The Evolution of Broadband: DSL and Beyond

Judith Hellerstein
President
Hellerstein & Associates

Introduction

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 changing the economy of the United States and much of the rest of the world at breathtaking speeds. 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."

As the Internet market continues to explode, demand for greater bandwidth and faster connection speeds has led to several technological approaches to provide broadband access to all consumers. Former Federal Communications Commission Commissioner William 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. Any operator that fails 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. 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. Key questions, such as the following, need to be asked:

- 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?

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 personal computers (PC) purchased and extrapolate from there, while others look to the number of Internet users. Falling PC prices have resulted in more first-time purchases or consumers purchasing a second or third PC.

PC Owners
According to the ***Washington Post***, PC penetration is now more than 56 percent of all households in the United States, with an expected rise to 64 percent in 2005. Analysts at Parks Associates and Morgan Stanley Dean Witter, on the other hand, estimate that by 2004 PC penetration will be more than 70 percent.

Consumer demand spans 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. Many college campuses require that incoming students purchase either a desktop or a laptop

computer, which has helped fuel the growth in laptop sales. At the University of North Carolina, every one of the 3,500 freshmen is required to own a laptop computer.

The PC has reached commodification because manufacturers now offer it as a bonus for purchasing a more expensive item such as a car. Other drivers for PC growth include the substantial 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 (OEM) are looking at different ways in which they can sell PCs, and tying in with a multinational company is one of them.

However, the number-one reason in 1999 why PC purchases have been increasing is the demand for Internet and on-line access, with most of the major manufacturers joining phone 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, digital subscriber line (DSL), or cable modems built in. All this coordination with other companies outside the industry is geared toward convincing consumers that they need to purchase newer PCs sooner than planned.

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, and 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 even higher, at 500 million. Whatever figure is used, the rapid uptake of Internet and broadband access is occurring regardless of income, education, ethnicity, location, age, or gender.

In August 2000, there were 117 million Americans on-line at some location. Today this figure is much larger, with more than half of all Americans using the Internet. The Internet has gone from a tool for academics and researchers to a daily source of e-mail, shopping, research, and news. Promotional material and ads now prominently list the store's or company's Web site address, and practically every store or company has a Web site.

Not only is the Internet growing larger, but the ways in which it is being used are changing as well. The Department of Commerce found that 80 percent of all users send and receive e-mails with files or attachments. Some 22 percent of all users have created or updated a Web page within the last three months. 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 is becoming the primary method for delivering multimedia clips such as pictures, cards, digital images, movies, voice messages, PowerPoint files, and large, e-commerce-related files.

Because of this growth, broadband services will begin to rise significantly. 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.

In comparison, traditional voice networks are growing at a rate of 10 percent a year. Cellular services, although growing faster (on the order of 30 to 40 percent per year), are being eclipsed by data and Internet network growth. Data traffic used to grow at rates of 20 to 30 percent a year in the 1980s and 30 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. 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.

Other Access Users

The proliferation of alternative technologies, 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. 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. Consequently, they will begin to demand higher 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 TV, a cell phone, a personal digital assistant (PDA), or any other type of Internet appliance. There has been 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.

Demand for Broadband Access Services

As the Internet market continues to explode, demand for greater bandwidth and faster connection speeds have led to the development of several technological approaches to provide broadband access to all consumers. The demand is 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-size businesses and small offices/home offices (SOHO), consumers, and multiple-tenant units (MTU) or in-building fiber builders and universities.

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, as well as the continuing deregulation and privatization of 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 in the home for fax and Internet dial-up.

Additionally, demand is coming from homebuyers seeking high-speed connections in their homes. For builders, high-speed access is a way to have a continuing revenue stream even after they have sold all their houses. High-speed-access services provided by these builders are often significantly cheaper, as much as 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 up to $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.

Small Business/SOHO/Teleworker

According to the Small Business Administration, 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. According to ***The Industry Standard,*** the number of small businesses with Internet access will more than double by 2001, resulting in a compound average growth rate of 11 percent from 1997 to 2001. However, only 20 percent of these will have had a broadband connection.

There are about 24 million teleworkers today, and this figure is expected to grow significantly in the future, 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 local-area network (LAN) access. Also, many people work and operate a business at

home. In 1997, The Department of Transportation reported that as many as 11 million people telecommuted. This figure has now climbed to 23.6 million.

Consumer Market

Analysts expect the consumer market to continue to account for more than 80 percent of total Internet subscriptions through 2009. Although dial-up access is the most prevalent, broadband access is growing strongly. 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 3 percent.

MTUs or In-Building Service Providers

The MTU broadband and equipment market is exploding 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 2 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.

Because these large 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 month for 8.5 megabits per second (Mbps) of bandwidth. In contrast, the average business DSL subscriber pays $200 a month for one Mbps or less of bandwidth.

DSL Growth

The DSL market has undergone a complete makeover. There are now nine different variants of DSL, and it seems that every year another is invented. Competitive local-exchange carriers (CLEC) and Internet service providers (ISP) have realized the huge pent-up demand created by the large number of small and mid-sized businesses, the huge expansion of the SOHO market, and the growing needs of teleworkers. And they are heavily targeting 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 shows no signs of slowing in the coming months.

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 equipment. In a few years, we will probably see DSL deployed not only on all digital loop carriers (DLC) but also on channel banks, ATM switches, voice switches, and on next-generation DSL access multiplexers (DSLAM).

Nevertheless, widespread installation of DSL has been impeded by physical constraints of the local loop (number of load coils and bridge taps and its distance from the central office), 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, shortage of experienced technicians, and the lack of true plug-and-play modems has also hindered the spread of DSL.

Self-Installation
Self-installation continues to be the Holy Grail of the DSL industry. 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, install it on their PC, and immediately sign up for DSL with little or no support.

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. But without a significant improvement in customer service, the deployment of DSL to the mass market will fall far short of expectations.

Quality of Service
Without service guarantees, small and mid-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 who offer tier-1 Internet service, and the same can be said for service providers who offer service-level guarantees to small businesses.

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. 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 in the way that 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.

Standards and Compatibility
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, the use of standards-based DSL promotes 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 both 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 helps focus the industry to resolve other challenges hindering its mass deployment.

Market Forecasts

The two main target markets for broadband are the small and mid-sized enterprises (SME) and the consumer markets. Morgan Stanley Dean Witter estimates 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. 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 on whether DSL or cable 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. Poor customer service is the Achilles'

heel of DSL providers, and the success of the DSL service provider hinges almost entirely on the ability to obtain and retain customers.

Forecasting in general is an inaccurate science, and thus analysts' estimates tend to be all over the board. However, 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 the future demand for DSL. Internet traffic is doubling almost every year, and switching and fiber capacity from wavelength 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. 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.

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 getting to plug-and-play.

Network Infrastructure Changes

The Internet was never designed to handle the amount of traffic 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 and services. The average speed of the Internet is 80 times too slow to offer full-motion video, and the problems are only getting worse as more people use it. Modem speed—or the first and last mile as it is known—has been a significant factor in the development of more bandwidth-heavy applications. As broadband penetration rises and consumers have access to faster modem speeds, these speed restrictions will be significantly alleviated.

However, 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 kilobits (kb) per subscriber available. Local caching is required to guarantee a positive user experience and to differentiate broadband content. To eliminate delays and improve the way content is delivered on the Internet, all aspects of the process must be improved.

Despite the bottlenecks, the Internet and the increasing penetration of broadband access are quickening the spread of new applications and 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. Napster was a success because it brought people back to what they liked most about the Internet—the ability to connect people with people, even if it was to exchange music without having to pay copyright fees. According to recent studies, consumers, when asked whether they would give up e-mail or the phone, were equally split; 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.

The increasing popularity of sharing pictures or videos and the cumbersome nature of e-mail in this sharing will lead to an increasing use of peer-to-peer networks, and the growth of local storage and the increasing availability of tools to fill 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 or are being developed will be used in unexpected ways. Napster came out of nowhere, and the next file architecture could do the same.

Technology Hurdles for DSL

The widespread installation of DSL has been impeded by the physical constraints of the local loop (such as number of load coils and bridge taps and distance from the central office), by interoperability problems between products, and by spectral compatibility issues.

The problem with sending a high frequency over an unshielded pair of copper wires is that the electrical 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 phone 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, a phenomenon called crosstalk.

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 or other high-speed lines.

A second problem with deploying DSL is the use of bridge taps, which are branches attached to circuits to reroute the line to another location. 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. According to Bellcore, 56 percent of the loop population has bridge taps. Telephone companies have used bridge taps to cheaply build in extra capacity in a neighborhood without knowing in advance whether the demand for such capacity existed. About 20 percent of all lines also have load coils attached to them.

The number of load coils and bridge taps on the lines, and the telcos' inability to locate them without a costly analysis and mapping of all lines, is a real problem without an easy solution. Provisioning DSL service means removing all these load coils and bridge taps from the line.

Another way telcos try to improve line quality and lower costs when the line extends farther than 18,000 feet is to install remote terminals so that the signal can terminate at an intermediate point and then be backhauled to the central office or to a wire center over high-speed lines. These remote terminals are called digital loop carriers (DLC). A DLC is a remote unit that connects a number of subscribers to a central office. A single connection runs from the central office 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 the customer premises to the central office.

One main obstacle to a successful deployment of DSL to the mass market is loop testing and qualification. The mass deployment of DSL is fraught with difficulties, in addition to technical limitations and the fierce competition by CLECs and cable providers. For carriers such as CLECs and incumbent local-exchange carriers (ILEC) 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 mass deployment of DSL. The ability to qualify the loop without having to dispatch a technician to either the central office 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 are key steps to a successful deployment.

Spectrum compatibility and management are critical issues that need to be addressed quickly. The 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 high-speed services in a multiple-provider environment.

Spectral compatibility is a significant concern for carriers 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.

DSL Deployment Issues

In the past, DSL deployment debates centered around standards, modulation techniques, technology, and price. Today, operational issues, including the provisioning of service, loop qualification, monitoring, troubleshooting, fault isolation, and repair are of prime importance and are key to a successful 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 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.

The mass deployment of DSL technology is fraught with difficulties in addition to technical limitations 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.

Automated provisioning and the 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 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 looming 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.

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 videocassette recorders, digital video disk drives, and Walkmans. DSL suppliers can expect the same model to apply to them.

Standards-Based DSL

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 development and manufacturing costs as well as cycle times by moving industries down the scale curve faster than would normally occur. For example, the adoption of the data over cable service Internet specifications (DOCSIS) standard in the cable industry has helped to drive down cable infrastructure costs dramatically. The lack of

standards leads to market fragmentation, low volumes, and high cost. Standards also promote the interoperability of DSL technologies and devices, leading to increased customer choice. The adoption of standards results in a 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 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.

DSL versus Competing Broadband-Access Technologies

The demand for bandwidth has led to several technological approaches developed to provide broadband access to business and residential customers, and though 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

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 with mass-market residential DSL service. Cable modems can offer speeds as high as 10 Mbps, much faster than all but very-high–data rate DSL (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. Most of the expense of cable operators is in upgrading the plant to carry two-way traffic. Once this has been accomplished, the cost of adding subscribers is incremental.

Wireless

Fixed wireless technologies, such as local multipoint distribution system (LMDS), microwave multipoint distribution system (MMDS), 39 Gigahertz (Ghz), and digital electronic messaging service (DEMS), are beginning to challenge traditional wireline and cable for the data marketplace. A big advantage of wireless is that a large portion of the deployment costs is only incurred 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. Each wireless technology operates on a different part of the radio spectrum. 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 increase dramatically the amount of data that can be sent in a finite amount of spectrum.

Satellite

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 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 kilobits per second (kbps). What is new is the adaptation of this technology to consumers.

Conclusions

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 location or asset size. There are many players in the same space, and the winners will be those technologies and 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.

The demand for high-speed bandwidth continues to grow at a fast pace, driven mostly by growth in data, as the Internet and related networks become more central to businesses. 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 video-on-demand; and the continuing deregulation and privatization of the telecommunications networks throughout the world are all helping to fuel the demand for bandwidth. Moreover, an increasing number of teleworkers are fueling the demand for second and third lines at home 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.

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. Consumers need to be able to purchase a modem at an electronics store 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 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. Without a significant improvement in customer service, the deployment of DSL will fall far short of expectations.

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

The information presented in "The Evolution of Broadband" is the summary of a 400-page research report by the same title. All attempts have been made to provide a true summary of the entire report. Nevertheless, not all topics discussed in the complete report are adequately addressed in this white paper.

About the IEC

The International Engineering Consortium is a nonprofit organization dedicated to catalyzing positive change in the information industry and its university communities. Since 1944, the IEC has provided high-quality educational opportunities for industry professionals, academics, and students. The IEC conducts industry-university programs that have substantial impact on curricula. It also conducts research and develops publications, conferences, and technological exhibits addressing the major opportunities and challenges of the Information Age. More than 70 leading, high-technology universities are affiliated with the IEC. Industry is represented through substantial corporate support and the involvement of many thousands of executives, managers, and professionals.

About the Author

Judith Hellerstein is the president of Hellerstein & Associates, a telecommunications and technology research group specializing in market and industry analysis, competitive intelligence, and regulatory analysis of the broadband and high-speed-access marketplace. Ms. Hellerstein specializes in niche marketing and segmentation analysis, competitive intelligence, market and regulatory analysis, and other marketing opportunities that help companies compete more effectively as the telecom market migrates to a network-centric data market.

Judith Hellerstein has more than 12 years of experience in business and competitive analysis in the telecommunications and technology marketplace. Ms. Hellerstein has a master's degree in public administration with a concentration in international management from Columbia University's School of International and Public Affairs. Prior to starting Hellerstein & Associates, she worked for MCI Communications, the Federal Communications Commission, the Office of the Vice President of the United States, and two New York City government agencies.

Ms. Hellerstein has written extensively on telecommunications, competition policy, broadband access, and wireless issues for both clients and trade and academic journals, and has provided consulting services to law firms and investment houses. She has extensive experience in the broadband and high-speed-access markets as well as in the wireless, local, and long-distance marketplace, both domestic and international. Ms Hellerstein speaks annually at several different broadband-access conferences.