 6 or 7. Imposition of regulation before the early losses are recovered would ensure that the service would never become profitable.

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[2] Appendix A contains a longer version of this technology study that was performed by SRI International.

[3] Appendix B contains a longer description of this study of users of high-speed access.

Once you get this stuff, you will sell your first-born before you go back to a normal modem.

Howard Anderson, quoted in the New York Times, 20 January 1998

2. Digital Access Services - A Technological and Market Primer

a. High-Speed Consumer Digital Access Technologies

Recently developed technologies permit high-speed communications from homes or offices to the Internet and other computer networks and services. This chapter reviews the essential elements of these technologies in order to give the reader a better perspective on the market and regulatory challenges created by these technologies.

Three technological foundations – telephone lines, cable television, and wireless – offer alternatives for improved consumer access to network services.

i. Telephone Lines

Copper telephone lines can carry far more data per second than is normally transmitted by the modems in home computers. The shortcomings of computer modems derive from the fact that such modems are designed to work on both local and long-distance connections. But most local switches and all long-distance connections transmit signals in only a narrow band of frequencies. A modem connected to the copper telephone line at the home can communicate with a modem at the telephone office (with the signal being separated from the telephone line before the connection through the voice switch) at speeds far higher than are possible on dial-up connections. The technologies for such high-speed local communications over telephone lines are known as digital subscriber line, or DSL, systems.

Unfortunately, several constraints limit the performance of these connections. The limitations can be so severe that service delivery becomes impossible. One limitation is distance. The longer the copper wire from the telephone company to the consumer, the harder it is to transmit

digital information over that wire. Thus, when the range is a few hundred yards, data rates in the tens of millions of bits per second can be achieved. As range increases, practical data rates fall. Some DSL products have a maximum range beyond which they do not work at all – typically two or three miles for a DSL system capable of six million bits per second. A second limitation arises from the condition of the copper wire. Wire with extra connections, called *bridge taps*, works fine for ordinary voice telephone service but works poorly for DSL services. Other uses of the wires in a cable create yet a third class of problems. Energy can leak from one pair of wires in the cable to others – a property called crosstalk. Crosstalk between DSL services using different standards but running in the same cable can seriously damage performance.[4]

ii. Cable Modems

The cable industry can also provide the route for high-speed communications to the home. Cable modems are capable of impressive data rates – in the millions to tens of millions of bits per second.[5] Working with manufacturers, the cable industry has defined a standard for cable modems called the Multimedia Cable Network System (MCNS) specification. One example of this technology is the General Instruments (GI) SURFboard cable modem model SB1000, which was recently launched for retail sales.

Cable modems use the cable plant for the high-speed link from the cable system headend to the consumer's home. If the cable system is equipped for two-way operation, the return signal from the consumer can flow over the cable network. Alternatively, if the cable system lacks two-way capabilities, a telephone connection can be used for the return path.

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[4] Notice that such interference between DSL services in the same cable poses difficult issues when access to loops is unbundled. The technical feasibility of permitting a CLEC to use a specific DSL technology on an unbundled loop depends upon the LEC's current and future plans for the use of DSL technologies (and other similar technologies) on other loops in the same cable. Interference between the technologies depends upon the technology choices made by each firm.

[5] @Home, a cable Internet service provider, claims to offer consumers connections at speeds of 1.5 to 3 million bits per second. See http://www.home.com/home/speed.html

Typically, cable modems share a pool of transmission capacity among several subscribers. That is, the cable system may provide a data transmission rate of six million bits per second to one customer at a time and rapidly move that capacity from one customer to another. At 2:00 a.m., the only active subscriber will be able to consume the full six megabits. During prime time, when many people are browsing the net, the average user may see an effective bandwidth significantly less than six megabits. Because most people request data in blocks from the Net (e.g., a person will download a web page, spend several seconds looking at it, and then respond), such sharing of capacity does not necessarily degrade performance to an unacceptable degree. The amount of such sharing is under the control of the cable operator. The cable operator can either dedicate more bandwidth in the cable system to modem use or reduce the number of customers who share each segment of the cable system.

iii. Wireless Alternatives

Wireless (radio technologies) offer the third major technical alternative. Today, there are three wireless technologies that are widely available and that are used for Internet access – cellular digital packet data (CDPD), Metricom's Ricochet, and Hughes DirectPC. CDPD is a packet data communications technology that uses cellular frequencies and infrastructure. CDPD carries data at only 19.2 Kbps – slightly slower than most dial-up lines and vastly slower than DSL technologies. CDPD does have the great advantage of mobility.

Bell Atlantic offers CDPD Internet connectivity for a flat fee of $54.95 per month for use within Bell Atlantic territory (usage charges apply outside Bell Atlantic territory). AT&T offers a similar service with a different pricing schedule.[6] Other cellular carriers also offer CDPD services.

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[6] AT&T does not offer a flat-rate option. Rather, it offers monthly service rates ranging from $19 per month to $115 per month. Associated with each rate is an allowed traffic volume. Traffic exceeding the allowance incurs extra charges. See http://www.attws.com/nohost/data/order/pricing.html.

Metricom, a firm originally founded to provide wireless communications for electric meter reading, offers a wireless Internet access service in a few markets in the United States.[7] The nominal data rate on Ricochet connections is 100 Kbps, but congestion and retransmission effects (similar to those occurring with cable modems) limit average transmission rates to the range of 14.4 to 28.8 Kbps – the same as current dial-up connections. The monthly price is $29.95 for unlimited use (academics pay only $19.95 per month for the same service). The Ricochet fee includes both communications charges and an Internet account.

Hughes offers a satellite-based Internet service called DirecPC. To use this service, the consumer must install a dish antenna (similar to the small receiving dishes used for Hughes' DirecTV service) and receiving electronics. The high-speed satellite link is used only for the transmissions from the Internet to the consumer. Information from the consumer back to the Internet must be carried over another path – usually a dial-up telephone call. DirecPC offers average download speeds of up to 400 Kbps. Hughes offers several pricing plans for DirecPC. For example, unlimited prime time use with an average rate of 400 Kbps costs $129.95 per month.[8] The capacity of DirecPC is limited by the capacity of current-generation satellites. The specific capacity varies with user activity and the tolerance users have for periods of congestion and degraded performance. It is possible that current satellites can serve many tens of thousands of users – perhaps in the low hundreds of thousands of users. The next generation of satellites, with spot beams and frequency reuse, will increase the number of users that can be supported by about a factor of ten.

These three wireless alternatives have vastly different characteristics. DirecPC is available everywhere in the forty-eight contiguous states (at least at those locations having a good view to

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[7] Current markets include Washington, D.C.; San Francisco; Casper (Wyoming); Kearney (Nebraska); and Seattle. Additionally, Ricochet service is available at some airports.

[8] http://www.direcpc.com/about/perf.html

the south towards the geostationary arc), but DirecPC is not easily portable.[9] CDPD is the slowest of the technologies, but it is portable, supports communications while on the move, and offers coverage in much of the nation. Ricochet is also portable and is somewhat faster than CDPD but is available only in limited areas. Of course, these are all new services. DirecPC was first commercially offered in 1996. CDPD hit the market slightly earlier – 1994. Ricochet had fewer than ten thousand subscribers at year-end 1996. It is far too early to discern the ultimate competitiveness of these offerings.

While these three services are the primary wireless alternatives for Internet access today, we expect the range of wireless alternatives to increase. Metricom has announced new technology that will increase the data rate on their system to 85 Kbps. In the FCC's WCS auction, Metricom purchased licences covering most of the western half of the forty-eight contiguous states and much of the Northeast. The next generation of geostationary satellites, due to be operational in two to three years, will support two-way communications to terminals similar to those used for the DirecPC service today at high speeds. Aloha Networks, Inc., a start-up in the Bay Area, has announced that it will supply a two-way Internet access capability using current generation satellites and small dishes by early 1999.[10] Several firms are developing low-earth-orbit satellite systems that will support voice and data communications. MMDS operators are testing use of their channels for the provision of Internet access, and the FCC has just auctioned off over 1,000 megahertz of spectrum for the LMDS service.

In addition to these visible developments, there are a variety of substantial development efforts in wireless that are not yet public. The FCC, with its PCS and WCS auctions and its authorization of the unlicenced NII band, has made available sufficient radio spectrum to support a wide

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[9] DirecPC is portable in the sense that the equipment can be mounted on a trailer or van and the vehicle moved from place to place. The user must then manually repoint the antenna toward the serving satellite.

[10] See www.alohanet.com.

variety of terrestrial radio systems. Manufacturers and service providers are working to develop voice and data services that will allow them to compete with existing wireless providers or to meet currently unmet consumer needs.

b. Factors Affecting Adoption of LEC DSL technologies

DSL services are still in their infancy. At present, LECs face a numbers of uncertainties regarding standards, the complexity of separating transport from ISP service, the difficulty of serving customers at longer distances from central offices, and – potentially – regulation. In this section, we discuss the effects of the technical constraints (distance, standards, Internet addressing) and touch upon regulatory issues as needed. However, this section does not focus directly on regulatory constraints.

i. Standards and Changing Technology

Digital subscriber line technologies come in many flavors – it seems that a new variant is being announced every few weeks. These rapid changes in technology create opportunities and problems for both consumers and service providers. A service provider may be reluctant to commit to large investments in a specific DSL technology if there is a significant risk that a superior technology will soon emerge. Similarly, consumers will be less willing to invest in DSL technologies if they run the risk that their investment will not be useful if they move to the service area of another LEC. On the other hand, such improvements will eventually make DSL more attractive.

The American National Standards Institute (ANSI) has adopted a standard for one version of DSL – asymmetric digital subscriber line (ADSL). ADSL is designed for high-speed connections from the network to the user (down link) and lower speed connections from the user to the network (up link). The maximum down-link speed of ADSL is 9 megabits per second, the maximum up-link speed is about 800 kilobits per second. Unfortunately, even this ADSL

standard comes in two slightly different variants: CAP and DMT.[11] These variants are incompatible. Two customers served by a single cable cannot use both CAP and DMT – the two technologies create interference with each other .[12] Thus, a LEC must standardize on one or the other. Consumers served by a LEC using DMT cannot move to a community served by a LEC using CAP, take along their ADSL modem, and use it in the new location.

More complicated tradeoffs face LECs and their customers. For example, consider three variants of DSL – DSL-lite (with limited capacity but easier installation), ADSL (substantial capacity, range of up to about three miles from the central office), and VDSL (enormous capacity [12 to 50 megabits per second] but limited range). Today, neither consumers nor information service suppliers are set up to exploit VDSL capacities. VDSL speeds are more than sufficient for high-definition television. VDSL speeds match or exceed the speeds most ISPs use to connect to the larger Internet and are far higher than the average end-user speeds the ISPs are set up to handle. Similarly, consumer computers running the usual applications cannot yet exploit connections at this speed.[13]

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[11] CAP and DMT are acronyms derived from the names for the modulation method used to code digital information onto the phone line. CAP stands for carrierless amplitude phase; DMT stands for discrete multitone.

[12] Technically speaking, the proceeding sentence is not quite correct. Two customers using these conflicting technologies cannot share a binder group, which is a subunit of a large cable but may comprise the entirety of a small cable serving a neighborhood.

[13] More correctly, consumer computers will perform about the same whether they are connected to the Internet over a digital pipe with a capacity of 5 million bits per second or one of 50 million bits per second. Using a 5 million bit per second line, a 60 K byte digital object – a reasonably large digital object (e.g., a compressed figure or a very complex web page) – can be downloaded in a tenth of a second. But, many computers take more than a tenth of a second to display such an object. Speeding up the transfer of the object will not improve performance if the computer itself is the bottleneck. Similarly, compressed standard definition television can be transmitted over a 5-million-bit-per-second line – but most computers in use today can just barely process such a signal. Of course, in a few years computer hardware and software can be expected to improve sufficiently that the capacity offered by VDSL can be exploited.

But that will change as computers and service providers evolve. If consumer needs and preferences change rapidly at some time in the future, the LECs may end up with substantial investment in an out-of-date technology. Similarly, some LECs may find that DSL-lite technologies offer adequate performance for the next few years – and thus provide a simple hedge against technological uncertainty.

ii. Geographical Range and Digital Loop Carrier

DSL technology suffers from an unfortunate tradeoff – as range goes up, capacity goes down. Some designs have maximum ranges beyond which they cannot operate.[14] Typically, ADSL technology is claimed to work over ranges up to about 12,000 to 18,000 feet of copper cable or about two to three miles. This means that the technology works fine for people with homes and offices in the core of the city and thereby close to the LEC central offices. But users at greater distances from the central office will get either poorer performance than do people close to the central office or no DSL service at all. This lack of universality can be remedied – but only by substantial LEC investment, which will raise the cost of DSL services.

Digital loop carrier (DLC) poses a related issue. For about two decades, the least cost method of providing telephone service to areas of substantial new growth (e.g., new subdivisions, large office buildings) has been to run a high-speed digital signal out to the neighborhood that is converted to analog voice at a remote terminal. Copper wire pairs are then used to carry this analog signal to the nearby subscribers. Customers served by loop carrier systems do not have copper connections all the way from the LEC central office to the home or office, therefore they cannot be served from the central office using DSL modems. Equipment is being developed that will allow LECs to provide DSL service to customers now served over loop carrier. However,

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[14] Other impairments or restrictions limit the use of specific wire pairs as well. Such limitations include the presence of bridge taps, loading coils, and particularly noisy signals in nearby pairs in the cable.

those technologies are less developed and require space in remote terminals – space that is not always available.

These two constraints imply that there are two quite different cost structures for DSL services – one cost for existing plant and one for upgraded plant. If we accept the constraints in the existing loop plant, then DSL is a relatively low-cost innovation. In contrast, if we want to offer universal DSL service, then substantial investments must be made to upgrade LEC plant, thereby substantially increasing the unit cost of the service.

iii. ISP Portability

The systems developed for LEC provision of DSL service have been designed to allow the LEC to connect its customers to multiple Internet service providers (ISPs) in much the same fashion that LECs now connect consumers to their long-distance carriers. That is, consumers can connect to any one of several ISPs connected to the LEC's ADSL network.[15] Several LECs have offered this portability feature in their ADSL trials and service offerings. In contrast, cable systems offering high-speed Internet access typically bundle their access service with their own Internet service.[16]

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[15] Alcatel presentation at XIWT, Fall 1997.

[16] The method used for Internet addressing creates some of the complexity associated with ISP portability. Typically, when a user calls his or her ISP over a phone line, their computer is set up to use a special protocol (SLIP) for the connection. One of the tasks performed by that protocol is obtaining for the user an Internet address for the duration of the connection. That Internet address is one of many addresses assigned to the ISP. When a packet of data is sent through the Internet to this address, the Internet merely has to be smart enough to route that packet to the ISP who then takes over the task of delivering the data to the user. To properly work with the Internet, the consumer's software must be aware of the Internet address assigned to the consumer's computer. Some technical solutions to the problem of supporting multiple ISPs over DLS networks require the implementation in the LEC networks of some of the Internet-address control functions normally performed by the ISPs. Doing so permits existing software to be used on the consumer's computer to support DSL connectivity.