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The Rise and Fall of Third-party High-speed Access

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Abstract: While Internet usage blossomed during the entire 1995 – 2001 time period, there was a large change in the nature of the high-speed Internet access business. Initially, connection, routing and content were three separate parts of high-speed Internet service. Cable companies initially teamed with affiliated third-party providers to create their high-speed access combination of connection and routing whereas telephone companies resisted working with third-party providers for their high-speed access product. In the end, both cable and telephone providers moved toward a more integrated approach to the provision of high-speed access. However, content has remained, for the most part, separate from connection and routing. This paper finds that changes in the cost of caching, bandwidth and more standardized technical knowledge led cable companies toward the integrated approach favored by telephone companies, and changes in regulation facilitated integrated provision by telephone companies. At the same time, integration of access with content did not provide similar efficiencies and content remains provided for the most part by independent companies.

Keywords: Internet; telecommunications; competition; vertical integration.
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I. Introduction

From the commercialization of the Internet in 1993 and the introduction of the Netscape browser in 1994, the widespread public view of the Internet has been one of incredible leaps forward in usage and technology despite the dot.com and telecom meltdowns of 2000-2001. This overarching view is true. Internet usage, adoption and technology have been relentlessly advancing: more users have gotten online, more users have adopted higher speed services, and many more applications are now available to make the online experience more enjoyable and productive (and counter-productive).

At the same time, many observers seemed to think that the Internet would change the laws of economics – that old style thinking just didn't "get it" in the lingo of Silicon Valley circa 1999. The rush to get "eyeballs" and ensure scalability were important phenomena of the early Internet, but, at the end of the day, the rules of economics were still applicable and drove the path of high-speed access.

The Bresnahan and Greenstein (1999) analysis of the evolution of the computer industry shows how it transitioned from vertically integrated industry into an industry with "divided technical leadership" ("DTL") where different firms competed at different vertical levels in the provision of the ultimate product. The vertical integration-DTL framework is useful in analyzing the evolution of high-speed access from the AOL dial-up world through the time of divided connection, routing, and content to the current world where connection and routing are provided together and content is provided separately for the most part. Just as the government played a role in the development of the structure of the computer industry through the IBM antitrust case, the government played a role in the evolution of the market structure of high-speed access.

The introduction of high-speed access service in the mid-1990s and associated regulation led to various different business models. Ultimately, despite the attempts by regulators to divide high-speed access into separate connection and routing layers, and the attempts by companies to provision high-speed service in different ways, cable and telephone high-speed access provision moved to a model of integrated connection and routing. At the same time without regulation (but with a threat of regulation) content has been provided primarily by unaffiliated companies.

This paper shows how the economic and regulatory forces led to the initial divisions between connection, routing, and content and ultimately led to integrated provision of connection and routing ("access") and separate provision of content. Werbach (2002) compresses the seven-layer OSI model (physical, data link, network, transport, session, presentation, and application) into four layers (physical, logical, applications and services, and content) to distinguish how regulation should apply to Internet services. For the purposes of this paper, I use three layers based on how firms have divided service in practice: "connection" is the physical connection between the user and the provider; "routing" is the service that is provided over the physical connection that allows transmission to take place.[1] Routing also has included routine applications like e-mail. More general content services that are not generally bundled with access provision are considered "content."

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[1] Together, connection and routing roughly map to the bottom four layers (physical, data, network and transport) of the TCP/IP protocol stack.

The study ends in 2001 when the current industry structure developed. Although the number of high-speed access customers has grown substantially, the industry structure has not changed – connection and routing are generally bundled together and only a limited amount of content is provided with that bundle.

The endogeneity of market structure is an important issue in economics – how do cost characteristics, changes in cost characteristics, and new technology combine to affect market structure and the delivery of services. Bresnahan and Greenstein (1999) provide an analysis of the development of the computer industry market structure. Noam (2006) looks at the overall telecommunications industry and argues that it is becoming more cyclical and oligopolistic. Downes and Greenstein (2002) analyze the Internet Service Provider ("ISP") industry and the competitiveness in different geographic areas.

The Internet started as an academic network, but quickly changed when it became a commercial network without restrictions. In 1995, at the start of home broadband access, it was unknown how the new market forces and technological advances would play out. Blumenthal and Clark (2001), Clark et al (2006), Lemley and Lessig (2001), and Werbach (2002) are examples of studies that have examined the organization of the Internet marketplace through engineering and legal prisms. In most cases, these studies provide very interesting views about the history of the "end-to-end" principle of the original Internet design, but do not focus on the economic factors that drive market structure. For example, Clark et al (2006) provides a very insightful description of the development of overlay networks and the regulatory issues that arise from the changing nature of the services that are provided. However, there is little or no discussion about the economic forces that have led to the development of the overlay networks.

This paper attempts to fill the gap between the two strands of the literature by taking the economic approach of Bresnahan and Greenstein (1999) to understand market structure drivers and using the detailed institutional detail as in Clark et al (2006) about the integration of high-speed access provision to understand how we arrived at the current market structure.

Section II provides a background of the industry and technology. Section III explores the initial responses of cable, telephone, and third-party access providers to the new opportunity to provide high-speed services. Section IV examines the economic and regulatory changes that took place between 1996 and 2001 and discusses how those changes affected the provision of high-speed access. Section V describes the attempt by @Home to tie content provision to access and Section VI presents conclusions.

II. Background

In 1995, the Internet was relatively new – Netscape introduced its browser only the year before which began the widespread adoption of home-based Internet service. Residential Internet access was primarily on dial-up access lines with very little high-speed access service available. There were a large number of small ISPs who were able to provide dial-up service because the economies of scale for bare-bones dial-up access was relatively low and the interface with telephone service meant that modem banks did not have to be inside the incumbent local exchange carrier ("ILEC") central office.

At the most basic level, high-speed access requires a connection to the end user, routing equipment, and a connection to the broader Internet where users can find content. This somewhat overly simplistic model shows three possible divergences in the vertical chain – connection, routing and content. In 1996 it was unclear if high-speed access providers would provide one, two or all three services, and whether consumers wanted integrated provision or not. For dial-up service, which was most prevalent at the time, connection and routing were primarily separate. AOL was the largest dial-up provider and also provided a large amount of content to its customers, but used telephone lines for connection.

The small economies of scale and common carrier requirements allowed a large number of independent Internet Service Providers (ISPs) to use the telephone network to provide service and as a result, ILECs were not the dominant provider of dial-up Internet access (Downes and Greenstein, 2002).

The divided nature of the business changed with the advance in technology that allowed high-speed access. To implement high-speed access, cable companies adopted a semi-divided business model while telephone companies wanted a fully-integrated business and fought regulatory mandates to facilitate independent access providers (Noll and Rosston, 2002). The differences between cable companies and telephone companies in networks, geographic scope and historical structures help to explain the different attitudes toward self-provision and divided technical leadership at that time.

High-speed access posed substantial technical hurdles in the mid-1990s: technology risk; requirements to install and deploy equipment throughout the network; and systems challenges (At Home, 1999; Covad, 1998). The incumbent cable and telephone companies had physical connections to homes, but did not have the complete package necessary to provide high-speed Internet access, in part due to their technical and business capabilities. On the telephone side the 1984 antitrust settlement and subsequent

FCC decisions separated Internet access from the provision of telecommunication services, making it easier for third parties to provide service (Cannon, 2003).

Other firms leapt into the void to provide the necessary complementary services. On the cable side, @Home and other firms including Roadrunner and High-Speed Access began to provide high-speed access with the backing of cable companies. Such investments complementary service were not new to cable companies; they had also invested in the initial cable programming networks (Waterman and Weiss, 1997)

On the telephone side, independent Competitive Local Exchange Carrier ("CLEC") DSL providers like Covad, NorthPoint, and Rhythms among many others came into existence after the passage of the Telecommunications Act of 1996 ("TelecomAct") because the Telecom Act required ILECs to lease unbundled network elements to competitors at regulated rates.

With the entry of firms providing service complementary to the wires provided by cable and telephone companies, the high-speed access industry looked like it might move to the computer industry divided technical leadership model, where cable and telephone companies provided the connections to the household, other firms provided routing service over those wires and a third set of firms provided content.

However, the Internet marketplace changed substantially between 1996 and 2001. The changes in the marketplace were not limited simply to the run up and subsequent significant diminution in value of Internet companies (the so-called "bubble" and subsequent "crash"), but also involved substantial core economic issues that affected the underlying value of third-party access providers network and business value. Changes in the cost of backbone transport, storage, competition in the marketplace, and regulation all adversely affected the profitability of third-party high-speed access. In addition to the high-speed access capabilities, the content side of the Internet suffered from a substantial drop in advertising revenue in 2000 and 2001. This revenue drop hampered the business plans of some of the third-party access providers, most notably @Home, which had diversified into content as well as access.

The fundamental economics led to a world where the divided technical leadership in home high-speed access is very different than many investors thought it would be in the late 1990s, and nearly all of those companies that jumped in to fill the void between the physical connection and the Internet ended up without anything to show for their efforts. The comparative advantages third-party routing providers brought to the table in the late 1990s disappeared rapidly. They were unable to develop up a sustainable position in the chain because their technical leadership disappeared with the commoditization of their skills and assets. In addition, some of the ideas and market niches they attempted to serve did not materialize or were not profitable. Finally, there may have been efficiencies from vertical integration or strategic incentives that may have caused the dominant firms to try to force them out of business (Noll and Owen, 1994; Rey and Tirole, 2003).

Cable companies embraced partial outsourcing of high-speed access initially whereas telephone companies resisted use of third parties to provide high-speed service. The differences between cable and telephone companies allow us to discern the key economic forces that drove the collapse of a division between connection and routing, but continued the separate provision these two layers and content.

The remainder of this section provides a background of high-speed access provision.

A. Access and content

From 1996 through the end of 2001, the Internet grew rapidly. Traffic on Internet backbones in the U.S. increased from 1,500 terabytes per month in 1996 to 20,000 – 35,000 terabytes per month in 2000.[2] Not surprisingly, the number of cable modem and DSL subscribers and the associated revenue grew rapidly over this time period as well. However, despite rapid growth, even by the start of 2000, there were only 2.7 million residential and small business high-speed access lines. The number of high-speed subscribers was smaller than many people had expected and planned for, resulting in substantial overinvestment and leading to rapid price declines in parts of the industry. Even while the marketplace was small compared with the more than 82 million (FCC, 2007) high-speed access lines in 2006, the economic lessons and early changes and experimentation in delivery methods were important for the current mass market delivery of home high-speed access.

Access and content are interrelated – content is a prime driver of the demand for access. and access leads consumers to demand content and associated advertising. While the marketplaces for access and the marketplace for advertising and content have interrelationships, it is better to analyze them separately because the market forces affecting the two over this time period were very different. As used in this paper “access” means the connection of cable and telephone company subscribers’ premises to the Internet. Access includes the subscriber connection as well as the routing and backbone networks. “Advertising and content” (sometimes referred to as “media”) include the

[2] Coffman and Odlyzko (2002a).

revenues generated from advertising on the various associated websites and the expenses incurred to create website content.

One concern in the provision of content has been the incentive and ability of access providers to favor their own content over that of rival content providers, and the ability of an integrated content provider to withhold content from a rival access provider (Rubinfeld and Singer, 2001). The vertical power concern was examined in the context of "open access" proposals around 1999 and continues to be an issue now under the name of "network neutrality."

High-speed access companies adopted different strategies with respect to the integration of content and conduit. This differentiation allows us to identify better the separate effects of each part on the ultimate market structure of the high-speed access industry.

B. Features of the new high-speed access networks

New high-speed access network design depended on assumptions about how the marketplace and cost structure would evolve. The use of caching in the network and the ability to develop technical standards for networks were important issues in the early development of high-speed access.

1. Caching

If the Internet is slow, the benefits of high-speed local access will be limited. According to Rhythms Net Connections in 1998, one of the new CLECs, "[l]ittle if any distributed storage capacity currently exists in either private or public networks. As a result, when user volume exceeds network capacity, data transmission is either slowed or information is lost. Today, each time a user accesses a high usage company database or web site, the data must traverse the entire local and wide area network, wasting capacity and decreasing user performance."[3] In 1996, there were approximately 10 national Internet backbone providers.[4] The speed of the backbone was 45 Mbps – 144 Mbps.[5]

Caching was developed as a response to the problem of shortage of backbone capacity and provided end users with much faster access by storing web pages on a server that was closer to the end user so that the information could be transferred more rapidly.

@Home cached information at its regional data centers and also cached some information at some of the cable headends because it believed that the Internet backbone was not sufficient to provide a reliable, high-speed experience. Rhythms and other CLECs also cached information, but not to as great an extent as @Home.

2. Technology standards

Standards are important in many high-tech applications. Both cable and DSL providers relied upon the TCP/IP building blocks for their networks, but the structure of the underlying wired networks made it so that they had different mechanisms for transporting those signals. Within cable and telephone networks, there were benefits to being part of a standard technology to achieve economies of scale and benefit from coordinated research and development and the development of complementary products.

In addition to providing much of the technology employed in the cable high-speed access network, @Home also served as a coordination point for the technology that cable

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[3] Rhythms Net Connections (1998).

[4] Kende (2000)

[5] Curran (1997)

systems eventually implemented in the local portions of their networks, and in the consumer premises equipment (CPE or cable modems) that cable subscribers used to connect to the high-speed network. The existence of @Home made it easier for a group of cable companies to standardize on a single technological solution for cable high-speed access despite the differences in the quality of their networks. This in turn facilitated the development of more standardized cable modems, leading to the ability to achieve economies of scale in production and made it easier to provide customer service. Even though there were other cable high-speed access companies, the small number and the guidance of CableLabs (a cable industry research consortium) made it easier to agree on common technology standards and realize economies of scale in equipment production.

On the DSL side, telephone networks were more homogeneous and BellCore (a local telephone company industry research consortium) had helped guide the development of DSL technology over a long period of time (Marples, 2004). Thus, the need for a third party to implement a consistent standard to achieve economies of scale in equipment and market was not as necessary. Most CLECs and ILECs used similar equipment for the provision of DSL service.

III. Access technologies and initial business models

The initial reactions of cable providers and telephone companies to the high-speed access opportunity were very different; their reactions were driven by their networks, experience and regulation.

A. Cable modem

Cable companies responded to the high-speed access opportunity by working with other cable companies to "outsource" routing and technology. In 1995 TCI, the largest cable company, and Kleiner Perkins Caufield & Byers, a leading venture capital firm, founded @Home to develop a business that would provide high-speed Internet access for households and businesses. In 1996 and 1997 other cable firms joined, and the company issued shares to the public in 1997. In 1999, AT&T acquired TCI's cable assets and its ownership stake in @Home and later that year @Home merged with Excite Inc. ("Excite"), a leading portal/search engine business (At Home, 1999).

@Home's residential Internet access business was predicated on the ability to use the coaxial cable plant (which provided cable television signals) as the "pipe" to provide high-speed Internet access to the home. @Home's role was to provide system management, Internet backbone service, regional data centers, connectivity services, hardware, content and some marketing and customer service.

@Home and its cable partners developed a model whereby @Home was responsible for the service between cable headends and the Internet. Figure 1 shows the cable high-speed Internet access network provided by @Home and cable companies. The lines from the subscribers' homes to cable headends were provided by cable companies. @Home provided the regional data centers, caching, and Internet backbone. @Home also assisted cable companies with the development of customer billing and support mechanisms.

The main features of the @Home portion of the network were that @Home took traffic at the cable headends, aggregated and managed the traffic at regional data centers (RDCs), and provided some "caching" of popular content at the regional data centers (and some closer to the cable headends). Past the RDCs, @Home had a virtual private national backbone that interconnected with other Internet backbone providers at a variety of network access points.

Time Warner was the only large cable company not aligned with @Home. Instead, Time Warner developed its own high-speed access service called Roadrunner. Roadrunner was a competitor to @Home – both companies attempted to provide third-party high-speed access service to other cable companies.

There were a number of possible reasons why most cable companies decided to "outsource" part of the provision of high-speed access to @Home. The cable companies may have seen that there were economies of scale in developing the technology and platform for cable high-speed access. Because, in 1995, each cable company covered only a fraction of the country (TCI had 26% of nationwide cable subscribers, Comcast 5.7% and Cox 5.3%), no one company alone would be able to realize the full extent of the economies of scale in product development.[6]

In addition to having relatively small national shares in 1995, cable companies had not amalgamated "clusters" as they did subsequently. As a result, it would be more efficient for the multiple cable operators in a geographic area to band together to provide regional aggregation for their high-speed access services. In the beginning of high-speed access, only a few customers in any geographic area would be expected sign up for service, increasing the benefits of having a regional provider. Economies could be in traffic aggregation, in caching services and also in promotion and advertising. Without a

[6] Federal Communications Commission (1995).

partnership like @Home, cable companies might not have been able to realize fully the benefits of their investments in high-speed access.

Cable companies had previously banded together to produce complementary products that enhanced the value of their connections to homes. Much of the early cable television programming was undertaken by cable television companies themselves (Waterman and Weiss, 1997). Cable companies made equity investments in cable networks to provide the content that could make their cables more valuable. But, in many cases, no single cable company owned 100% of the programming.

The @Home/Cable partnership solved some of the perceived problems in 1995 by allowing for technology coordination, and realization of the economies of scale that smaller and less concentrated cable companies could not achieve on their own in 1995. One important feature of the business was that cable companies had substantial ownership stakes in @Home and Roadrunner.

B. DSL

The initial residential Internet access business began with third-party dial-up companies providing service using standard telephone lines connecting consumer modems to modem banks and subsequently to the Internet. While AOL became by far the largest provider of dial-up Internet access, there were thousands of dial-up providers and telephone companies were not large providers (Downes and Greenstein 2002). For high-speed access, the story was very different. Prior to the 1996 Telecom Act, only telephone companies provided higher speed access using their facilities. This was generally done through T-1 lines and ISDN service, both of which were relatively expensive and focused on business customers. The Telecom Act changed the framework for high-speed access because it required ILECs to allow CLECs to lease unbundled pieces of the network (UNEs) at regulated rates.

In response to this opportunity, several entrepreneurs developed business plans to provide service through leased lines. Covad Communications provides a typical example.[7] Covad was started in 1996, right after the FCC order implementing the Telecom Act and mandating that states use a forward-looking cost model to determine UNE prices. Covad was started by several venture capital firms and Intel Corporation. It began service in the San Francisco Bay Area in December 1997 and expanded to Los Angeles, New York and Boston in 1998 and other areas thereafter.

CLECs generally predicated their business plans on "collocating" facilities in the ILECs central offices and leasing unbundled loops from the ILECs at regulated rates. Typical CLEC networks are illustrated in Figure 2. The CLEC uses an unbundled loop supplied by the ILEC. The loop is routed from the main distribution frame inside the central office to a CLEC collocation cage in the building. The CLEC provides the DSL electronics at the consumer end and at its end of the loop. It aggregates the traffic from multiple central offices, often using ILEC transport services and then manages the network in a manner similar to @Home. However, the CLECs did not generally provide as extensive caching services, and provided their own billing services.

CLECs had a fixed cost for each central office collocation facility and additional costs for each line served; the CLEC paid for the unbundled loop as well as DSL electronics on each line. CLECs believed that they could provide better service to their

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[7] Information in this section comes primarily from Covad's S-1, September 21, 1998 and S-1's of NorthPoint and Rhythms NetConnections.

customers then the ILECs in several respects: they were dedicated to providing high-speed access; they monitored the network to ensure quality; and they could provide service across vast geographic territories which would be attractive to enterprises wishing to have a single point of supply for their high-speed access needs.

The CLEC business model was predicated on continued regulation of rates for unbundled network elements. Essentially, the CLECs were using the ILEC network for the bulk of their services and providing other services “on top” of the ILEC network as their value-added. To take advantage of the situation, CLECs made upfront investments for their equipment in the ILEC central offices and make monthly payments for leased elements.

The ILECs did not want to outsource high-speed access provision, but were forced to accommodate third-party provision on a price-regulated basis (Brock, 2003). On the DSL side, ILECs were actively trying to prevent the emergence of separate DSL companies and not entering into partnerships with these companies. Virtually none of the “agreements” under the 1996 Telecom Act between ILECs and CLECs were voluntary agreements, but instead the result of mandated state arbitration, and there were virtually no investments by ILECs in CLECs, either in their own regions or in other service territories.

Telephone network quality across the country was much more homogeneous than cable network quality. A DSL solution that worked for one telephone company would generally work for all. The major difference between ILECs was the percentage of loops that were longer than 18,000 feet (the length of loops over which DSL worked at the time) and the percentage that were served by Digital Loop Carriers (DLC) (Bernstein and

McKinsey, 2000). Other factors such as load coils also affected the ability to deliver high-speed access. The Bell companies worked jointly through their research arm, BellCore on common DSL technology. Also, because DSL implementation required expertise more akin to the management of a telephone network with two-way traffic and load management than the one-way cable television network, telephone companies also believed that they had the requisite in-house expertise to manage a high-speed access network.

In 1995, telephone companies were much more clustered than cable companies. There were very few major metropolitan areas with multiple telephone companies. As a result, telephone companies could internalize the benefits of advertising and consumer education more easily than the less clustered cable companies and did not need to construct a new entity to capture the externalities.

The 1984 Consent Decree tried to keep the ILECs from leveraging market power in a regulated business into potentially competitive unregulated businesses (Noll and Owen, 1994). The CLECs used unbundled loops to compete with the ILECs own high-speed offerings as well as the ILEC second line service used for dial-up access. But, because of the regulation, in addition to general vertical strategic incentives, the ILECs had similar incentives as they did before the 1984 breakup. With unregulated DSL service and regulated wholesale and other retail services, the ILECs would have liked to push as much profit to the DSL business. For example, while opposing line-sharing obligations at the FCC, some ILECs used a zero cost intra-firm transfer price for internal line sharing, but wanted to charge the entire cost of the line to CLEC competitors (Bernstein and McKinsey, 2000).

Telephone companies had also had experience with outsourcing a complementary service: long distance telephony. As part of the AT&T antitrust suit and divestiture, the RBOCs were prevented from providing long distance telephone service beginning in 1984. Over the ensuing 12 years, they continually petitioned the court and congress to be allowed into the long distance business. During this time, RBOCs were forced to sell "access" to the long distance companies at regulated rates rather than to provide integrated service. The regulated mandate of UNE prices akin to the old access charge regime signaled to the RBOCs that they would again be at the mercy of regulators and might again be hobbled in their ability to provide integrated services.

Finally, the existing competitive positions of the firms were probably important. As discussed above, most of the Internet access in the mid-1990s through 2001 was dial-up access (NTIA, 2004). Despite problems with heavy traffic loads at certain switches, ILECs benefited from the increased demand for Internet access through the sale of second lines. FCC data show that residential access lines increased nearly 20% from 1995 through 1999 (FCC 2005). Much of that was due to demand for second lines for Internet access – as of 2001, more than 44 million households had dial-up internet access compared with about 10 million on broadband (NTIA, 2004). Because the supply of substitute high-speed access lines reduced the demand for second telephone lines, the ILECs stood to benefit less from the transition to high-speed than did cable companies or the CLECs.

For the ILECs, the opportunity cost of a high-speed line included the foregone second line contribution. Cable companies and the CLECs accurately saw this offset as zero while ILECs realized this cost. The nature of the opportunity cost changed over time. In the late 1990s, much of the conversion to high-speed came from people who had second lines for their Internet access. Over time, the opportunity cost has changed for at least two reasons: more customers did not have second lines to abandon signed up for high-speed access; and competition increased failing to sell a DSL line would still result in a lost second line if customers chose cable high-speed access. The diminished perceived opportunity cost may complement or provide an alternative to Bazelon and Hazlett's (2005) regulatory failure explanation for the relative increase in DSL subscriber gains.[8]

IV. Economic changes in the access marketplace

Changes in regulation and the marketplace affected the structure of the high-speed access business. While all high-speed access companies increased subscribers, there were still problems generating positive cash flow. Despite several rounds of private financing and initial public offerings that were followed by substantial increases in their stock price reflecting high expectations, @Home, Covad, Northpoint, and RhythmsNet all went through bankruptcy in 2001 (as did other third-party access providers). Some of the changes were general and affected all companies; others were more specific. In addition, while the Internet marketplace grew rapidly during this time period, it did not grow as fast nor generate as much revenue as some had predicted (and had based business plans upon).

[8] In addition to the new high-speed access business opportunity alone, cable companies stood to benefit from the ability to bundle high-speed access with cable television to try to protect themselves from satellite competition that did not have a high-speed access component.

A. Pricing and exclusivity

One of the touted competitive advantages for the CLECs was the ability to operate on a wide geographic scale. However, the cost structure for CLECs was based on decisions in each state by the state Public Utilities Commission. The FCC's implementation of the Telecom Act gave the states the duty to set prices for unbundled elements on a forward-looking basis in at least three different geographically disaggregated zones. This led to wide variation in UNE prices across states and within states.

Determining UNE pricing was a long and involved process – negotiation and then lengthy arbitration. The ultimate contracts between the ILECs were relatively short – Covad's contracts with ILECs had a maximum term of three years.[9]

More importantly, the UNE price decisions were not fixed – they were subject to periodic review and prices change relatively frequently. In addition, FCC and court decisions led to changes in pricing and ultimately eliminating the unbundled network element platform (UNE-P).

On the cable side, under the initial contracts in 1995 and 1996, @Home and its cable company partners originally agreed to split revenue from cable high-speed access with @Home getting 35% of the revenues (At Home, 1999).

In March 2000, @Home extended its relationship with AT&T, Comcast and Cox at the same 35% revenue share. In 1998, Roadrunner was charging 25% to 30% for its services.[10] With competitors such as Roadrunner in the marketplace and the ability to

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[9] Covad, S-1, 9/21/1998, p-12.

[10] Cable Datacom News (1998).

self-provision due to commoditization of @Home's competitive advantages, it would have been difficult for @Home to effectuate a price increase for its service.

B. Network quality

The FCC semi-annual "High-Speed Services for Internet Access" show that both DSL and Cable high-speed access subscriptions were increasing very rapidly from the end of 1999 through the end of 2001. At the time, consumers believed that network quality was high for both services.

However, @Home began to have some network quality problems, including with its e-mail servers in 2000-2001. This was a problem for cable companies because their brand names were associated with the product. While cable quality and reputation varied, some of the companies, such as Cox, had worked hard to build a reputation for quality, and the reputation was important both the high-speed access business and also to the cable television business that was facing increasing competition from satellite providers. As a result, the cable companies wanted to ensure that @Home's service quality would improve. Ensuring high quality service was consistent with the cable companies' economic interests and also standard practice for companies relying on a key supplier to provide a service to end user customers.

The ILEC/CLEC quality interface was different. Because they had both a complementary wholesale/retail and a competitive relationship, the ILECs and CLECs did not have the same incentives to work together to ensure the quality of the product as the cable companies and @Home did. The ILECs spent large amounts to ensure that "cross-talk" in the binder groups of wires did not ruin the ability to provide service and also to set up ordering and provisioning systems so that CLECs could interface with the

ILEC systems. However, these interactions were contentious, time-consuming, and not as efficiently done as they likely could have been had both parties had the incentive to make them work as smoothly as possible. In addition, a loop cutover requires physically disconnecting the connection between the main distribution frame and the switch for a specific wire for each order and then reconnecting the wire to the CLEC's facilities. This process requires manual labor and quality control to ensure that the correct wire is disconnected and reconnected.

Since the ILECs were providing competing service, each disconnection represented either a lost customer or a lost opportunity. The incentive would be to make the transition seem riskier and to try to retain or obtain the customer for the ILEC's own service since the UNE price was below the efficient component pricing rule ("ECPR") (Baumol and Sidak, 1994) price.

C. Complementary service to the last mile became less valuable

When developing the complementary pieces to the customer connection, CLECs and @Home faced technical challenges and bottlenecks in the backbone network. There were three key pieces of the complementary access network: the Internet backbone (and associated peering arrangements); the local caching and regional data centers; and the technical expertise and ability to manage the high-speed access business.

Cable and telephone companies and their associated third-party access providers approached the challenges similarly in some ways and differently in others: they all acquired technological expertise and had Internet backbone connections. @Home added caching services as well. The economics of the marketplace changed substantially thereby diminishing the value of the competitive advantages of the third-party providers by reducing the barriers to self-provision by cable and telephone companies. Bandwidth prices dropped dramatically from 1999 to 2001. In addition, competitive caching services developed. Quality monitoring and measuring services allowed better alignment of incentives with third-party providers. As a result, the value in the marketplace of the complementary service and network diminished.

1. Standards

Initially, cable modem access was not standardized. Although there was debate about how to provide DSL service, standardization was settled earlier for DSL (Marples, 2004) so third-party provision added less value on the DSL side. As discussed earlier, the inability to standardize and realize economies of scale may have been one of the motivations for the outsourcing of the development of the backbone network and initial development of the high-speed cable modem access to @Home.

The cable companies were able to come together to develop a standard high-speed access modem utilizing the DOCSIS standard. They did this in part through utilizing the technical expertise of CableLabs, the industry research arm.

The success of coming together to develop an industry standard may have made cable companies realize that they were less likely to choose a “wrong” technology in the future and be stranded with a unique solution, unable to realize the benefits of higher volume production for equipment.

2. Clustering

Like standardization, clustering was already in place on the DSL side. In 1995, cable “clusters” were much less concentrated than they were in 2001. Cable companies developed more and larger clusters of systems, the clusters themselves grew larger making it easier to exploit internally the economies of scale associated with regional networks.[11] In addition, by controlling their own regional networks, cable companies might better be able to control the quality of their product, develop uniform products across their territory and diversify their service offerings. These changes made cable companies' incentives more like the ILECs in limiting their desire or need for a separate third party.

3. Bandwidth pricing

@Home provided private backbone service for the cable modem Internet traffic and also provided peering with other backbone providers. During the late 1990s, there was a substantial increase in the capacity of Internet backbone services. This increase came from the construction of new networks by entrants such as Qwest and Level 3, from the expansion of fiber in networks of existing backbone service providers, by increases in the amount of fiber that was "lit", and by increases in the carrying capacity of lit fiber through advances and investments in transmission technology. All of these factors led to increases in the capacity/speed of backbone services. In economics terms, this led to a substantial shift to the right of the supply curve representing an increase in supply.

Changes in demand are also critical to the result in the market place. During the late 1990s, there were reports of traffic doubling every three to four months, but later it

[11] The clustering trends during this time period are noted in the 3rd through7th Federal Communications Commission Annual Reports on Cable Competition.

became clear that those reports were substantially inflated.[12] Even though Internet traffic was not growing that astronomically, it was expanding quickly.

This means that the demand curve shifted out to the right as well. When both demand and supply increase, the resulting market quantity is higher, but the price can be higher or lower depending on the relative increases. Since @Home had its own private backbone under a 20-year Indefeasible Right of Use ("IRU"), the value of this asset depended on the market price for bandwidth.

Figures 3 and 4 show the market price for OC-3 and OC-48 bandwidth from January 2000 through September 2001 for transport between various different cities. The market price dropped by 41% - 56% for OC-3 and 40 - 53% for OC-48 lines in the space of 9 months in 2001 according to the Telegeography data.[13] OC-3 prices declined by 70% from January 2000 to September 2001 (The Telegeography data for 2000 does not include OC-48 prices).

The steep decline in bandwidth pricing has at least two implications for the analysis of third-party access providers. First, the value of a backbone supply contract diminished substantially from at least January 2000 to September 2001.

Second, and relatedly, the cost to replicate the backbone portion of the high-speed access service declined substantially from at least January 2000 to September 2001. Companies had a number of different options from which to choose in developing an

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[12] Coffman and Odlyzko (2002b).

[13] The Bandwidth Pricing Database consists of pricing information for long-haul capacity lines. *See h*ttp://www.primetrica.com/products/bandwidth_pricing/index.php?PHPSESSID=c4c0c9d58689812f7e99c81e77c22aff

alternative network in 2001, and the prices of those alternatives were substantially lower in 2001 than they had been earlier.

For the CLECs, this part of the story was not as stark. Many of them had not invested as much in backbone capacity and thus the dramatic decline in backbone prices was an advantage to them as customers. But the price decline was also an advantage to their ILEC competitors who also were purchasers of backbone capacity.

4. Competitive caching

One of the unique features of the @Home network was the ability to “cache” web pages at the regional data center and sometimes at the local cable system headend. These caching servers responded to consumer demand and stored copies of the most heavily requested web pages closer to the customer so that requests for these pages did not have to travel throughout the Internet backbone.

As discussed above, the cost of bandwidth dropped substantially. At the same time, the cost of caching dropped as well. The idea of caching is relevant to cable modem access, DSL, and general business users who connect through higher speed lines. Because of the correlation in the web pages that are accessed by these different groups of users, the costs of storage and processing, and common bottlenecks, there are economies of scale in caching for a variety of different local access providers. Services such as Akamai Technologies emerged in the late 1990s to provide caching services for web pages that were accessible to all different types of access providers in a local area.[14] Because of these economies of scale, the cost penalty and performance penalty for a

[14] Akamai Technologies (1999).

high-speed access provider of not having an internal caching system would be very small. In fact, Akamai charges website providers rather than access providers so that the cost of "caching" using Akamai can be substantially less than the cost of providing caching within the network itself. The nature of many web pages changed between 1995 and 2001 – web pages became more dynamic and more personalized so that caching was relatively less valuable than directly accessing the web page.

D. Regulatory changes and uncertainty

In contrast to the negotiations and re-negotiations between @Home and the cable companies, the agreements between the CLECs and the ILECs were battled out at state regulatory commissions, at the FCC and in the courts. The ILECs challenged virtually all of the FCC's initial implementation of the 1996 Telecom Act. Ultimately, however, the forward-looking pricing standard was upheld by the Supreme Court (Noll and Rosston, 2002). That did not stop the battles, as the state commissions had substantial leeway in setting prices, and the FCC ultimately made it much more difficult for CLECs to get full access to the unbundled elements they wanted by eliminating the "platform" (UNE-P) approach that was initially an important tool for CLECs.

As discussed above, access providers' vertical integration was a competitive issue. "Open access" (or "forced access" depending on which side of the issue was framing the debate) which has now morphed into "net neutrality" was an important regulatory concern. Open access proponents called for mandating that cable and telephone companies allow access providers to use their wireline transport facilities to customers' homes. Had there been real open access mandated at the time, which was a serious question, then third-party access providers would have developed another mechanism to provide service in the market. Ultimately, however, no open access mandate developed to change the business models.

E. Marketplace changes

These regulatory changes combined with the change in access to capital and the slower than hoped for growth in high-speed access demand combined to make it much more difficult for successful CLEC operation. At the same time, the ILECs were able to forge ahead with their own DSL services, worry less about second line cannibalization and more about the success of cable in acquiring customers. By sticking with their plan to provide their own high-speed access, ILECs were able to use the marketplace and the regulatory process to ensure integrated supply of connection and routing for DSL access.

On the cable side, the value of the @Home routing service had decreased relative to the value of the cable company connection. As a result, the willingness of the cable companies to pay @Home decreased. With a high 35% of revenue fee for @Home service, the attractiveness of self supply increased and the cable companies ultimately spent relatively small amounts of money to provision their own routing networks. Cox spent about $150 million to build its network.[15] Comcast said that it spent $75 million on its new high-speed Internet network by the time it transitioned about half of its customers from @Home to this network.[16] The dramatic reduction in the value of the @Home network and the cost to replace led the cable providers to adopt a similar integrated provision of connection and routing.

[15] Cox Communications (2002)

[16] Chattanooga Times (2002).

V. The content marketplace

Although many of the CLECs entered into “content” deals in the late 1990s to increase their appeal to end user customers, @Home was unique in its more aggressive approach to team up with content providers in the hopes of gaining synergies that would increase profitability.

During this period, content continued to be very competitive. As a result, while overall content revenue increased, the revenue for any particular advertising space decreased substantially.

As a result of the decreased rates, @Home’s content revenues declined dramatically. The difference in its approach compared to the CLEC approach helps to identify some of the different effects due to content and due to the economics of the access marketplace and reasons why content remained separate from access.

The decline in valuations of Internet and technology stocks had direct and indirect impacts on @Home. The direct impacts were that financing became more expensive as investors demanded higher returns and more security in order to provide capital to the company. This also hurt the prospects of the CLECs.

The decline in advertising rates hurt the content side of @Home’s business and @Home had substantially increased its exposure to the advertising market through the Excite merger and through numerous other acquisitions. Content revenue did not affect the CLECs because they had minimal exposure to advertising revenues.

The desire to “jumpstart” the high-speed content market may not have been completely wrong-headed at the time. There were few content providers giving customers strong reasons to adopt high-speed and there was no “killer app” that was causing high-speed adoption to accelerate on the hoped-for path. So, @Home and others, similar to the early cable operators investments in programming, made investments to try to accelerate the availability of content and applications that would then feedback into increased high-speed subscriptions. This was an attempt, in some ways, to try to marry the access and content layers together. But, so far, the content layer has been independent of access. The presence of multiple providers of access and huge economies of scale in content provision helps to explain the divergence in control of content compared to connection and routing.

A. Content and access

On January 19, 1999, @Home agreed to acquire Excite, Inc. for about $7 billion. Excite and @Home hoped to capitalize on potential synergies between the two companies' lines of business – high-speed Internet access and online content and advertising: the number of @Home subscribers would increase from @Home's exposure on the Excite portal; the acquisition of the Excite portal would increase the service offerings for @Home's customers; and the two companies would be better able to target advertising and thus be more attractive to advertisers (@Home S-4, 1999).

Some investment analysts thought that the merger would make the combined company more like AOL at the time in its ability to generate additional revenues:

> "…AOL learned quickly that while ease of access brought customers, it did not do all that much for operating margins or profits. Only when AOL learned to leverage its customer base into incremental advertising and commerce dollars did the opportunity begin to look truly compelling from an investment standpoint. …Excite brings that leveraged revenue opportunity to @Home. …If the lesson from AOL is that access is not enough, then the missing piece of the @Home puzzle has been interesting proprietary content – something to keep users on the @Home system beyond the home page. The longer subscribers stay within the

> bounds of @Home's content, the more opportunity that company has to show them ads and sell them products."[17]

While AOL was the largest ISP in 1999, Excite@Home and the CLECs were different than AOL, and the market was changing. At that time, AOL's customers were much more likely to stay within AOL's "walled garden" and less likely to venture to the broader Internet.[18] General internet customers were different – while they still clustered around a relatively small part of the Internet (leading to the value of caching discussed earlier), these sites were not necessarily Excite-related, even though @Home customers were directed to a default Excite home page after the merger.

In addition to the Excite acquisition, @Home made several other acquisitions including Bluemountain.com for nearly $1 billion and another $1 billion on other acquisitions. These acquisitions increased @Home's exposure to the content business and the reliance on advertising revenue to generate cash flow.

B. The drop in advertising revenue

The media side of @Home's business suffered from the steep decline in Internet advertising rates during the 2000-2001 time frame. While Internet use continued its steady growth, advertising rates dropped rapidly.

> "Based on Internet CPM data in 2H00 and so far in 2001, double-digit pricing declines seem to be the order of the day. Despite the falling CPM, Internet advertising revenues have grown faster than any other media in history as the supply of inventory has more than offset the declining price per unit."[19]

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[17] Credit Suisse First Boston (1999).

[18] The Boston Globe, 11/19/2000, Bear Stearns (2001).

[19] Morgan Stanley Dean Witter (2001).

The drop in Internet advertising rates had a significant impact on @Home's media revenue, especially in 2001. This change in the marketplace was relatively sudden and the company's reports and projections did not presage such a dramatic drop.

@Home was not alone – other suppliers of Internet advertising such as Yahoo! And Double-Click also experienced substantial drops in revenue despite increases in Internet usage and page views on these sites.

The incursion into content was very problematic for @Home in two ways. First, it overpaid for a number of companies and apparently focused on that part of the business to the detriment of the access business. The second part of this was that @Home was never able to gain any of the hoped-for synergies from developing its own content and marrying that with its access service. Subsequently, we have not seen any large examples of content provided by access providers – Amazon, eBay, Google, Facebook, New York Times, etc. are all content providers who have large user bases without any of their own access service.[20] While access providers might have some ability to generate synergies, the content business appears to be very different from the access business and success is also based on the ability to reach users from a variety of access providers.

There may be strategic reasons for integrating content and access: in essence this is part of the debate about exclusive programming on cable and satellite services. Whether that becomes a problem for Internet service depends on the structure of the marketplace for the services and the incentives of the providers. With a large amount of differentiated content, exclusivity is not currently a problem.

[20] Google is providing free WiFi service in its home city of Mountain View.

VI. Conclusion

The Internet marketplace changed substantially between the initiation of residential high-speed access provision in 1995 and the bankruptcies of many of the new third-party Internet Service Providers in 2001 when the current structure solidified. Initially, cable companies provided high-speed access through affiliated third-party providers, but by the end of 2001, most cable companies operated their own ISPs without any third-party providers on their systems. Telephone companies resisted third-party ISP provision from the outset of high-speed access and were generally successful in these efforts. In the end the provision of Internet access on cable and telephone systems, while technically different, had similar economic structure – integrated connection and routing service provided by a single firm.

There were two main forces behind this common structure: the ultimate economic costs of providing service that left little room for value-added by independent third parties compared to integrated service provision; and changes in regulation that eliminated much of the cost advantage enjoyed by third-party providers on telephone systems.

The backbone and caching assets and the unique technical expertise that cable ISPs provided in the early stages of broadband became more widely available and cheaper to replicate. As a result, the package of services they offered to cable companies became less valuable, especially when compared with the sacrifice of possible vertical integration efficiencies.

However, offering content tied to access did not prove profitable as the synergies between these services were not as strong as the economies of scale of offering content to all access platforms and the ability of new and different content providers to emerge over time.

Because of the changes in the marketplace and regulation, what looked like it might become a replica of the computer industry circa the 1990s and 2000s with divided technical leadership between connection and service provision has instead evolved more to the computer industry of an earlier era where single companies provide both connection and service provision. As high-speed access service evolved through the late 1990s, the artificial demarcation and division between connection and routing was not tenable and the ultimate integration of the two pieces worked its way through the system.

At the same time, experiments to meld these two layers with content failed and the major content providers are unaffiliated with access/service providers. The division in technical leadership appears to be between access and content. In the future, there are likely to be continued investigations into the effect on the content marketplace of integrated access providers.

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Figure 1

@Home Network Architecture

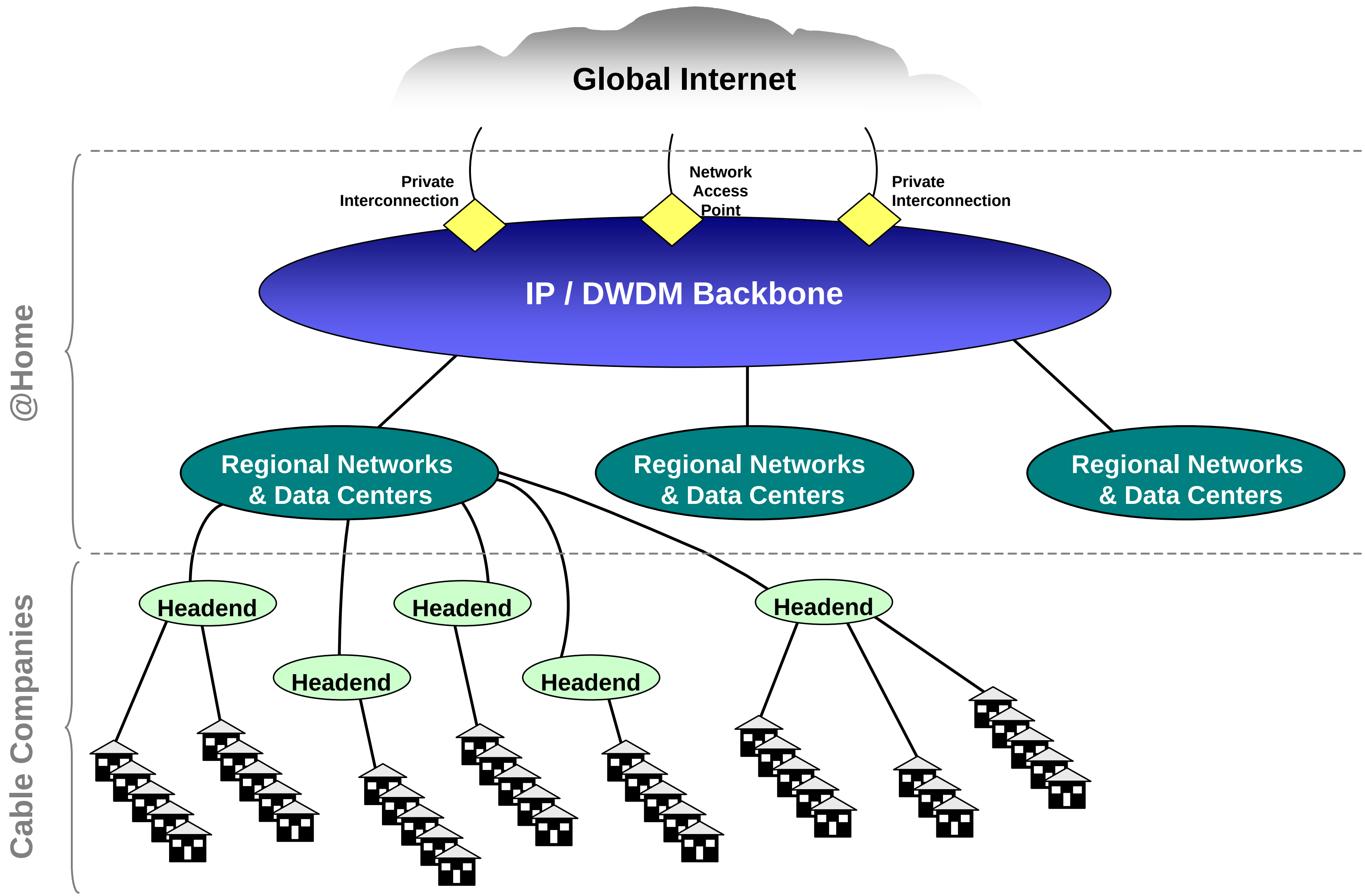


Figure 2

CLEC Network Architecture

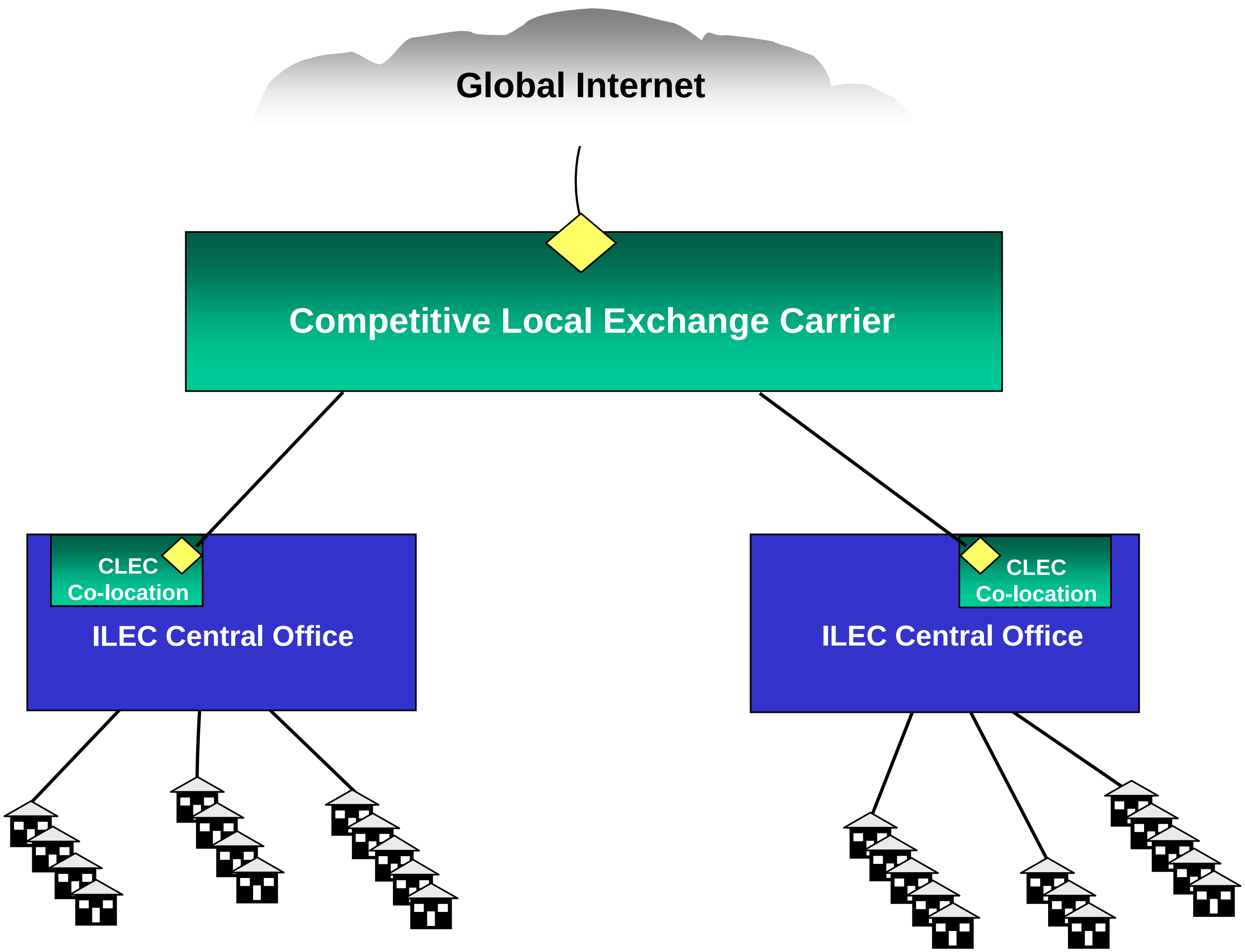
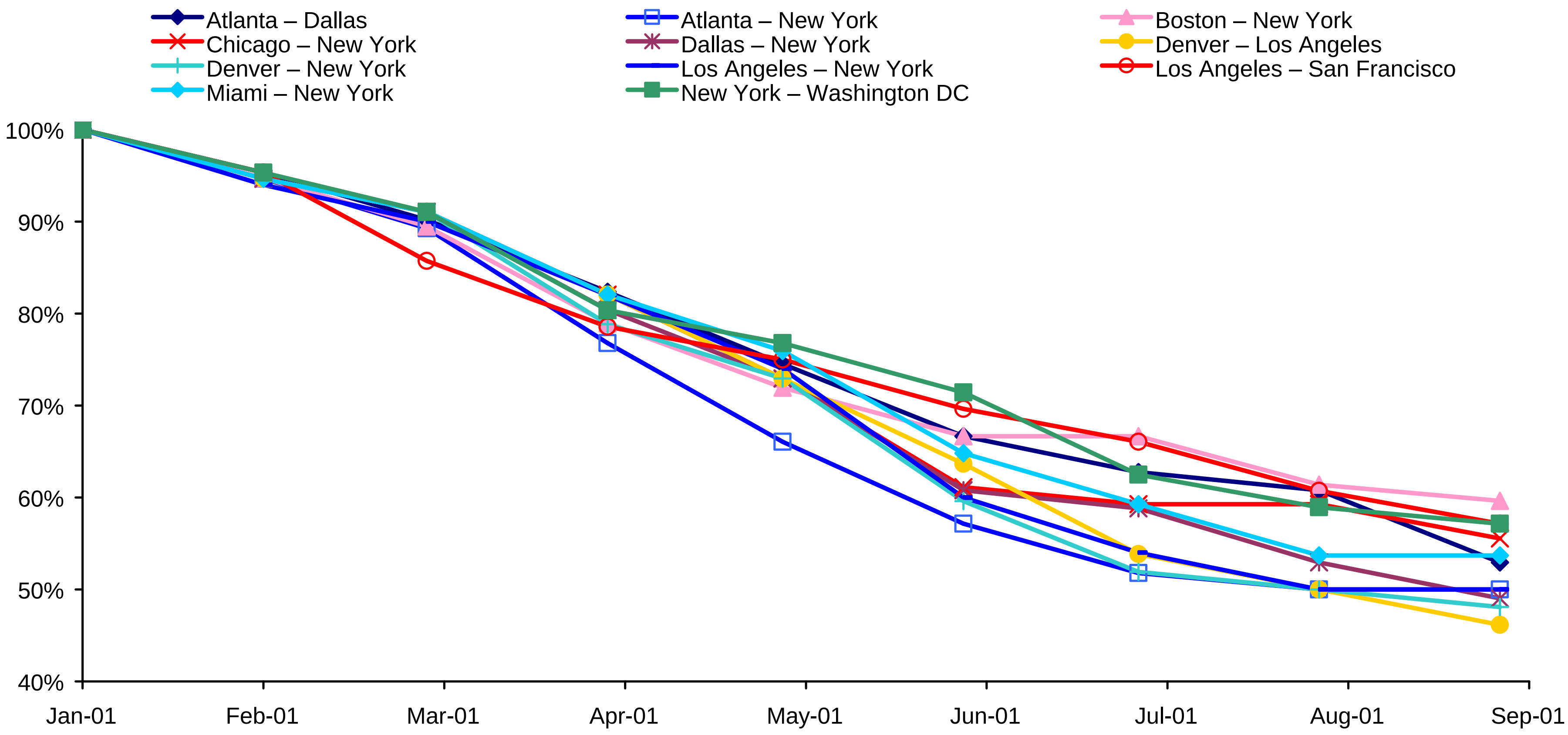


Figure 3
Optical Carrier Level 48 (OC-48) Monthly Lease Price – Percentage Change
Intra–U.S.
1/2001 – 9/2001

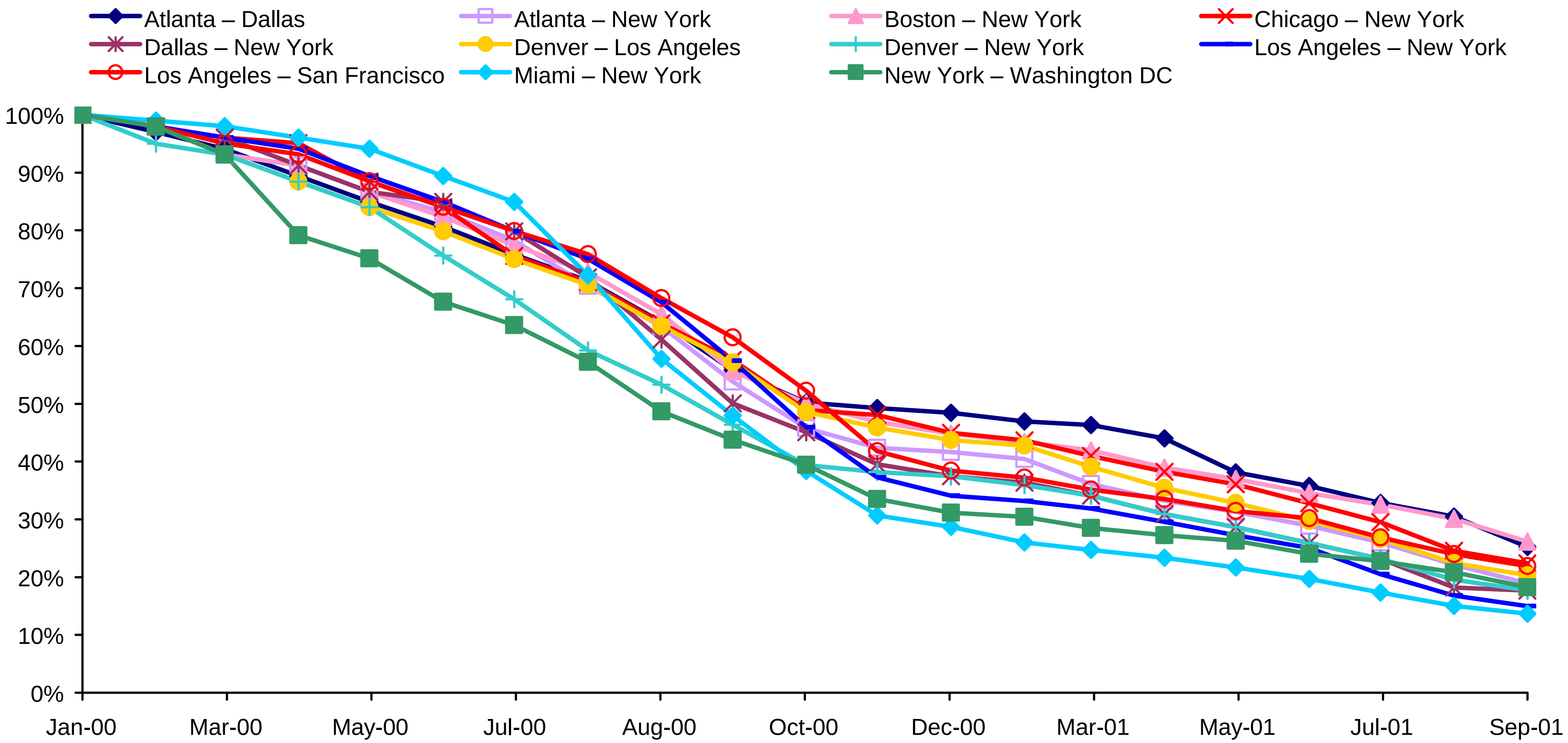
Source: Wholesale Bandwidth Pricing Database



Note: OC-48 has a capacity of 2.488 Gbps.

Figure 4
Optical Carrier Level 3 (OC-3) Monthly Lease Price – Percentage Change
Intra–U.S.
1/2000 – 9/2001

Source: Wholesale Bandwidth Pricing Database



Note: OC-3 is equal to three DS3s, with a capacity of 134.2 Mbps.