The Evolution of Broadband

Definition

The confluence of two forces—the globalization of business and the networking of information technology—has created the Internet economy. Electronic commerce and technology industries are growing and changing the economy of the United States and much of the rest of the world at breathtaking speeds. Today's economic shifts are having a more profound impact on the lives of individuals than did the Industrial Revolution. By leveling the playing field for everyone, advances in telecommunications and data technology are creating new opportunities for businesses, countries, and individuals—just as the Industrial Revolution changed fortunes around the globe. The new economy is defining how people do business, communicate, shop, have fun, learn, and live on a global basis—connecting everyone to everything.

This tutorial describes the evolution and technologies in broadband access. A brief history tracing the evolution of Internet and broadband access will be presented as well as the specific market drivers propelling this shift. The Telecommunications Act of 1996 created great opportunities for service providers of all types to maximize their revenue by offering new and exciting services. Voice over digital subscriber line (DSL) is one such opportunity; streaming media and video conferencing are another. It is hard to say whether deregulation or technology had a larger impact on competition in the telecom industry. What is clear is that both of these have completely changed the communications landscape forever.

The Internet and broadband revolution, and the network congestion that followed, has led people to focus both on the first and last mile as well as on creating a different network infrastructure to avoid the network congestion and access problems.

The information presented in The Evolution of Broadband Web ProForum is the summary of a 400-page research report published by the IEC and Hellerstein & Associates. While all attempts have been made to design this Web ProForum to provide a true summary of the entire report. Nevertheless, not all topics discussed in the complete edition of the report are adequately addressed in this Web ProForum.

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Topics

1. Introduction

The confluence of two forces—the globalization of business and the networking of information technology (IT)—has created the Internet economy. Electronic commerce and technology industries are growing and changing the economy of the United States and much of the rest of the world at breathtaking speeds. Today's economic shifts are having a more profound impact on the lives of individuals than did the Industrial Revolution. Innovation and productivity gains are valued above all else in this new economy. By leveling the playing field for everyone, advances in telecommunications and data technology are creating new opportunities for businesses, countries, and individuals—just as the Industrial Revolution changed fortunes around the globe. The new economy is defining how people do business, communicate, shop, have fun, learn, and live on a global basis—connecting everyone to everything.

As Former Vice President Al Gore stated, "We are in a new economy—an economy driven by information, research, knowledge, and technology." Alan Greenspan, Chairman of the Federal Reserve, echoed these comments when he stated that a "significant segment of our economy's growth reflects output of high-tech equipment." According to Greenspan, it is only a matter of time before the Internet becomes the prime venue for the trillions of dollars of business-to-business (B2B) commerce conducted each year. "Virtually every part of our

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economic structure is, to a greater or lesser extent, affected by the newer innovations in computers and in telecommunications....With few exceptions, little of a truly old economy is left. In the past five years, the long-term prospective profit growth of companies engaged in the computer and telecom industry have been revised up by more than double the amount as the profits earned by old economy-aligned industries."

Technological innovation and, in particular, the spread of IT has revolutionized the conduct of business over the past 10 years and has resulted in large increases in productivity. The surge during the past few years in business capital spending is a direct result of the higher rates of return brought about by the application of new technologies. The pace of innovation may have slowed down temporarily, but it is expected to resume as soon as companies begin to exploit the largely untapped potential for e-commerce, especially in the B2B section, from where much of the growth is expected to come.

The increasing importance of the Internet has brought about dramatic changes in the way goods and services are produced and distributed to end users. The Internet continues to play a significant role in shaping the new economy by enabling firms to communicate and conduct business on a global basis without regard for location or asset size. Investment in high technology continues to serve as an engine of strong productivity growth for the U.S. economy. Alan Greenspan expects this trend to continue in the years ahead. Moreover, the increasing penetration of broadband access among business and consumer users significantly augments this trend. This transformation from the old economy to the new economy will quicken in the coming years with the pace of innovation. Electronic marketplaces that automatically solicit bids from suppliers have the potential to reduce transaction costs substantially for companies and for the economy as a whole. Already, major efforts are under way in the automotive industry to move purchasing operations to the Internet. Similar developments are planned or are in operation in many other sectors and industries as well.

As the Internet market continues to explode, the demand for greater bandwidth and faster connection speeds has led to several technological approaches developed to provide broadband access to all consumers. Former Federal Communications Commission (FCC) Commissioner Kennard stated, "The most important issue on our agenda today is broadband....Broadband is going to change America....We want four things for consumers in the broadband world. We want fast deployment. We want ubiquitous deployment. We want competitive deployment. And we want open deployment." Ubiquitous broadband access to the Internet is an essential ingredient needed to gain the most out of what the Internet has to offer.

Broadband access is one of the most important issues for telecom equipment manufacturers and content and technology providers, as well as for cable operators, satellite providers, and fixed wireless operators. Any operator that fails

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to announce and implement a broadband strategy, including providers serving rural communities, will suffer consumer defections and a decline in retention rates for both business and residential customers. The pervasive influence of the Internet and the introduction of many Internet-ready appliances have fueled demand for broadband access.

The Evolution of Broadband examines the forces driving the rapid growth of broadband and high-speed access to U.S. homes and businesses. Broadband access is not only about providing the pipes to carry traffic on the Internet, but also about how that traffic will be carried. The report will raise numerous questions regarding partnerships, such as the following:

- What role will partnerships play in this new type of Internet environment?
- Will sites be more responsive to consumers who come from one of their partner sites?
- How will the formation of partnerships around content and infrastructure affect consumer behavior, a site's responsiveness, and any additional or custom features available?

These are just some of the questions that need to be asked and answered to provide clues to the future of broadband access and content delivery. Some of these questions were posed to a panel of experts that the International Engineering Consortium (IEC) had convened and were included on the broadband access surveys that were distributed at several IEC conferences throughout the year.

In only a few short years, all Internet appliances or electronic devices will be able to access the Internet and obtain the same content as personal computers (PC). Advances in technology and the needs of e-commerce are driving the Internet economy. Technology drivers include the integration of voice, data, and video on a single network as the traditional voice and data networks converge. Internet technology has become mainstream and is a requirement for companies interested in competing in today's global business world.

According to Alan Greenspan, the extent of the application of existing technology is far from complete. Greenspan predicts that total productivity growth rates will continue to remain high and are likely to increase further, despite the uncertainty in the markets about the pace of future productivity growth. The United States will continue to have increased productivity because despite the surge in demand, cost increases have been held in check. Moreover, Greenspan states that as "knowledge is irreversible, so much—if not most—of the recent gains in productivity appear permanent." Higher levels of productivity growth affect the demand for goods and services. A more rapid pace of technological change makes investments in capital goods that use these new technologies more profitable. As

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businesses recognize the new technological possibilities open to them, capital spending is increased to take advantage of these new opportunities. The higher level of business spending on capital goods results in increased employment and higher income, and also leads directly to a boost in consumer spending, setting off another round of investment spending. These higher-productivity growth rates translate into higher real income growth for employees and leads to higher consumer spending, raising aggregate demand. This rise in aggregate demand results in higher purchasing of goods and services, such as broadband access.

2. Market Drivers: Current Demand for Broadband Access Technologies

Market Size

Many organizations have adopted different methodologies for determining the size of the market for high-speed access. Some groups look toward the number of PCs purchased and extrapolate from there, while others look to the number of Internet or on-line users. The falling prices of PCs have resulted in many more consumers purchasing PCs for the first time or purchasing a second or third PC.

PC Owners

According to the *Washington Post*, PC penetration is now at more than 56 percent of all households in the United States, with an expected rise to 64 percent in 2005. The Department of Commerce's "Digital Divide" study found slightly lower figures of 51 percent. Penetration figures from Parks Associates, a consulting firm, found slightly higher results at 55 percent. Analysts at Parks Associates and at Morgan Stanley Dean Witter estimate that by 2004, PC penetration will be more than 70 percent. PC penetration continues to rise as PC prices drop and as more first-time buyers begin purchasing their first PC.

Consumer demand spanned a range of price points from value to moderately priced models. What has changed is the type of PC purchased and the design. Newer, more compact PCs account for 28 percent of all PC shipments and by 2003 are expected to account for 80 percent of all shipments. The move to compact or portable PCs has been encouraged by the fact that many college campuses require incoming students to purchase either a desktop or a laptop computer. At the University of North Carolina, every one of the 3,500 freshmen is required to own a laptop computer. The move to laptops by universities is connected to the creation of wireless networks in many of the campuses across the United States.

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Analysts at Morgan Stanley Dean Witter break down PC penetration into business and home use. They estimate that business use of PCs has climbed to more than 50 percent, while PCs used exclusively for the home have climbed to 40 percent. Moreover, they expect these figures to continue to rise, with household consumer PC penetration rising to 45 percent in 2000. These analysts expect penetration to approach 80 percent over the long term.

The PC has reached commodification because manufacturers now offer it as a bonus for purchasing a more expensive item such as a car. According to IDC, car dealers in New England offered their customers a free Dell PC if they purchased a sport utility vehicle (SUV). The promotion of a bundled PC applied to both leased and purchased vehicles and was extremely successful in selling and leasing SUVs. It is likely that promotions such as these will multiply as companies seek other methods of adding value to their products. A free or heavily discounted PC is one such option. Other establishments will begin giving free PCs to consumers who purchase their high-end products.

Other drivers for PC growth are the sizeable number of large corporations that began offering discounted or free PCs to their employees. Because more than 50 percent of the U.S. market already owns a PC, PC original equipment manufacturers (OEMs) are looking at different ways they can sell PCs, and tying in with a large multinational company is one of them. PeoplePC got a large boost after both Ford Motor Company and Delta Airlines selected them as the primary vendor for PCs to employees.

The main reason why the number of PC purchases has increased is the demand for Internet and on-line access. Most of the major manufacturers have joined with telephone and cable companies to promote broadband access. Broadband access has spurred, and will continue to spur, consumers to purchase newer PCs that have universal serial bus (USB) connectors, DSL, or cable modems built in. All this coordination with other companies outside the industry is geared to convincing consumers that they need to purchase newer PCs sooner than planned.

More than 30 percent of U.S. households own more than one PC. The number of multiple–PC households is increasing very rapidly, by more than 30 percent annually, with large numbers of families purchasing PCs first for their children and then for themselves. As a result, the number of multiple–PC homes is growing faster than the number of single–PC homes. This percentage, along with the percentage of people who are on-line today (about 38 percent), illustrates how large the potential market for high-speed access is. Following these estimates and the rising growth rate for Internet subscribers, we can expect that by 2002 close to 50 percent of all households will have Internet access, with more than 30 percent of these households owning more than one PC. The increasing number of multiple–PC households is a major driver for broadband access.

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Internet Users

According to the Department of Commerce, in 2000 a total of 304 million people worldwide had Internet access—up almost 80 percent from 1999. The United States and Canada account for 50 percent of the total. Andy Odlyzko, the head of AT&T's Math Lab, places the number of worldwide Internet users at 500 million. Whatever figure is used, the rapid uptake of Internet and broadband access is occurring regardless of income, education, race or ethnicity, location, age, or gender. In August 2000, there were 117 million Americans on-line at some location. Today, this figure is much larger—more than half of all Americans are using the Internet.

Not only is the Internet growing larger, but the ways it is being used are also changing. The Department of Commerce found that 80 percent of all users send and receive e-mails with files or attachments weekly. Some 22 percent of all users have created or updated a Web page within the last three months. In 1999, more than 3.5 billion e-mail messages were sent in the United States and 5.3 billion worldwide. Analysts at Robertson Stephens expect e-mail volumes to exceed 22 billion by 2004 (10.4 billion in the United States alone). Some 94 percent of all adults on-line, representing 73 million people, access their e-mail at least once a month.

As the volume of e-mail messages rises, the size of messages and the types of attachments also change. E-mail becomes the primary method for delivering multimedia clips such as pictures, cards, digital images, movies, voice messages, PowerPoint files, and large e-commerce-related files. Today, all of the top Web-site destinations offer content, communications, community, and commerce. Sending or receiving e-mail, obtaining information about a hobby, general news, and information for business continue to outrank on-line shopping as popular on-line activities. Internet advertising revenues have more than tripled since 1997, highlighting the importance that businesses place on using the Internet to reach customers.

There was also a transformation in 1999 of how people used the Internet and how integrated it has become in people's daily lives. Some 61 percent of all home users of the Internet go on-line at least once a day, with 50 percent of them using the Internet more than once a day. The Internet has gone from a tool that only academics and researchers use to being a daily source for e-mail, shopping, research, and news. E-mail and Web addresses are everywhere—from ads on buses to receipts to shopping bags. All promotional material and ads now prominently list the store's or company's Web-site address. Practically every store or company has a Web site. The Internet has ramped up faster than any other medium in history. According to the U.S. Department of Commerce, television took 13 years to reach 50 million users, while radio took 38 years and cable 10 years. The Internet reached 50 million users in only four years. Analysts from

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Robertson Stephens expect the Web's audience to double during the next 12 to 18 months and to reach more than 300 million in 2002.

On-line audience sizes continue to grow dramatically, particularly with the help of both broadband and e-mail access at home and at work. According to a 1999 study by the Department of Commerce, the number of Web users worldwide increased by 55 percent, the number of Internet hosts rose by 46 percent, the number of Web servers increased by 128 percent, and the number of new Web address registration rose by 137 percent.

According to IDC, in just six months from January 2000 through June 2000, the number of Web users increased by more than 45 million to 290 million. Morgan Stanley Dean Witter analysts are estimating a four-fold increase in Web usage within the next two to three years. Moreover, they state that the number of Internet users could double as a result of higher PC penetration and cheaper and easier access to the Net through information appliances and less costly access. Furthermore, they predict that Web usage will double as new applications are introduced and as broadband penetration rises. As the Internet becomes integrated into people's lives, its growth will increase significantly.

Morgan Stanley predicts that Internet penetration will jump by 65 percent of all workers and 50 percent of all households in the United States by 2003. Broadband services will rise significantly beginning in 2000. Merrill Lynch estimates that by the end of 1999, 39 percent of all households had access to the Internet. Because PC penetration is 54 percent, this represents about 80 percent of all PC-enabled households. Moreover, by 2001, on-line access subscriptions will begin to exceed PC households. Merrill Lynch predicts that by 2002, nearly 65 percent of all U.S. households will have some kind of on-line access to the Internet. And according to figures from Parks Associates, two-thirds of all PC households are interested in obtaining high-speed Internet access.

These penetration rates continue to climb. Traffic on the Internet doubles every year, and Web usage appears to be growing at a rate of 10 million people per quarter. In comparison, traditional voice networks are growing at a rate of 10 percent per year. Cellular services, although growing faster (on the order of 30 percent to 40 percent per year), are eclipsed by data and Internet network growth. Data traffic used to grow at rates of 20 percent to 30 percent a year in the1980s and 30 percent to 40 percent in the 1990s, but that was when the only traffic was from private-line networks run by corporations to provide internal communications. However, in today's data economy, where the public Internet is the dominant network, annual growth rates of 100 percent or more appear to be setting the pace for the entire telecommunications network infrastructure.

Morgan Stanley estimates that by 2000, the number of Internet users will reach 160 million and then double every two years. Because no single person or company controls the Internet, entrepreneurs are constantly bringing new

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applications and markets to the Internet. IDC estimates that by 2003, there will be 723 million Web-attached information devices, up from 87 million in 1998.

3. Other Access Users

The proliferation of alternative technology, such as WebTV and Worldgate, has introduced families without PCs to the Internet. Forrester estimates that spending on Internet appliances will rise four-fold during the next two years—from $350,000 to $1.5 million. Several manufacturers have come out, or plan to come out, with Internet-ready appliances. These devices are all part of America Online's (AOL's) "AOL Anywhere" strategy. The devices are small and lightweight and will launch AOL and offer content and different types of features. These devices, unlike PCs, could be placed throughout the house, including the kitchen or living room. As consumers become more familiar with the Internet, they will spend more time on it. Consequently, they will begin to demand higher access speeds either through cable modems or DSL.

The world has evolved from one where all Internet access comes from PCs to one where Internet access can come from anywhere—a television, a cell phone, a personal digital assistant (PDA), or any other type of Internet appliance. There is an explosion in the number of Internet appliances. In late September, Yahoo! announced that it was fitting 10 New York City taxicabs with Internet-enabled PDAs. Continental Airlines went one better and announced it was testing fully functional Internet systems on one of its planes. Today, Internet access is available in amusement parks, ballparks, sports clubs, bars, car washes, and even waiting rooms in doctor's offices.

Moore's law is behind the technical progress that is being made in Internet appliances and is also the reason that there are so many different types of appliances. Moore's Law enables small, inexpensive processors that can be embedded into portable devices-such as Internet access through PDA and mobile phones. However, Moore's law also drives multimedia capability into digital technology as access networks, storage, and processing devices all become able to handle the large volumes of data required in transmitting audio and video content. It is this trend that is driving the industry to a plethora of entertainment-oriented appliances, such as digital photo displays (Ceiva), net-top boxes (AOL TV), and Web TV and digital VCRs (Replay TV and TiVO). Ceiva's picture frame sells for $250 plus a $50 annual subscription to its Web server, where users queue photos for downloading.

Demand for Broadband Access Services

As the Internet market continues to explode, demand for greater bandwidth and faster connection speeds have led to several technological approaches developed to provide broadband access to all consumers. The demand for high-speed

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bandwidth is growing at a fast pace, driven mostly by growth in data volumes as the Internet and related networks become more central to business operations. Today's telecom industry is undergoing a bandwidth shortage driven mostly by the continuing explosion of the Internet and data markets. Demand comes from three primary sources: small and mid-sized businesses and small offices/home offices (SOHOs), consumers, and multiple-tenant units (MTUs) or in-building fiber builders and universities that are installing high-speed wireless connections throughout their campuses.

The rapid growth of distributed business applications; the proliferation of private networks, e-commerce, and bandwidth-intensive applications (such as multimedia, videoconferencing, and video on demand [VOD]); as well as the continuing deregulation and privatization of the telecommunications networks throughout the world, all help fuel the demand for bandwidth. Moreover, an increasing number of teleworkers are fueling the demand for second and third lines for fax and Internet dial-up. To meet this explosive demand for bandwidth and to capitalize on this growing data opportunity, many data competitive local-exchange carriers (CLECs) are aggressively targeting small businesses, SOHOs, and teleworkers in the selected areas of the country in which they are operating.

Additionally, demand is coming from homebuyers seeking high-speed connections in their homes. According to the *New York Times*, high-speed access has become as important as a two-car garage, fireplace, kitchen, or a nursery in a new home. For builders, high-speed access is a way to have a continuing revenue stream even after they have sold the houses. In most of the places built, the builders retain a small ownership interest. Many builders are weighing revenue-sharing arrangements with broadband access companies that will wire all new developments as well as existing ones, similar to the deals developers have struck to wire office buildings with broadband providers. High-speed access services provided by these builders are often significantly cheaper, up to 15 percent, than services provided by other broadband providers. These providers give homeowners a bundled service that often includes phone, cable, and high-speed access at as much as $20 a month less than the typical cost of the items priced separately. Moreover, instead of a separate bill, they simply pay one fee to the homeowners association.

Consumers are tending to remain in apartments longer than average, require high-quality services to the homes, spend more money on new services such as high-speed access, and waiting longer before getting married. As a result, people in their late 20s and early 30s have more disposable income and are more inclined to purchase products that are not necessities, such as high-speed broadband access. Recent surveys show that nearly 44 percent of apartment occupants are 34 years old or younger and have a combined income approaching $125 billion annually.

Small Business/SOHO/Teleworker

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Access to a corporate local-area network (LAN) at reasonable prices is one of the main reasons why small businesses and teleworkers purchase DSL; access to a corporate LAN often requires a 1 megabit per second (Mbps) connection in both directions. DSL eliminates the poor performance and busy signals of analog modems and the complexity of the integrated services digital network (ISDN) with a high-speed dedicated service that costs a fraction of the price of T1 leased lines.

According to the U.S. Small Business Administration (SBA), some 85 percent of businesses with fewer than 100 employees had PCs in 1999, and more than 61 percent of these had access to the Internet. Home-based businesses invest about $1,100 on Internet technology with very small businesses; those with fewer than five employees spend about $1,150 annually.

There are about 24 million teleworkers today, and this figure is expected to grow significantly in future years as many more companies are offering workers the ability to telecommute. Furthermore, according to the Gartner group, about 80 percent of the 1.5 million enterprise locations in the United States are small or branch offices with six to 75 employees. Like telecommuters, these branch offices typically need connectivity to the corporate network.

Many teleworkers work from home on a full-time, part-time, or after-hours basis and require high-speed, remote LAN access to best perform their jobs. Also, many people work and operate a business at home. In 1997, The U.S. Department of Transportation reported that as many as 11 million people telecommuted. This figure has now climbed to 23.6 million. Servicing this demand should lead to rapid innovation and rapid deployment of services designed to meet the needs of corporations and their teleworkers as well as Internet service providers (ISPs) and their small-business customers. Many firms have already created special products targeted at these people.

IDC states that small businesses and teleworkers spend a combined total of $73.9 billion on voice and data services. Moreover, because these small businesses lack economy of scale, they typically pay higher rates for voice and data services than large businesses. However, despite their smaller size, small businesses and SOHOs have many of the same communications requirements as large companies. Many small and branch offices require multiple phone lines but cannot justify the cost and expense of a dedicated T1 line. DSL solutions that include voice are perfectly suited for this market.

According to the trade periodical *The Industry Standard*, the number of small businesses with Internet access is expected to more than double by 2001, resulting in a compound average growth rate of 11 percent from 1997 to 2001. By the end of 2000, 61 percent of all small businesses had Internet access, but only 20 percent of these had a broadband connection.

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Morgan Stanley Dean Witter estimates that the value-added services market represents a $40 billion opportunity. These analysts forecast the value-added service market will increase from $34 billion in 2000 to $45 billion by 2005. Today, voice services for small-to-medium enterprises (SMEs) account for 96 percent of all value-added services revenue, but in the coming years the deployment of voice-over–DSL (VoDSL) or voice-over–IP (VoIP) technology will enable SMEs to reduce their spending on voice services. As a result, the addressable voice market will decrease to 71 percent by 2005.

Consumer Market

According to various analyst forecasts, at the end of 1999, there were about 34 million consumer households on-line, or about a 33 percent market penetration. Additionally, this 33 percent penetration equaled about 82 percent of all PC households. By the end of 2000, Internet access penetration in the consumer market increased to almost 41 million and is expected to rise to 81 million by 2005, or 73 percent of households and 97 percent of PC households. Analysts expect the consumer market to continue to account for more than 80 percent of total Internet subscription through 2009. Although dial-up access is the most prevalent, broadband access is growing strongly as was discussed at length in the earlier sections.

Morgan Stanley Dean Witter estimates that the consumer market for broadband services will reach $108 billion by 2005, up from $95 billion in 2000 for a compound annual growth rate (CAGR) of less than three percent. Today there are more than 104 million households in the United States, with a penetration rate of almost 40 percent for Internet access. However, only a small percentage of these consumers—less than one percent—are served by a broadband connection. There is a race between the cable operators and the DSL providers concerning which can gain the largest market-share. The fight over the consumer market has led to massive industry consolidation and has also led SBC to spend $6 billion to perform a massive upgrade to its network infrastructure to ensure that it captures the lion's share of this market. Furthermore, the inability to gain access to the consumer market is what led NorthPoint to merge with Bell Atlantic.

All growth in the consumer market is for Internet access services. The voice services market is expected to remain relatively flat because consumer versions of VoDSL using asymmetric DSL (ADSL) are a couple of years away. Morgan Stanley Dean Witter analysts estimate that consumer Internet access revenues will increase at a 17 percent CAGR from $9.4 billion in 2000 to $20.8 billion in 2005.

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MTUs or In-Building Service Providers

The MTU broadband and equipment market is rapidly expanding and is expected to increase from $370 million in 2000 to $2 billion in 2004. Shared-tenant facilities also offer excellent opportunities for rapid payback from broadband applications. These facilities began owning their own copper loops in the early 1980s, as customer premises equipment (CPE) was deregulated. These private copper loops are an extremely valuable hidden resource. The resource is hidden because most building owners are not cognizant of the opportunities available to them. There are about 750,000 commercial office buildings in the United States, with only two percent or 17,000 having more than 100,000 square feet.

However, these commercial office buildings with more than 100,000 square feet account for 40 percent of the total commercial office space. Some 42 percent of all tenants rank built-in wiring for high-speed Internet access as one of their most desired business features.

In-building service providers offer building owners significant benefits. Building owners receive state-of-the-art fiber networks, warrants to purchase equity with the service provider, and approximately a four to six percent share of all revenues derived from the building tenants, with little or no capital contributed. These in-building broadband providers provide tenants with significant amounts of bandwidth at very competitive prices. Allied Riser, one provider, is offering tenants 10 Mbps of bandwidth at prices comparable to 1 Mbps. This allocation of large amounts of bandwidth to the desktop will enable providers to supply a whole host of value-added services such as Webcasts, video, application hosting, and real-time videoconferencing.

Because these large commercial office buildings are predominantly located in large cities—more specifically in downtown areas—they are likely to be connected via fiber. The average customer in a fiber-fed building pays $750 per months for 8.5 Mbps of bandwidth. In contrast, the average business DSL subscriber pays about $200 a month for 1 Mbps or less of bandwidth.

4. Digital Subscriber Line Growth

The DSL market has undergone a complete makeover. There are now nine variants of DSL, and it seems that every year another variant is invented. CLECs and ISPs have realized the huge pent-up demand created by the large number of small and medium-sized businesses, the huge expansion of the SOHO market, and the growing needs and requirements of teleworkers and are heavily targeted these markets. During 2000, the U.S. DSL marketplace saw explosive growth, adding more than 1.9 million new subscribers for a growth rate of 382 percent from the end of 1999. This impressive growth of the DSL market shows no signs of slowing in the coming months.

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DSL builds on the work of engineers in developing dial-up modems to offer data over voice access to the copper spectrum. DSL uses the existing copper plant to provide data over voice, independent voice and data transmission, and plain old telephone service (POTS). Because DSL is a loop technology, rather than a broadband access technology, it can be deployed in many different configurations and in many different types of telecommunications equipment. In a few years, we will probably see DSL deployed not only on all digital loop carriers (DLCs), but also on channel banks, asynchronous transfer mode (ATM) switches, voice switches, and on next-generation DSL access multiplexers (DSLAMs).

Demand for bandwidth has led to several technological approaches developed to provide broadband access to business and residential customers. DSL is not the only path to achieving high-speed broadband access. Several competing technologies, such as cable modems, broadband satellites, and broadband fixed wireless services, are trying to achieve the same goal—to provide high-speed broadband access to consumers. This report examines the market strategies and deployment of these alternative services. Although DSL has numerous advantages, other means of obtaining high-speed access might be preferable to some customers. Several fixed wireless technologies are beginning to challenge traditional wireline and cable for the data marketplace.

Widespread installation of DSL has been impeded by physical constraints of the local loop (number of load coils and bridge taps as well as its distance from the central office [CO]), inability to access customers served through a DLC, interoperability problems between products, and spectrum compatibility issues. The need for automated provisioning and flow-through of orders, better training and customer service, a shortage of experienced technicians, and the lack of true plug-and-play modems have also hindered the spread of DSL.

Self-installation continues to be the holy grail of the DSL industry. Finding a way to move beyond service-provider CPE channels and into the retail market is the key to a successful mass-market deployment of DSL. DSL needs to become as easy to purchase and install as an analog modem is today. Consumers need to be able to purchase a modem at an electronics or other retail outfit, install it on their PC, and immediately sign up for DSL with little or no support.

If DSL providers and vendors can achieve this goal and if customer service and technical support of the service provider can follow, then a mass-market deployment will happen much sooner than expected. Besides implementing automated provisioning and configuration system and processes, the biggest obstacle facing the industry is the need to significantly improve the customer and technical support provided to all potential and actual subscribers. If these obstacles can be overcome, DSL will have a bright future. Without a significant improvement in customer service, the deployment of DSL to the mass market will fall far short of expectations.

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For DSL to be successful, it must not only meet the expectations generated by its marketers, but also guarantee service quality and be as easy to install as an analog modem with a dial-up ISP. Otherwise, the advantages it offers (e.g., high-speed access, low cost, videoconferencing, access to company LANs, and other applications that require higher bandwidth) will be reduced substantially.

Without service guarantees, small and medium-sized businesses are unlikely to use the service for their mission-critical applications. Quality of service (QoS) guarantees are essential to any business and have become one of the main value-added services that DSL service providers can offer to differentiate themselves from other providers. Businesses have always paid more to ISPs that offer tier-1 Internet service, and the same can be said for service providers that offer service-level guarantees to small businesses.

Newer technologies are not only reducing the costs of transforming inputs and outputs that result in goods and services, but also are decreasing interaction costs, i.e., the costs that are incurred in getting different people and companies to work together to exchange goods and services. According to Roger Ferguson, these interaction costs account for about 55 percent of all labor costs, with some industries, such as financial services, having interaction costs as high as 70 percent of labor costs.

The industry needs to focus on measures to strengthen customer service initiatives, review current support processes and service levels, and map future demand for customer support. Otherwise, deployments of broadband access infrastructure will be significantly impaired. Companies need to ensure that both their customer and technical support teams, as well as their partners or affiliates, are well trained and responsive to customer needs. Otherwise, these companies risk permanently endangering both their business success and the rollout of a broadband infrastructure in the United States. We see this total inattention to customer service as the biggest danger facing all broadband access and e-commerce providers today. If this situation continues the way it is, with companies not paying much attention to customer service, the true promise of high-speed access will never be achieved. Broadband access needs to become a lifestyle, and this means that the complexity of DSL or other forms of broadband must be hidden from the consumer.

Establishing standards and resolving spectrum compatibility concerns are other items critical to a successful deployment of DSL. The lack of standards leads to market fragmentation, low volumes, and high cost. Moreover, use of standards-based DSL promotes the interoperability of technologies and devices, which is key to a successful rollout of DSL. The interoperability of devices also vastly increases customer choices, provides a greater selection of products, and reduces costs to the supplier and the consumer. Standards-based DSL also allows the market to provide more product and supplier alternatives to consumers than would have been possible without standards. Moreover, standards-based DSL

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helps focus the industry to resolve other challenges hindering its mass deployment.

Broadband access is one of the crucial pieces of the next-generation networks. Today companies are investing massive amounts of money to build and deploy next-generation backbone technologies. Hence, it is clear that the Internet and other packet-based networks will shortly have the necessary bandwidth and capacity to meet this explosive growth of data and video traffic. Companies are using various technologies and streaming techniques to move content closer and closer to the edge of the network, thereby avoiding the congestion that is currently slowing down the network. Edge devices are increasingly becoming smarter and smarter. What is lacking is access to the last or first mile, the residential area, and the small-to–mid-sized customer. Unless this existing bottleneck at the edge of the network is removed, next-generation networks will have massive core capacity with no way for consumers to access it. DSL is one of the access technologies that can be used to reduce, if not eliminate, this bottleneck.

As mentioned, there are nine types of DSL service:

1. ADSL
2. G.lite
3. Rate-adaptive DSL (RADSL)
4. ISDN DSL (IDSL)
5. Symmetrical DSL (SDSL)
6. G.shdsl
7. High-bit rate DSL (HDSL)
8. HDSL2
9. very-high–data rate DSL (VDSL)

The majority of all business deployments to date of any type of DSL have been made by data CLECs such as Covad, NorthPoint, and Rhythms (before bankruptcies). The incumbent local-exchange carriers (ILECs), notably SBC, have the majority of all residential deployments. Also, while the CLECs have focused on the less price-conscious business (e.g., the SOHO and teleworker markets), the ILECs have chosen to go after the truly residential consumer–a much tougher marketplace. This marketplace is extremely price conscious and will likely have a high degree of churn. More than 46 percent of the respondents to the broadband access survey thought that churn would be between 10 percent and 20 percent.

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Although currently churn is less than two percent, it will likely increase to 10 percent as deployment grows. The survey respondents predicted that within two years, 37 percent of all broadband users would shift from one type of access technology to another and drop their present provider in favor of another. The ILECs have focused on the consumer marketplace, for regulatory reasons and because of a fear of cannibalizing their T1 revenues.

Although the conventional voice circuit has only a 3.4-kilohertz (KHz) bandwidth, the physical wire connection's bandwidth is more than 1 megahertz (MHz). In the 1930s, when the U.S. government had decided to offer all Americans universal phone service, the most expensive parts of the network were the links connecting the COs. To keep telephony affordable, the industry decided to maximize the number of calls on each wire that went between the COs and the network. As such, they limited each transmission to 4 KHz. However, now that the United States has switched from analog switches to digital switches, the cost considerations that these guidelines were based upon are no longer necessary. DSL exploits this extra bandwidth to send data to the CO, where it connects with the company's fiber-optic network.

Much of the downstream bandwidth is unusable today because of the distances and length of the lines. DSL downstream rates depend on the length of the copper line, its wire gauge, the presence of bridge taps, cross-coupled interference, and the services provisioned on adjacent circuits. Signal attenuation in the copper and crosstalk are the biggest stumbling blocks for DSL. Technical solutions to the problems of larger dynamic ranges and longer distances are extremely complicated and expensive.

5. Market Forecasts

The two main target markets for broadband are the small and medium-sized enterprises and the consumer markets. Analysts at Morgan Stanley Dean Witter estimate that the SME market will reach $52 billion by 2005. SME services include Internet access, voice services, application hosting, virtual private networking, and Web hosting. The same analysts estimate that the consumer market will grow to $108 billion by 2005, up from $92.5 billion in 1999. Morgan Stanley Dean Witter analysts expect that by the end of 2000, DSL technology will be the access method of five percent of all consumer Internet users, growing to 28 percent of all Internet users by 2005.

Analysts are split regarding which technology will be the winner, and thus the forecasts vary greatly. However, one clear trend emerges: until all service providers concentrate more on customer service and solving back-office issues, DSL will continue to lag behind cable. Poor customer service is the Achilles' heel of DSL providers. The lack of attention to customer service is one of the most troubling issues facing the broadband marketplace today. Customer service is a

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critical but overlooked ingredient of any e-commerce or broadband access provider. The success of the DSL service provider hinges almost entirely on the ability to obtain and retain customers. Retaining customers is directly related to customer satisfaction.

Forecasting in general is an inaccurate science, and thus analysts' estimates tend to be all over the board. However, that being said, we can make intelligent guesses about DSL subscribership and the growth of the industry. Both Moore's Law, which states that processing speed doubles every year, and Metcalf's Law, which states that network impact increases exponentially, can be used to project future demand for DSL. Internet traffic is doubling almost every year and switching and fiber capacity from wave division multiplexing (WDM) and terabit routers have allowed the network to rapidly carry more traffic than was thought possible only a few years ago. Technology growth will continue to drive down costs, making available more types of applications and value-added services. Internet video—the ability to watch full-motion movies through your PC—is but one example. Providers are building fiber deeper into the networks and moving intelligence to the edge of the networks. The technical problem of delivering video is well on the way to being solved through the use of caching and by bypassing the Internet backbone with satellite or fiber to deliver programming to a server at the edge of a network. The second bottleneck is inadequately provisioned networks. This too is being solved through the use of a new network architecture similar to the designs that SBC is implementing as part of Project Pronto.

Cable continues to have an early lead in deploying high-speed services, but its lead is primarily in residential services, rather than in the more lucrative business services. This lead will likely continue for the next few years as DSL continues to have technical and provisioning problems in getting enough lines deployed on a timely basis. These problems likely will ease significantly with the widespread implementation of line sharing and the work of the DSL Forum on autoconfiguration and in getting to plug-and-play.

6. Network Infrastructure Changes

The Internet was never designed to handle the amount of traffic that we are seeing today. The increasing penetration of broadband access and the demand for multimedia applications is exacerbating this problem. The increasing importance of the Internet and the importance of delivering Web content quickly and reliably have put strains on the network. As broadband penetration increases, users will demand higher-quality content such as more streaming media.

The Internet continues to be prone to significant delays and congestion that frustrate all users, even those on broadband connections. Performance is so poor that content providers are able to offer only the most rudimentary applications

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and services. The average speed of the Net is 80 times too slow to offer full-motion video, and the problems are only getting worse as more people use the Internet. The speed of one's modem—or the first and last mile as it is known—has been a significant factor in the development of more bandwidth-heavy applications. Modem speed places considerable restrictions on a content provider's ability to offer applications and services requiring faster speeds. As broadband penetration rises and consumers have access to faster modem speeds, these speed restrictions will be significantly alleviated.

Speed and reliability are the two most common problems cited by Internet users. The typical Web page contains 15 to 20 kilobits (Kb) of information, so it will not overload the network. In comparison, one second of video contains more than 125 Kb of information, or close to 10 times that of the average Web page. Thus, the speed and reliability problems of the Internet limit the applications that run on it. Median download times on the Net are close to 3.5 seconds, while mean times are approaching 10 seconds. Given the limitations of the Internet to deliver reliable high-speed connections, current Web pages are designed not to exceed 15 to 20 Kb of information. This is to ensure that sites can be downloaded within at least a few seconds. In a recent Dataquest study, they found that streaming media often travels through 20 different routers and experiences 25 percent packet loss. (Packet loss occurs when a portion of the signal does not reach its destination the first time it is sent). The further a packet must travel, the more likely it is to run into delays.

Today's DSL networks offer only a slight improvement because they only affect the first- and last-mile bottlenecks, and not the router and server bottlenecks. DSL and cable modems are great at resolving the first- or last-mile bottlenecks, but they simply push the bottleneck further upstream. Streaming applications put more stress on the network because they demand more bandwidth than the 25 Kb per subscriber available. Local caching is required to guarantee a positive user experience and to differentiate broadband content from others. To eliminate delays and improve the way content is delivered on the Internet, all aspects of the process must be improved.

The other two bottlenecks, router and server congestion, are being addressed by a number of service providers such as Akamai, Digital Island, and Cidera. Moreover, new routing technologies, faster equipment, content-distribution systems, and caching are helping to address these problems.

Despite the bottlenecks, the Internet and the increasing penetration of broadband access are quickening the spread of new applications and of new technologies. In less than one year, Napster attracted more than 38 million users, proving that the market for peer-to-peer and other file-sharing technologies is huge. Since then, hundreds of new Internet start-ups have been seeking to capitalize on this success. Napster was a success because it brought people back to what they liked most about the Net—the ability to connect people with people,

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even if it was to exchange music without having to pay copyright fees. According to recent studies, when asked whether they would give up e-mail or the telephone, consumers were equally split as to which they would give up. However, when a similar choice was offered between the Web and e-mail, more people said they would give up Web access. This statement is just as true for individuals and large corporations. E-mail is what makes enterprises run.

Andy Odlyzko, in a recent paper titled "Content Is Not King," found that people are willing to pay a lot more for point-to-point communications than for anything else. E-mail is the killer application precisely because it is all about one-to-one communications. While content can be profitable, as is seen by the amount of money earned annually by media companies, content by itself is often not a profitable endeavor. Every newspaper, with the exception of the *Wall Street Journal*, has failed in their efforts to convert their readership from a free model to a subscription-based model. Inexpensive Web browsing, even if it is at higher speeds, is not what consumers are looking for in the Internet. What they really want is the ability to interact with other people.

The increasing popularity of sharing pictures or videos and the cumbersome nature of e-mail in sharing these photographs will lead to an increasing use of peer-to-peer networks that will be specially designed for this. The growth of local storage and the increasing availability of tools to fill up this storage with video clips and other material will likely make peer-to-peer networks increasingly important. Although it is difficult to determine the path the Internet will take, one can be reasonably sure that the growing storage and communications capacities that exist and are in the process of being developed will be used often in unexpected ways. Napster came out of nowhere, and the next file architecture could also. Odlyzko predicts that as the Internet becomes ubiquitous, point-to-point communications will provide higher value than broadcast communications. As for the question of whether the Internet will continue to become an open network or whether peer-to-peer networking will eliminate the openness of the Internet, Odlyzko argues that effective point-to-point communications will demand easy interconnection and openness—two items that can only be provided if the Internet remains open. He predicts that we will likely end up with a system where commercial users contribute the most, but households paying for point-to-point communications will be close behind, with the transport component of charges for content coming in last.

7. Technology Hurdles for DSL

Widespread installation of DSL has been impeded by physical constraints of the local loop (number of load coils and bridge taps, distance from the CO, etc.), by interoperability problems between products, and by spectral compatibility issues.

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The problem with sending a high frequency over an unshielded pair of copper wires is that the electric field travels outside the wire. If the wires are too long, as most wires in local loops are, the signal at the end of the wire may become too weak to be understood. If the telephone company tries to mitigate this problem by increasing the power at the originating end, the signal tends to transfer itself to nearby wires in the same cable bundle. This transferring of signal is called crosstalk. In the telephone network, multiple insulated copper wires are bundled together into a cable binder. Adjacent systems within a cable binder that are sending or receiving information in the same range of frequencies can create significant crosstalk interference. This is because crosstalk signals combine with signals that were intended originally for transmission over the copper wire loop. As a result, a slightly different shaped waveform becomes transmitted.

While crosstalk was not much of a problem in the analog world, it has the potential to become a severe problem for DSL users. DSL requires much higher frequencies than analog; consequently, the number of lines subject to crosstalk or other interference increases significantly. Performance will be severely impaired if the DSL line is tied to a T1 line or other high-speed lines.

A second problem with deploying DSL is the use of bridge taps, which are branches that are attached to circuits to reroute the line to another location. According to Bellcore, 56 percent of the loop population has bridge taps. A bridge tap is any portion of the loop that is not in the direct path between the CO and the end user. For example, a bridge tap could be an unused cable pair connected at an intermediate point or an extension of the circuit beyond the end user's location. Telephone companies have used bridge taps so they could cheaply build in extra capacity in a neighborhood without knowing in advance whether the demand existed.

The number of load coils and bridge taps on the lines and the telcos' inability to locate them quickly without a costly analysis and mapping of all lines is a real problem without an easy solution. The local telecom customer's loop is said to have anywhere from 20 to 33 bridge taps along the line. About 20 percent of all lines also have load coils attached to them. Provisioning DSL service means removing all these load coils, bridge taps, and repeaters from the line.

Another way telcos try to improve the quality of the line and lower the costs when the line extends farther than 18,000 feet is to install repeaters and/or remote terminals (RTs) so that the signal can terminate at an intermediate point and then be backhauled to the CO or to a wire center over high-speed lines. These RTs are called digital loop carriers. A DLC is a remote unit that connects a number of subscribers to a CO. A single connection runs from the CO to a DLC. Copper pairs then connect the DLC to the end user. DLCs' key advantage is that they reduce the length and number of direct connections from customer premises to the CO.

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One main obstacle to a successful deployment of DSL to the mass market is loop testing and qualification issues. Mass deployment of DSL technology is fraught with difficulties in addition to the technical limitations of the technology and the fierce competition by CLECs and cable providers. For carriers such as CLECs and ILECs to establish service, they must manage loop qualification and conduct monitoring, troubleshooting, and repair in a new local-loop environment that hosts voice as well as data services. The inability to prequalify copper loops remains a significant obstacle to a successful mass deployment of DSL. Prequalification is the testing of loops to determine if the loop is capable of supporting DSL transmission prior to attempting to provide the service to the customer and is critical because DSL deployment is dependent on the design and quality of the copper loop. The ability to qualify the loop without having to dispatch a technician to either the CO or the customer premises will result in significant cost savings to the service provider. As DSL growth begins to explode, automated testing and provisioning of loops is key to a successful deployment. The current manual methods of testing loops will not be able to keep pace with the explosion in demand for DSL. What might have been an adequate system when only 100 lines were being installed will crash under the heavy burden when thousands or millions of lines are installed.

Spectrum compatibility and management are critical issues that need to be addressed quickly. Development of spectrum compatibility standards is essential to reduce crosstalk and other forms of spectrum interference. The continued development of spectrum compatibility standards will help to minimize crosstalk, which often results in the degradation of the intended signal. Spectrum compatibility and management become significant concerns with the introduction of new high-speed services in a multiple-provider environment.

Spectral compatibility is a significant concern for carriers that are interested in deploying DSL. For example, if an ILEC and a CLEC offer DSL services that use different line-encoding technologies, and if their respective customers' loops are located next to each other in the same binder pair, the two technologies may unintentionally interfere with each other and interrupt the signals traveling over each loop.

8. DSL Deployment Issues

In the past, DSL deployment debates centered around standards, modulation techniques, technology, and price. Today, operational issues are of prime importance. Operational issues, including provisioning service, loop qualification, monitoring, troubleshooting, fault isolation, and repair, are key to a successful mass deployment of DSL. Internet access alone is not going to add the profits necessary to make DSL a moneymaker. If service providers cannot automate the provisioning process, they will not be able to deploy service fast enough. Moreover, service providers cannot bill customers for extras and

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enhanced services. It is only by selling value-added services with DSL that carriers can hope to gain profits. Carriers with a data-only strategy will not be successful.

Mass deployment of DSL technology is fraught with difficulties in addition to the technical limitations of the technology and the fierce competition by CLECs and cable providers. As discussed previously, loop management and testing are the keys to a successful DSL deployment. However, without automated provisioning of the system and flow-through of all orders—new orders and repairs—as well as a dramatic improvement in customer service, technical support, and the adoption of standards-based DSL and interoperability testing, it will be difficult to deploy DSL successfully in the mass market.

Automated provisioning and flow-through of all orders is thus essential to any successful deployment of DSL. To be successful, an automated system must automate each element of the network, including CPE, Internet protocol (IP) DSL switches, aggregators, and core transport switches. The creation of automated provisioning systems is critical because providers will need to scale services rapidly as DSL deployments ramp up. If DSL is to be deployed in the mass market successfully, carriers need a system that can provision thousands—even millions—of lines quickly. Without such a system, carriers will not be able to roll out DSL in any large numbers.

Aside from operations, the lack of attention to customer service is one of the most troubling issues facing the broadband marketplace today. This issue is a looming issue for all broadband and high-speed access providers as well as for e-commerce providers. Customer service is a critical but overlooked ingredient of any e-commerce or broadband access provider.

Good customer service results in increased customer retention and provides a distinct competitive advantage that leads directly to increased market-share. The success of the DSL service provider hinges almost entirely on the ability to obtain and retain customers. Retaining customers is directly related to customer satisfaction. Customers should be continually updated on the status of their order or on any changes that have to be made to their order, such as a delay in receiving the loop from the ILEC or an update on a scheduled system downtime.

Standards continue to play a critical role in the evolution and mass deployment of broadband. The development and adoption of standards will set the pace for broadband development and adoption and will shape how the market for broadband services evolves. The benefits of standards have been seen in a number of different markets, such as VCRs, DVD drives, and Walkmans. DSL suppliers can expect the same model to apply to them.

The adoption of standards-based DSL has numerous benefits. It not only drives down costs but also speeds up provisioning. The adoption of standards reduces

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development and manufacturing costs and cycle times by moving industries down the scale curve faster than would normally occur without a standard. For example, the adoption of the data over cable service interface specifications (DOCSIS) standard in the cable industry has helped to drive down cable-infrastructure costs dramatically. Thus, the adoption of standards-based DSL allows service providers to mass deploy DSL. The lack of standards leads to market fragmentation, low volumes, and high cost. Without a standards-based adoption of DSL, there could be no mass deployment of DSL within the next few years.

Standards also promote interoperability of DSL technologies and devices and leads to increased customer choice. The adoption of standards and the interoperability of products allows the market to provide more product and supplier alternatives than is possible without a standard, increases the choice of providers, and provides a greater selection of products. The adoption of standards results in faster time to market with highly interoperable and integrated products, lower equipment costs for consumers and service providers, and minimized equipment problems for consumers.

Interoperability is key among different DSL technologies and equipment providers. Interoperability standards and qualifications processes also enable network operators to bid out new equipment orders to multiple vendors and reduce the complexity of installation and troubleshooting. Interoperability and standards help focus the industry on resolving other challenges necessary to reach mass deployment. National standards allow consumer-electronics and PC makers to bundle broadband equipment, such as DSL or cable modems, into new PCs, driving penetration and reducing service-provider costs for CPEs. Since the adoption of the G.lite standards, Compaq and Dell have announced plans to bundle a G.lite modem as a standard option on new PCs. Network interface standards allow subscribers to self-install home devices to the network, further reducing costs to service providers. As of September 2000, these PC OEM vendors have sold more than 500,000 PCs with G.lite modems built in.

Beyond standardization and interoperability, self-installation continues to be the holy grail of the DSL industry. Finding a way to move beyond service-provider CPE channels and into the retail market is the key to a successful deployment of DSL in the marketplace. DSL needs to become as easy to purchase and install as an analog modem is today. Consumers need to be able to purchase a modem at an electronics store or other retail outfit and be able to install it on their PC and then immediately sign up for DSL with little or no support.

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9. The IEC/Hellerstein & Associates Broadband Access and DSL Surveys

As a component in understanding the broadband marketplace and in obtaining critical insight into the future of broadband and DSL, the IEC and Hellerstein & Associates created two surveys, one specifically focused on broadband access issues and the other on DSL. Both surveys were given to all of the participants at the July 2000 DSL Communications Forum and at selected sessions of the October 2000 National Communications Forum.

Those who responded to the surveys came from incumbent telcos, CLECs, telecom suppliers, hardware providers, manufacturers, vendors, and content providers. Regulators, consultants, and academicians were also among the respondents. The majority of survey participants had more than 10 years of experience in the telecommunications field; a significant number had more than 20 years' experience.

The complete results may be found in *The Evolution of Broadband: DSL and Beyond*, published by the IEC and available on its Web site.

10. DSL versus Competing Broadband Access Technologies

Demand for bandwidth has led to several technological approaches developed to provide broadband access to business and residential customers. There are a variety of access technologies that can be used to provide broadband services. Although DSL has numerous advantages, other means of obtaining high-speed access might be preferable. What providers of each of the three technologies have in common is their desire to provide broadband access to as many people as possible.

Cable companies offer broadband service, most notably high-speed Internet access services using cable-modem technologies. Cable modems, because they are already being deployed rapidly, are the most direct competitor to mass-market residential DSL service. Cable modems can offer speeds as high as 10 Mbps, much faster than all but VDSL technology. Cable operators had already begun upgrading their networks to handle more channels and offer more services before the Internet and the Web became household items. Cable operators were primed to take advantage of this opportunity to provide high-speed access, because once their network was upgraded, adding high-speed access would not be a large expense. Additionally, these operators saw that if they sped up their planned upgrades of the cable plant, they could take a large chunk of the market for broadband consumer access.

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Once the cable plant has been upgraded to two-way broadband, adding high-speed access is extremely cheap. Most of cable operators' expenses lie in upgrading the plant to carry two-way traffic. Once this has been accomplished, the cost of adding subscribers is incremental. Adding new subscribers on a traditional wireline network is expensive, as it is on a wireless network.

Fixed wireless technologies—such as local multipoint distribution system (LMDS), multichannel multipoint distribution system (MMDS), 39 Ghz, and digital electronic messaging service (DEMSs—are beginning to challenge traditional wireline and cable for the data marketplace. Satellites are beginning to emerge as another technology to compete against fixed wireless, DSL, and cable. Broadband access through satellites is mainly for the thousands of consumers who cannot gain broadband access through any of the wireline access solutions. The chief advantage of wireless technology is the speed of deployment. Another big advantage of wireless is that a large portion of deployment costs is incurred only when a customer signs up for service. Because microwave can be rolled out on a segmented basis, it is often less costly than other technologies, especially for carriers penetrating a new market or in regions with widely dispersed customers.

Broadband wireless systems consist of a radio transmitter that sends a signal on a combination of channels to numerous receivers, including homes and businesses. Digital versions of wireless cable promise to provide digital television, interactive services, high-speed Internet access, and data networking services. Breakthroughs in digital technology and digital compression now permit operators to dramatically increase the amount of data that can be sent in a finite amount of spectrum. Each of the three wireless technologies operates on a different part of the radio spectrum. Spectrum allocation varies widely from country to country and is controlled by regulators.

Satellites have always been able to transmit data at very high speeds, but it was not until recently that consumer-friendly applications became popular. Data over satellite is not new; very small aperture terminal (VSAT) providers—such as Gilat, PanAmSat, Comsat, and GE—have been providing data connections to businesses for many years. In many large-business satellite-based offerings, the end user's terminal or satellite dish is capable of both sending and receiving data, thereby allowing for downstream and upstream speeds that exceed 200 Kbps. What is new is the adaptation of this technology to consumers.

11. Conclusion

As was said at the outset, the Internet has changed our sense of time itself. The increasing importance of the Internet has brought about dramatic changes in the way goods and services are produced and distributed to end users. The Internet continues to play a significant role in shaping the new economy by enabling firms to communicate and conduct business on a global basis without regard for

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location or asset size. Investment in high technology continues to serve as an engine of strong productivity growth for the U.S. economy. Federal Reserve Board Chairman Alan Greenspan expects this trend to continue in the years ahead. The increasing penetration of broadband access among both business and consumer users significantly augments this trend. There are many players in the same space, and the winners will be the technologies and the companies that clearly define their products and services, know and satisfy their customers, are forward-looking and flexible, and set the pace for the industry.

In the past five years, the long-term prospective profit growth of companies engaged in the computer and telecom industry have been revised up by more than double the amount, as the profits earned by old economy-aligned industries. According to Alan Greenspan "virtually every part of our economic structure is, to a greater or lesser extent, affected by the newer innovations in computers and in telecommunications....with few exceptions, little of a truly old economy is left."

Technological innovation and, in particular, the spread of IT has revolutionized the conduct of business during the past 10 years and has resulted in large increases in productivity. The surge over the past few years in business capital spending is a direct result of the higher rates of return brought about by the application of new technologies. The pace of innovation may have temporarily slowed down, but it is expected to resume soon as companies begin to exploit the largely untapped potential for e-commerce, especially in the B2B sector, from which much of the growth is expected to come.

The demand for high-speed bandwidth continues to grow at a fast pace, driven mostly by growth in data volumes, as the Internet and related networks become more central to business operations. Today's telecom industry is undergoing a bandwidth shortage driven mostly by the continuing explosion of the Internet and data markets. The rapid growth of distributed business applications; the proliferation of private networks, e-commerce, and bandwidth-intensive applications (such as multimedia, videoconferencing, and VOD); and the continuing deregulation and privatization of the telecommunications networks throughout the world all help fuel the demand for bandwidth. Moreover, an increasing number of teleworkers are fueling the demand for second and third lines for fax and Internet dial-up. To meet this explosive demand for bandwidth and to capitalize on this growing data opportunity, many data CLECs are targeting small business, SOHOs, and teleworkers in the selected areas of the country in which they are operating.

Self-installation continues to be the holy grail of the DSL industry. Finding a way to move beyond service provider CPE channels and into the retail market is the key to a successful mass-market deployment of DSL. DSL needs to become as easy to purchase and install as an analog modem is today. Consumers need to be able to purchase a modem at an electronics store or other retail outfit and be able to install it on their PC and then immediately sign up for DSL with little or no

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support. If DSL providers and vendors can achieve this goal and if customer service and technical support of the service provider can follow, then a mass-market deployment will happen much sooner than expected.

Besides implementing automated provisioning and configuration systems and processes, the biggest obstacle facing the industry is the need to significantly improve the customer and technical support provided to all potential and actual subscribers. If these obstacles can be overcome, DSL will have a bright future. Without a significant improvement in customer service, the deployment of DSL to the mass market will fall far short of expectations.

Companies need to put more of an emphasis on training, customer service, and technical support if they want to retain their customers. Ordering DSL continues to remain a substantial challenge for all service providers. There should be no reason why DSL cannot be installed correctly on the first visit. The industry needs to focus on measures to strengthen customer-service initiatives, review current support processes and service levels, and map future demand for customer support. Otherwise, deployments of broadband access infrastructure will be significantly impaired.

Establishing standards and resolving spectrum compatibility concerns are critical to a successful deployment of DSL. A lack of standards leads to market fragmentation, low volumes, and high cost. Moreover, use of standards-based DSL promotes interoperability of technologies and devices, which is key to a successful rollout of DSL. Spectrum compatibility, standards, interoperability, self-installation of modems, and autoconfiguration and provisioning are the four key ingredients to a success deployment of DSL. All parties need to be working toward the same goal—true plug-and-play DSL.

Broadband access is not only about providing the pipes to carry the traffic on the Internet but also about how the traffic will be carried. The report raised numerous questions regarding partnerships, such as what role partnerships will play in this new type of Internet environment. Will sites be more responsive to consumers who come from one of their partner sites? How will the formation of partnerships around content and infrastructure affect consumer behavior, a site's responsiveness, and any additional or custom features available? These questions were posed to a panel of experts that the IEC convened and were included on the broadband access surveys that were distributed at several IEC conferences throughout the year. These were just some of the questions that we asked respondents so as to gain insight into the future of broadband access and content delivery.

In only a few short years, all Internet appliances or electronic devices will be able to access the Internet and obtain the same content as PCs. The continued evolution of Internet appliances will continue the trend of making regulatory boundaries and lines between customer equipment and network services and

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communications and broadcasting very murky. It will become increasingly difficult to classify particular services, industries, and providers in nice little boxes, where it will be easy to tell if a service is subject to regulation or not. With accessibility to technology no longer an issue, how and when content and content providers will change to accommodate this ubiquitous access from any type of Internet-enabled device has yet to be answered.

Self-Test

1. DSL refers to _____.

    a. A specific gauge of wire used in modem communications

    b. A modem enabling high-speed communications

    c. A connection created by a modem pair enabling high-speed communications

    d. A specific length of wire

2. What percentage of total Internet penetration does the United States account for?

    a. 15%

    b. 20%

    c. 35%

    d. 40%

    e. 50%

    f. 75%

    g. 60%

3. Which appliance can be used to connect to the Internet?

    a. Phone

    b. Cell phone

    c. Personal digital assistant

    d. Television

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e. Information appliance

f. Picture frame

g. All of the above

4. What technologies can be used to provide broadband access?

   a. DSL

   b. Cable

   c. Satellite

   d. Fixed wireless

   e. Cell phones

   f. a, b, c, & d

5. Which of the following is expected to be the most popular with businesses and teleworkers?

   a. SDSL

   b. G.shdsl

   c. ADSL

   d. IDSL

   e. VDSL

6. What are the main target segments for broadband deployment by telcos?

   a. Kids

   b. Teenagers

   c. The elderly

   d. Large businesses

   e. Small businesses

7. What type of device is needed to interconnect the customer's premises and the DSL service?

   a. DSLAM

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b. CO switch

c. DLC

d. IAD

8. Widespread installation of DSL has been impeded by the physical constraints of the local loop.

   a. true

   b. false

9. What is the most troubling issue facing the DSL marketplace today?

   a. Poor customer service or technical support

   b. High prices

   c. Lack of demand

   d. Few competitors

   e. Distance or technological impairments

   f. Standards

   g. None of the above

10. Network testing, management, and service are not important in broadband media services.

    a. true

    b. false

Correct Answers

1. DSL refers to _____.

   a. A specific gauge of wire used in modem communications

   b. A modem enabling high-speed communications

   c. A connection created by a modem pair enabling high-speed communications

   d. A specific length of wire

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2. What percentage of total Internet penetration does the United States account for?

    a. 15%

    b. 20%

    c. 35%

    d. 40%

    e. 50%

    f. 75%

    g. 60%

3. Which appliance can be used to connect to the Internet?

    a. Phone

    b. Cell phone

    c. Personal digital assistant

    d. Television

    e. Information appliance

    f. Picture frame

    g. All of the above

4. What technologies can be used to provide broadband access?

    a. DSL

    b. Cable

    c. Satellite

    d. Fixed wireless

    e. Cell phones

    f. a, b, c, & d

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Glossary

ADSL
Asymmetric Digital Subscriber Line

ALTS
Association of Local Telecommunications Services

ANSI
American National Standards Institute

AOL
America Online

ATM
Asynchronous Transfer Mode

ATU–C
ADSL Transceiver Unit–Central Office

ATU–R
ADSL Transceiver Unit–Remote

CLEC
Competitive Local-Exchange Carrier

CO
Central Office

CONUS
Continental U.S.

CPE
Customer Premises Equipment

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DBS
Direct Broadcast Satellite

DEMS
Digital Electronic Messaging Service

DISH
Satellite Network Provided by Echostar Communications

DLC
Digital Loop Carrier

DMT
Discrete Multitone Technology

DOCSIS
Data over Cable Service Interface Specification

DSL
Digital Subscriber Line

DSLAM
DSL Access Multiplexer

DSP
Digital Signal Processor

DSS
Digital Satellite Service, a satellite network provided by DirecTV

DTH
Direct-to-Home

DTV
Digital TV

DVD
Digital Video Disk

FCC
Federal Communications Commission

FDM
Frequency Division Multiplexing

FSS
Fixed Satellite System

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FTTC
Fiber-to-the-Curb

GDP
Gross Domestic Product

HDSL
High–Data Rate Digital Subscriber Line

HTML
Hypertext Markup Language

IDC
International Data Corporation

IDSL
ISDN Digital Subscriber Line

IEC
International Engineering Consortium

IEEE
International Electrical Engineering

ILEC
Incumbent Local-Exchange Carrier

IP
Internet Protocol

ISDN
Integrated Services Digital Network

ISP
Internet Service Provider

IT
Information Technology

ITU
International Telecommunication Union

IXC
Interexchange Carrier

Kbps
Kilobits per second

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KHz
Kilohertz

LAN
Local-Area Network

LATA
Local Access Transport Area

LEC
Local-Exchange Carrier

LMDS
Local Multipoint Distribution Systems

Mbps
Megabits per second

MCNS
Multimedia Cable Network System

MDS
Multipoint Distribution Service

MDU
Multiple-Dwelling Unit

MMDS
Multichannel Multipoint Distribution Systems

MPEG
Moving Picture Experts Group

MTU
Multiple-Tenant Unit

NGDLC
Next-Generation Digital Loop Carrier

NIC
Network Interface Card

NID
Network Interface Device

NPRM
Notice of Proposed Rulemaking

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OEM
Original Equipment Manufacturer

OSS
Operations Support System

PAM
Pulse-Amplitude Modulation

PBS
Public Broadcasting Service

PBX
Private Branch Exchange

PC
Personal Computer

POP
Point of Presence

POTS
Plain Old Telephone Service

PPP
Point-to-Point Protocol

PSC/PUC
Public Service/Utility Commission

PSTN
Public Switched Telephone Network

PVC
Permanent Virtual Circuit

RADSL
Rate Adaptive Digital Subscriber Line

RBOC
Regional Bell Operating Company

RF
Radio Frequency

RT
Remote Terminal

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SDSL
Symmetric or Single-Pair Digital Subscriber Line

SOHO
Small Office/Home Office

TCP
Transport Control Protocol

UNE
Unbundled Network Element

USB
Universal Serial Bus

VDSL
Very-High–Data Rate Digital Subscriber Line

VPN
Virtual Private Network

VSAT
Very–Small Aperture Satellites

WAN
Wide-Area Network

xDSL
Any one of the family of DSL standards

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