Broadband

and Americans with Disabilities

by Frank G. Bowe, Ph.D., LL.D.

NAD

NATIONAL ASSOCIATION OF THE DEAF

ABOUT THE AUTHOR

Frank Bowe, Ph.D., LL.D., is a professor, Department of Counseling, Research, Special Education, and Rehabilitation (CRSR) at Hofstra University, on Long Island. He is also Governmental Affairs Consultant for the National Association of the Deaf.

Dr. Bowe has worked on technology and disability policy since 1977, when he was named by House Committee on Science and Technology Chairman Olin ("Tiger") Teague to a panel charged with reviewing the entire federal research enterprise to identify activities related to disability. In later years, he advised the Office of Technology Assessment in another review of federal policy on disability and served as director of research for the U.S. Architectural and Transportation Barriers Compliance Board. Dr. Bowe wrote the original version of section 508 and was also the key architect behind the Television Decoder Circuitry Act of 1990. He was also a key player in the early and mid 1990s in developing the Telecommunications Act of 1996.

ABOUT THE NATIONAL ASSOCIATION FOR THE DEAF

The National Association of the Deaf (NAD), established in 1880, is the oldest and largest constituency organization safeguarding the accessibility and civil rights of 28 million deaf and hard of hearing Americans in education, employment, health care, and telecommunications.

A private, non-profit organization, the NAD is a dynamic federation of 51 state association affiliates including the District of Columbia, organizational affiliates, and direct members.

Programs and activities include grassroots advocacy and empowerment, captioned media, certification of American Sign Language professionals; certification of sign language interpreters; deafness-related information and publications, legal assistance, policy development and research, public awareness, and youth leadership development.

Headquartered in Silver Spring, Maryland, the NAD also has program offices in Spartanburg, South Carolina and Morganton, North Carolina.

BROADBAND and AMERICANS WITH DISABILITIES

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Available online at http://www.newmillenniumresearch.org/broadband.html

EXECUTIVE SUMMARY

Broadband – or high-speed, always-on connectivity that facilitates the convergence of voice, video and data – features digital communications over a variety of delivery platforms.

Tens of millions of Americans with disabilities can benefit from widely available and affordable broadband services. The number of individuals with disabilities increases annually, largely because of the rapid aging of the population: as people get older, they tend to develop one or more disabilities.

Technology has improved the lives of people with disabilities. This has been true especially over the past 20 years, as electronics became commodities. Beginning with the Apple //e and the IBM PC and continuing to today's multimedia digital cell phones, adoption by Americans with disabilities of new developments has always lagged that by Americans with no disabilities. This has been true for several reasons. Affordability is one: the incomes of people with disabilities are, in general, lower than those of persons without disabilities. Accessibility is another: typically, new technologies are introduced to the market and only then are adaptive products created that make these usable by people with disabilities.

With broadband, we are seeing, for the first time, parallel adoption by people with and people without disabilities. The most recent Census Bureau survey on the question reveals that among Americans who have any type of Internet connection at home, equal proportions of persons with and without disabilities have a broadband connection. I believe this is happening because of the unprecedented value people with disabilities find in broadband.

Broadband makes possible remote interpreting, which greatly enhances the quality of life for people who are deaf or hard of hearing. It also supports peer-to-peer signing, a revolutionary development that for the first time allows people who are both deaf and limited in reading and writing to engage in meaningful and rewarding communication at a distance. No other technology – mailed letters, TTY conversations, telecommunications relay services, e-mail, Instant Messaging services or anything else – can make that claim. Broadband also offers what is called "telepresence" – or a continually open "window" to another location. Telepresence promises to alleviate the isolation that is the constant companion of too many Americans with disabilities. It could also bring together highly trained personnel with people who need training by those specialized professionals -- regardless of where these individuals live and work.

Despite these very encouraging developments, we are not yet "there". The United States needs to develop policies that will accelerate the availability, throughout the nation, of broadband connections that are affordable to all of us. The country also needs to insist that broadband content and end-user products are accessible to and usable by people with disabilities. The fact is that policy, rather than technology, is what is holding us back from truly universal deployment of broadband. The technology is here, or rapidly coming, that will make broadband ubiquitous, affordable, and accessible.

KILLER APPS AND OTHER INTERESTING APPLICATIONS

The Committee on Broadband Last Mile Technology (2002) described broadband in these terms:

> Broadband is a means to multiple, diverse ends encompassing family, work, and society generally. In addition to enabling entertainment and e-commerce applications, broadband can enrich the Internet's exploitation as a public space, making electronic government, education, and health care applications richer and more compelling and useful, and it can provide new modalities for communication, notably within communities or families. Broadband commands attention because it enables dramatically different patterns of use that offer the potential for significant changes in lifestyle and business. (http://books.nap.edu/html/broadband/summary.html).

In Chapter 3 of its report, Broadband: Bringing Home the Bits (http://books.nap.edu/html/broadband/ch3.html), the Committee identified several categories of potential applications for broadband. Some of these, notably "Video," "Telepresence," and "Telemetry" are groups within which applications with strong potential for people with disabilities exist. I can envision several "killer apps" and some lesser but still exciting applications for Americans with disabilities:

VIDEO

Broadband supports full-motion video of a clarity, speed and duration that is far in excess of what is possible over narrowband connections. Near-motion picture quality is possible with very high speed connectivity. While the Committee addressed video for entertainment purposes, I see applications of real importance to citizens in their everyday lives.

Sign Language and Other Interpreting. The United States has a long-term and severe shortage of qualified sign-language and other (oral, deaf-blind, etc.) interpreters. As a result, the costs of interpreting services rise every year at rates far outpacing that of consumer inflation. They currently are in the $50 to $60 per hour range. The interpreter referral services require a two-hour minimum, which translates into a minimum of $100 to $120 per assignment. Assignments lasting more than an hour usually involve two interpreters. Conferences often have as many as six (6) interpreters working. Given the persistent shortages, arranging for these interpreters to be on site can require several weeks of coordination.

A recent development, made possible by high-speed communications and low-cost digital video cameras, is remote interpreting. In this scenario, the interpreter works from one location (home, an office). She or he fields calls on a PC equipped with a video camera that is focused upon her/him. The interpreter signs what she/he hears. The consumer, who may be in a doctor's office, in an office meeting, or even in a social event, watches a PC screen displaying the interpreter's upper body and face. Now that digital video cameras have become very affordable, we are increasingly seeing them in professional offices and even in stores. With narrowband connections, the signing is jerky and difficult to follow. With broadband, it is sharp and clear. The interpreters bill by the minute, with no minimum length of engagement. Thus, a brief appointment (say, with a doctor) might cost the consumer or service provider as little as $30. To illustrate, Sign Language Associates (SLA), of Silver Spring, MD, bills $2.50 per minute for its service, Video Interpreting Program (VIP), with a $50 reservation fee (Alliance for Public Technology, 2002).

In fact, using "telepresence" (see below), a deaf person could even "open a window" to an interpreter at any time, from any location. This would make possible instantaneous interpreting -- anywhere! I could envision being at a gas station, asking for directions and becoming increasingly baffled as to where I should go. (This happens to me a lot!) With broadband, I could connect to my favorite interpreter within seconds, regardless of where she might be, and have her sign the directions to me.

Video interpreting makes far more efficient use of the scarce resource of qualified interpreters. These professionals now spend many hours each week in transit to and from jobs. With video interpreting, they can make use of virtually every working hour, fielding one request after another. This makes them more available for deaf and hard of hearing persons, especially in rural areas. That increases the quality of life that is possible for millions of deaf and hard of hearing Americans.

Peer-to-peer Signing. Many individuals who are deaf or hard of hearing read and write at primary-grade levels. This makes written communication at a distance problematic. I have often illustrated with an incident involving my wife. She was a therapist at a preschool. One morning, she called the deaf father of a young child to explain that, due to a change in schedule, he should pick up his daughter 90 minutes earlier than usual. She called him using a TTY -- an analog text technology that involves written text instead of speech. It required 45 minutes for my wife to make him understand what he should do. Had she been able to sign to him, using broadband video, he would have comprehended that within less than one minute.

This is peer-to-peer communication. The same technology would enable consumer organizations to communicate with deaf and hard of hearing consumers. This is what NAD executive director Nancy Bloch wants to do. Video streaming at the NAD's Web site would permit clear communication to deaf and hard of hearing individuals throughout the nation about issues of importance to them. The same technology, working in the other direction, would permit those consumers to pose questions to NAD staff with much greater clarity, and at much greater speed, than they can now do via written communications. Such interactive, two-way uses would require high speed in both directions (e.g., symmetric DSL). According to experts in Maine, who have used the Internet to teach American Sign Language at a distance, 2 Mbps to 3 Mbps speed is required (Keefe, March 5, 2002, personal communication). Barbara Keefe told me that "3 Mbps over an MPEG2 connection on our ATM transport is the Mercedes Benz of the industry. Unbelievable: our classes are as good as live!"

In an "FCC Chairman's Lecture Series" presentation on February 22, 2002, Vint Cerf (well-known as one of the creators of the Internet protocols, notably that for e-mail) celebrated MPEG multicast video capabilities. He also talked about speech recognition (see "Protocol Conversion," below).

Although e-mail and instant messaging are narrowband applications that enrich the lives and extend the communication reach of many deaf and hard of hearing persons, these text-based services are difficult to use for individuals who do not possess strong reading and writing skills. Those persons are far more likely to benefit from communication at a distance with the ASL transmission that broadband enables.

TELEPRESENCE

Broadband: Bringing Home the Bits described "telepresence" as "having a continuous window open into another space" (Chapter 3, p. 19), adding:

> In a personal setting, telepresence may enable a parent to have a continuous window on a child at a day care facility, thus enabling a closer ongoing relationship, even with working parents. Telepresence could possibly enable new forms of extended-family relationships over distances. An interesting attribute of telepresence is that it potentially poses higher bandwidth demands than one might expect from videoconferencing applications. This is because the premise of telepresence is that the window is always open, to enable spontaneous observations and interactions.

Telepresence is a radical idea, one familiar to most of us only from futuristic movies and TV programs. Once you grasp the concept, though, the possibilities spill out almost without end. I have already discussed instant interpreting at a gas station. Here is another example drawn from my personal experiences: I often meet parents who do not have as much time as they would like to advocate for their children who have disabilities. The Individuals with Disabilities Education Act (IDEA), the nation's premier special education law, anticipates that parents would be their children's best advocates. Telepresence potentially offers parents the privilege of "attending" meetings to prepare Individualized Education Programs (IEPs), without having to travel to school at inconvenient times. This is just one of many potential uses of the technology.

Some are even more dramatic.

Ending Isolation. Many Americans with disabilities are isolated for long periods of time. Whether because of chronic health conditions, environmental barriers, communication barriers, or other obstacles, loneliness is a sad reality for many hundreds of thousands of persons with disabilities in the United States today. An always-open "window" to people living elsewhere offers exciting opportunities. Children and youth who are sick could "be there" in class. Individuals with physical or health conditions who reside in northern states could "travel" over snowbound routes to take part in meetings, attend college classes, and work. Those needing group therapy could "sit in" on sessions without leaving home.

Integrating Into the Community People Who Have Been Institutionalized. I can imagine very high-speed broadband connectivity as supporting independent living by individuals with severe disabilities. Today, limited state, county, local and private organization budgets too frequently restrict the scope and reach of support services. This is most apparent in the case of individuals with mental illness. Hundreds of thousands of these persons have been deinstitutionalized -- released from state institutions -- over the past 20 years. The expectation was that community-based services would "pick them up" and provide the support these individuals needed to live in the community. Tragically, that often did not occur. Most of us have seen the all-too-common result: homeless individuals wandering the streets.

Deinstitutionalization has occurred, too, with many persons with mental retardation. Today, group homes -- single-family houses in the community -- offer housing for as many as eight or ten adults with mental retardation. Typically, a small number of counselors and other support personnel live in the house, as well, or come to it daily. High costs have constrained services. Group homes are plentiful in only a handful of states, among them New York and Michigan. Even in those instances, waiting lists can stretch out as many as seven or eight years. Agencies operating group homes often have difficulty attracting and keeping qualified staff members, due to persistently low levels of public funding.

Recently, deinsitutionalization has taken on additional urgency because of a Supreme Court ruling requiring community alternatives for residents of institutions, many of whom have mental illness and/or mental retardation. The Court's June 22, 1999 decision in Olmstead v. L.C. (see http://www.hhs.gov/newfreedom/) interpreted the 1990 Americans with Disabilities Act as requiring that individuals with disabilities be served in the "most integrated setting" appropriate for meeting their needs. In response to an executive order by President George W. Bush, the U. S. Department of Health and Human Services (2001) issued a preliminary report (http://www.hhs.gov/newfreedom/prelim/). That report noted that technology has an important role to play in carrying out the President's executive order to implement the Olmstead decision.

Semi-private community living, as in shared apartments with periodic in-person visits by counselors or other professionals likely would meet Olmstead "most integrated setting" standards. However, they are very expensive, in large part because of the high labor costs of in-person monitoring, supervision, and support by professionals and paraprofessionals.

Placement for people with severe disabilities in community settings typically is a high-cost, labor-intensive service. Many of these individuals cannot articulate clearly what they are doing and why they are encountering problems. Those with mental retardation may not even realize that they need to ask for help. For these reasons, counselors cannot rely upon traditional voice telephones to support these individuals. Rather, they must reside with, or frequently visit these persons, so as to support their efforts to live independently. Unless, that is, they can use broadband connectivity.

While it will not substitute for in-person support, telepresence potentially could stretch the available dollars. The technology offers the promise of enabling one such worker to simultaneously monitor the activities of as many as a dozen or more individuals, who may be residing in widely scattered locations. The worker may intervene to support any one person at any given time, by speaking to that person and by activating a video camera turned on himself/herself to demonstrate what should be done. The professional could dispatch a support worker for an in-person session on a when-needed basis. In these ways, broadband would lower costs.

Serving Low-Incidence Populations. People who are deaf, are blind, or have cerebral palsy require highly specialized education and vocational services. Our nation has chronic shortages of the trained interpreters, orientation and mobility specialists, and occupational and physical therapists these people need. Telepresence can connect consumers and professionals at a distance. To illustrate, a highly trained specialist can teach someone who is deaf how to fix a motor -- guiding the individual step-by-step, doing each step so the consumer can see it being performed -- despite the fact that the specialist is in New Hampshire and the consumer is in New Mexico.

TELEMEDICINE

Telemedicine is one aspect of what the Committee on Broadband Last Mile Technology (2002) referred to as "telemetry". The critical requirement for telemedicine is very high quality images. Physicians need to send X-rays and other images to specialists who can interpret them and then explain to local care givers what steps to take to meet the individual's needs.

As Enders and Seekins (1999) reported, disability is more common in rural than in urban or suburban locations. This means that many Americans with disabilities, including those with chronic and severe physical and health limitations, live far away from specialists whose help they need to survive. To illustrate, current medical practice enables many people with spinal cord injuries, including those with quadriplegia (high-level injuries affecting all four limbs), to live into their sixties and seventies. What is particularly needed is specialized care to deal with such secondary conditions as autonomic dysreflexia (bladder distension caused by intestine or colon obstructions). While such care is available in major metropolitan areas, it is rarely offered outside of urban hospitals and spinal-cord centers (Bowe, 2000).

Some applications of telemedicine do not require the always-on feature of broadband. Some do not require full-motion video. However, even in those instances, high-quality images that remotely located experts can read and interpret are necessary. That is why broadband is essential.

The Alliance for Public Technology (APT) recently described telemedicine applications, among other potential uses of broadband, in a report, Advanced Services, Enhanced Lives (http://www.apt.org/publica/casestudy.html).

PROTOCOL CONVERSION

Digital information consists of a series of 0's and 1's. These bits do not care what formats the creator puts them into, nor whether users change those formats. As someone who is deaf, I cannot make use of voice, whether digital or analog. I can, however, make good use of text.

Protocol conversion is one of a series of Internet access services. The Federal Communications Commission defines "Internet access services" as services which "alter the format of information through computer processing applications such as protocol conversion and interaction with stored data" (see FCC, 2002a, fn 27).

I can envision several ways of deploying protocol conversion. It is possible to have computer speech recognition, speech synthesis, and related software applications at the user's end. The fact that broadband communications are digital means that those programs can accept the data as input. Thus, were I to send a fax to someone who is blind, he/she could listen to that fax. Similarly, someday (when speech-recognition software is considerably more sophisticated than it is today) I may even be able to listen to Internet radio or other voice communications. The major advantage of this alternative is that I have the power to customize the software to reflect my needs and preferences. The downsides are that I incur high costs and that I need considerable technical know-how to make everything work smoothly.

I can also imagine a "flag" at the cable company's head end or at the telephone company's central office. This flag might say, in effect, "Do not transmit voice to F. Bowe. All transmissions should be in text or data." In this way, an intelligent network might meet my needs. There are several advantages to this second option. One is that the configuration of the system and the updating of the software are in the hands of network engineers. Those people possess technical expertise far in advance of any I might claim to have. Another is that I avoid incurring costs to secure, configure, and update communications systems at my end.

Vint Cert, who is hard of hearing and has a wife who is also hard of hearing, shares my enthusiasm for speech recognition. In his "FCC Chairman's Lecture," Cert noted that any speech-transporting medium (phone line, Internet, virtual private network, etc.) could convey commands to a speech processor located on the net. That speech recognition capability could "command" any device that is connected to the net -- and could also deliver commands to any online service. This might enable someone with quadriplegia to issue voice directives to virtually any net-attached device -- with no need to purchase, configure, and maintain his or her own speech-recognition system.

BRINGING IT ALL TOGETHER

Distance learning may be one way to illustrate the convergence of technologies made possible by broadband. Already, graduate study in engineering at Stanford University includes video streaming of professors' lectures. Complete with graphics and digitized versions of what the professor writes on a chalkboard, the video is posted within two hours of the lecture. At the University of Illinois, a Master's degree program in library science brings students to campus for 10 days. After that, lectures are delivered at a distance, via video streaming.

Potentially, this is just the beginning. The fact that the lectures and related visuals are digitized raises an interesting prospect, that of protocol conversion. What prevents those lectures from being captioned? The answer: Nothing. That would help deaf students, some students with learning disabilities, and some who are visual learners. Digitized versions of what I write on a chalkboard could be spoken out loud. That would help students who are blind or have low vision and many who are auditory learners.

For me as a professor who is deaf, another possibility is intriguing. Suppose I were to lecture in a classroom at Hofstra University, on Long Island, and to transmit the proceedings through a telephone company switching station right back to my classroom. Why, you may ask, would I do that? Simple -- when the transmission returns to my classroom, it is digitized. Whatever my students say in the classroom could be captioned. Hofstra no longer would have to employ a sign-language interpreter to translate between me and my students. While this is a ways off--it requires sophisticated speech-recognition technology, well in advance of what we now have available--it is nonetheless a fascinating prospect.

Civic Participation by Americans with disabilities could also benefit by convergence of technologies (Kennard, 2002). As this is written, legislation is pending in the U. S. Congress to make voting in elections fairer and easier. Even if this were to be enacted, further progress would be required before civic participation is truly equally available to people with and without disabilities.

Arizona pioneered the use of the Internet for voting during the 2000 elections. Since then, much progress has been made on such matters as security and voter authentication. Many polling places remain inaccessible for people with mobility limitations. Barriers in transportation and communication limit participation by people with disabilities in civic activities of all kinds. Broadband offers much promise in all these areas. Electronic voting options would increase participation in elections by individuals for whom traveling from home to a polling place is difficult or impossible. Meanwhile, speech recognition, with or without video streaming of interpreting, would make town meetings and other public events accessible for people who are deaf or hard of hearing. Similarly, protocol conversion could render printed documents into synthesized speech for individuals who are blind.

BACKGROUND

Broadband has captured my imagination for more than a dozen years now because it potentially offers some amazing services for Americans with disabilities. I first saw glimpses of what broadband could provide while touring a research facility in New Jersey in 1989. I saw full-motion video transported over phone lines. I was instantly captivated by the thought of signing with other people over the phone. Using a simple terminal, I could 'visit' a library, quickly find a document, and quickly view its contents. The thought of being able to review literature at any time and from any place appealed to the professor in me. Then I saw voice, video and data seamlessly integrated. This convergence of technologies let me click on an image (say, a hotel) and effortlessly call up pictures of its lobby and guest rooms, details about its daily rates, and a reservation form.

I did not fully appreciate at the time the fact that all of these wonders were made possible by high-speed connections, which existed only *within* that research facility. I do now. Thirteen years seems long enough -- too long, in fact -- to wait for such connections to be deployed in the real world. We need broadband and we need it now, as we just saw in "Killer Apps and Other Interesting Applications".

WHAT IS BROADBAND?

Let's step back a moment. We should define the term "broadband" so that we're all on the same page. The Federal Communications Commission (FCC) (2002a, footnote [fn] 2) noted that broadband and broadband services are "elusive concepts, as they have come to mean different things to many different people." I agree. In what follows, I will try to articulate my vision.

For me, broadband is high-speed, always-on, digital communications that provide convergence of technologies over a network. Let me break that down. The definition has five (5) distinct elements. They are: (1) high speed, (2) always-on connectivity, (3) digital communications, (4) technology-neutral (network independent) architecture, and (5) convergence of technologies. Let us look at each in turn. Then we will look at certain technical features of broadband.

High Speed. By "high-speed" we mean transmission that is much faster than is possible with dial-up modems. It is also faster than integrated signal digital networks (ISDN) technology, a mid-1990s technology that never gained acceptance. How fast is fast enough? Opinions differ. I agree with the International Telecommunication Union that broadband should be understood as comprising speeds of 1.5 to 2 megabits per second (Mbps). That is because I believe that such speed is required for broadband to reach its potential for Americans with disabilities (see "Killer Apps and Other Interesting Applications"). The key is for such speed to be achieved "in the last mile," meaning close to the user. I also believe that this speed should be available in both directions, that is, it should be **symmetric**. [Terms in **bold** are defined in the "Glossary" (below).]

The FCC (2002a), by contrast, defined "high-speed" to mean 200 kbps at the last mile, in one direction. It said it considered "advanced" telecommunications services to feature 200 kbps in both directions. The Commission was required to define broadband as services featuring speeds greater than were available via dial-up service at the time of enactment of the Telecommunications Act of 1996 (PL 104-104). **Dial-up** modems at that time offered speeds of about 33 kbps. The FCC justified the 200 kbps threshold as providing equivalence in user experience: between the time required to open a Web page and the time required to turn the page of a book. While the FCC's threshold complies with the Act's requirements, many observers have complained that the 200 kbps level is too low, particularly to support video streaming (e.g., TechNet, 2002). These thresholds strike me as being inadequate for optimal benefits for Americans with disabilities. The Committee on Broadband Last Mile Technology (2002), an expert group assembled by the National Academy of Sciences, called 200 kbps "at best, a lowest common denominator" and added that setting any minimum speed threshold is "unwise over the long run" (http://books.nap.edu/html/broadband/ch5.html).

Fortunately, 2 Mbps speed is achievable in the near future, using current technologies. The current generation of telephone system technology (displacing ISDN), **Digital Subscriber Line** (DSL) modems used by telephone customers, can handle several Mbps . The same is true for today's cable modems used by cable customers. These are, in both cases, speeds **downstream** (from the telephone company's switching station or the cable company's head end). **Upstream** (from the user's end) speeds are generally less. However, rapidly advancing technologies, combined with falling prices, promise to make very high-speed connections available to residential customers very soon.

A new report from the Committee on Broadband Last Mile Technology (2002) contains exciting information. (I found the report to be authoritative and stimulating. That is why I refer to it throughout this Background section.) First, the two wireline industries (cable and telephone) have "roadmaps" (to adopt the Committee's term) detailing how they can speed up broadband communications:

> The cable industry has a roadmap for performance innovation that does not depend upon substantial technical innovation, but only on the business decisions to deploy upgrades that have already been tested in the field. Similarly, the DSL industry has a roadmap for performance improvements that depends on redesign of the access network to install remote electronics in order to shorten the length of the copper pairs. In both cases, the technologies are relatively mature, so the rate of actual--as opposed to potential--performance improvement will depend mainly on the costs of upgrade, the depreciation cycle of investment, and competition from other providers. (http://books.nap.edu/html/broadband/ch4.html)

Notably, the Committee expressed the view that policy issues (e.g., incentives to invest, deregulation, etc.) may have much more to do with the speed with which residential customers secure broadband than will the pace of technology itself.

According to the Committee, fiber to the home (FTTH), long thought to be required for individuals to receive full benefit from broadband, no longer appears to be necessary for the benefits of broadband to reach consumers. The Committee estimated that FTTH might cost as much as $100 billion. However, fiber to the curb (FTTC), a much less costly alternative, may suffice because of innovations in technology--notably ways to reduce crosstalk over fiber lines and ways to push fiber deeper into the network. Wrote the Committee, speaking about hybrid fiber coax (HFC), the current generation of cable system technology, and DSL:

> Both HFC systems and DSL systems benefit from pushing fiber further into the system. To increase the performance of DSL, the copper links must get shorter. As penetration and the demand for higher speed increase, the upgrade strategy is to push fiber deeper, with each fiber feeding smaller service areas in which shorter copper connections run to the individual premises…. Similarly, to deliver higher performance over HFC, the number of subscribers in each cluster must shrink, so that the total capacity of a single coaxial segment is shared by a smaller number of subscribers and the per-subscriber performance goes up. (http://books.nap.edu/html/broadband/ch4.html)

The user's technologies, too, can support high-speed transmissions. The FCC (2002a, fn 18) recently reported that DSL modems can deliver speeds of up to 7 Mbps. The Committee generally concurred, reporting that the current generation of DSL modems can reach 8 Mbps in one direction. Higher speed is achievable, the Committee said, with very high data rate DSL (VDSL), now in development. VDSL modems can achieve speeds up to 60 Mbps on one phone line (http://books.nap.edu/html/broadband/appA.html). As for cable modems, the FCC noted that they can produce similar speeds (e.g., several dozen to several hundred times as fast as a dial-up modem).

Always-On Connectivity. The second key feature of broadband is the fact that it is "always on" (as opposed to **narrowband**, or the much slower connections that are reached via dial-up modems). Two anthropologists recently explored how the availability of always-on broadband changed people's lives. Ken Anderson and Anne McClard, studying five households equipped with dial-up modems and 11 supplied with always-on broadband modems, discovered that broadband households were online five times as much (some 22 hours/week v. fewer than five hours/week for dial-up modem users). They also moved their PCs into their living rooms, dining rooms, and kitchens. They made frequent, even impulsive, use of the technology. Because it was always on, broadband was seen as an instantly reachable resource. Concluded the researchers: always-on connectivity, combined with high-speed, creates a "killer environment" that makes a difference in people's lives (Anderson & McClard, 1998).

The Committee on Broadband Last Mile Technology (2002), noting that high-speed modems are designed to be left on at all times, concurred that always-on connectivity produces "more casual use of the network for very short tasks--sending a short message or looking up a piece of information" (http://books.nap.edu/html/broadband/ch2.html). The Committee added that some applications, notably telemedicine, may require always-on connectivity.

DIGITAL

The fact that broadband communications are digital, rather than analog, is important for many Americans with disabilities. **Analog** communications come in one inherent format. Traditional phone conversations, for example, are analog in nature at both ends. The speaker's voice moves in waves at the outset of the call. It is also analog at the listener's end. Today's phone networks often convert the speaker's analog signals into digital signals. **Digital** communications consist of 0's and 1's. These communications do not have any inherent format. They could just as easily be data as text or, for that matter, voice.

Because the 0's and 1's do not care what format their creators put them in, digital communications lend themselves well to **protocol conversion**. This turns out to have implications of great importance to individuals with sensory disabilities. Digital data can be converted to voice for someone who is blind (so he/she can listen to it). Or it can be converted to text/data for an individual who is deaf (so he/she can read it).

TECHNOLOGY-NEUTRAL

The Committee on Broadband Last Mile Technology (2002) urged that broadband be considered a "technology-neutral" platform:

> The future of broadband is sometimes described as a shootout among competing technologies that will result in a single technology dominating nationwide. This view, however, is simplistic and unrealistic: there is no single superior technology option. Broadband is going to be characterized by diverse technologies for the foreseeable future. (http://books.nap.edu/html/broadband/ch4.html)

The FCC concurred. In its February 15, 2002 Notice of Proposed Rulemaking (NPRM) on broadband, the Commission referred to "any and all platforms capable of fusing communications power, computing power, high-bandwidth intensive content, and access to the Internet," noting that "broadband is evolving across multiple electronic platforms as traditional wireless, cable, satellite, and wireline providers have expended substantial investments in broadband capable infrastructures."

The point is that broadband can be delivered via cable or telephone wireline networks. It potentially could also be provided via wireless technologies. Wireless, however, is significantly slower than is wireline. For example, when Verizon Wireless announced that it would begin providing 3G service in selected areas in the United States, it said that while transmissions speeds theoretically could reach 144 kbps, most users would experience connections in the 40 kbps to 45 kbps range--that is, equivalent to what dial-up modem users get via narrowband wireline connections (see, for example, Brewin, 2002). (Note: First-generation, or 1G, wireless was analog. Second-generation, or 2G, is digital; current "PCS" phones are examples. "3G" refers to a third generation that is not only digital but will, in time, feature broadband communications.)

The Committee on Broadband Last Mile Technology (2002) agreed that wireless is not likely to be widely adopted any time soon as a delivery mechanism for broadband: "While so-called third-generation (3G) wireless will provide more capabilities than present systems do, the throughput per user falls short of a reasonable definition of broadband" (http://books.nap.edu/html/broadband/summary.html). The relentless advance of technology may change this. Some time after July 2002, at least two providers of 3G wireless service (SK Telecom in South Korea, Monet Mobile Networks in the U.S.) expect to offer peak speeds of 2.4 Mbps (Hutheesing, 2002). Nonetheless, widely available broadband over wireless likely must await the arrival of 4G systems; as one expert put it recently, "The hope for 3G to become a true broadband service has all but vanished" (Jeff.Evans@gtri.gatech.edu; see also http://www.wirelessrerc.org).

Broadband could also be delivered via satellite. It could even be provided by power companies. However, as the Committee documented, satellite and power broadband services both are significantly limited at present and likely will remain so in the foreseeable future. I believe, however, that the fact that broadband services of high quality can be delivered over alternative wireline platforms is compelling enough that we must continue to regard broadband as a technology-neutral service.

CONVERGENCE OF TECHNOLOGIES

The ITU has stated that broadband is "the capacity to transmit large quantities of electronic signals (including data, video, text and voice) rapidly" (http://www.itu.int/osg/spu/ni/broadband/background.html). This implies that broadband brings together technologies that traditionally have been viewed as, and experienced by consumers as being, separate. We are accustomed to watching video on TV sets--but broadband brings full-motion video to the PC. We are accustomed to making phone calls using telephone receivers--but broadband lets us make and receive calls over the Internet. We have become used to effortless and rapid electronic communications, notably via e-mail and instant messaging--but broadband enables us to expand those by easily and quickly adding voice, pictures, and even video. All of this is what is meant by the term "convergence."

These five characteristics--high speed, always-on connectivity, digital networks, a technology-neutral platform, and convergence--define "broadband" well. However, to fully appreciate the technology, and to realize how it may help meet needs for Americans with disabilities, we need to look briefly at three other features of broadband.

These are packet switching, symmetric v. asymmetric designs, and peer-to-peer communication.

CERTAIN TECHNICAL FEATURES OF BROADBAND

Broadband differs from traditional telephony in several respects. One of the more interesting is the fact that information does not travel together throughout the network. Another is that speeds typically are much greater in one direction than in another. That fact makes peer-to-peer communication (something we take for granted in the "world" of narrowband voice telephone service) somewhat problematic in a broadband environment.

Packet switching. Broadband makes use of "**packet switching**". I have described this as analogous to a Stephen King novel printed on several thousand postcards (Bowe, 2002). Every postcard contains the address of the recipient. The postcards travel different routes, and at different speeds. They arrive at the destination at different times. However, because each is coded with its "position" in the novel (e.g., page number, paragraph number on that page, etc.), the postcards can be re-assembled. The recipient gets the entire novel, in the correct sequence. The Committee on Broadband Last Mile Technology (2002) offered a somewhat different analogy:

> The journey of a bit over a phone line is analogous to a long, arduous trip with several borders to cross, potentially dangerous trip segments, with various difficulties and costumes imposed upon the traveler, potentially disguising the person's appearance to all but those who know well how to recognize the traveler at the destination. Only the best prepared travelers (bits) can successfully complete the journey, if the receiver also knows well how and what to look for. (Appendix A).

Symmetric vs. asymmetric. Most broadband today is **asymmetric**. That is, it transmits data much faster in one direction than in the other. Asymmetric Digital Subscriber Line (**ADSL**), for example, offers high speed from the telephone company's central office or switching station but much slower speed from the customer's home to the central office/switching station. Symmetric DSL (**SDSL**) is much less widely available to residential customers. Cable, too, is commonly asymmetric. These characteristics of today's broadband make sense to the service providers. Residential customers need high speeds to download Web pages, but not such high speeds to request them (by addressing a particular Uniform Resource Locator, URL, or Uniform Resource Identifier, URI). The difference is even more apparent with cable. Customers actually have to make a phone call to order a pay-per-view film from their cable service provider. Even with digital cable service, customers need high speed to receive video on demand, but little speed to order the video.

However, asymmetric network designs pose serious obstacles as broadband technology matures. The assumption behind the model is that the service provider is the creator of content and that the recipients are merely passive consumers. What happens, though, when that assumption is violated? To illustrate, Nancy J. Bloch, executive director of the National Association of the Deaf (NAD), the nation's oldest and largest advocacy group representing Americans who are deaf and hard of hearing, reports wanting to deploy **video streaming** on the NAD's Web site (personal communication, February 4, 2002). Video streaming is important to the NAD because it allows the association to produce video in which complicated subjects are explained clearly to members using American Sign Language (ASL). To answer their questions in ASL, the NAD -- which is of course neither a telephone company switching station nor a cable company head end -- needs robust sending capacity. In this instance, the asymmetrical design of a broadband network raises a high hurdle. The situation becomes worse when one considers the fact that many NAD members also write at low skill levels. They could explain their needs and articulate their questions much better through ASL. The solution for the NAD is to have sufficient speeds in any direction to permit video streaming to occur. That is not necessarily symmetric broadband but it is high-speed broadband in more than one direction.

Peer to peer communication. The NAD's vision of two-way video streaming would involve what the industry terms "**peer to peer communication**" -- with both the NAD and one of its members playing the role of peers. Reported the Committee on Broadband Last Mile Technology (2002):

> While Web browsing has been a dominant application of residential broadband, accompanied by more limited audio/video streaming, peer-to-peer applications have surged recently. These applications, which use many individual computers instead of a central server to distribute content, require significant upstream capacity for each computer. They have, as a result, presented ISPs with traffic loads that are at odds with the ISPs' assumptions about asymmetric traffic and have raised questions about what shape user demand will take in the long term. Similar pressures result from other applications in which users host content on their local machines, creating upstream demand whenever this content is requested. (http://books.nap.edu/html/broadband/ch2.html)

The point, which the National Telecommunications and Information Administration of the U. S. Department of Commerce (http://www.ntia.doc.gov) has repeatedly made, is that full development of the potential of broadband requires carriers to respect the fact that users are not merely passive recipients of content. They are, rather, also creators of content.

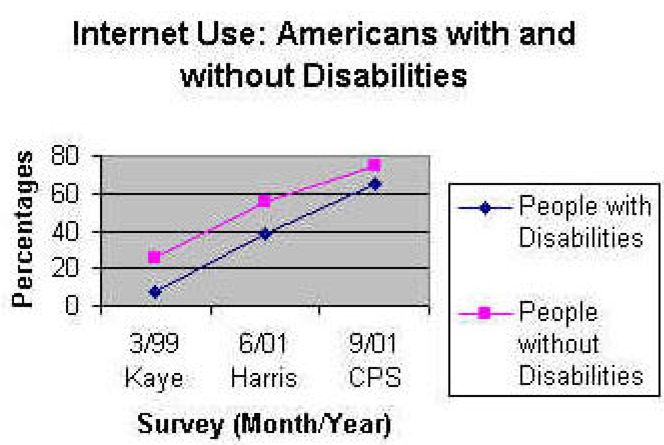
With this background on broadband technology behind us, we can return to the central focus of this paper: People with disabilities as users of broadband.

INTERNET USE BY AMERICANS WITH DISABILITIES

American youth and adults with disabilities are going online in increasing numbers, as they discover the many ways the Internet can help them -- to find information, to shop, to bank, to work, and to pursue an education. A report issued in February 2002, A Nation Online (2002), shows that people with disabilities tend to use the Internet for many of the same things other people use it for: e-mail, instant messaging, searching for information, shopping, etc. (U. S. Department of Commerce, 2002, Table 7.4, p. 68).

The Commerce Department's new report and other recent studies convincingly demonstrate that the number of Americans with disabilities using the Internet is **increasing rapidly**. In fact, the most recent data show that Americans with disabilities have caught up with their neighbors who have no disabilities in one key measure of broadband use: about the same proportions of individuals with and without disabilities who have any kind of Internet connection have a broadband connection. I believe this is because people with disabilities have discovered real value in the Internet, so much so that many are surmounting very real obstacles (see "Consumer Concerns" in this report) to their use of broadband.

The studies apply somewhat different definitions of "disability," ask different questions, and use different methodologies. For these reasons, direct comparisons from study to study are problematic. We can, however, draw broad trend lines. The chart below does that. It shows rapid growth in the number of Americans who have Internet access at home -- and an even steeper curve among Americans with disabilities. This section discusses the studies upon which the chart is based.



SEPTEMBER 2001 CURRENT POPULATION SURVEY (CPS) SUPPLEMENT

The most recent data, collected in September 2001, indicate that *a clear majority* of adults aged 25 to 60 who reported having disabilities of hearing, vision, mobility, and/or typing use the Internet: from a low of 64% of those who reported blindness or severe visual impairments to a high of 68% of those who reported deafness or severe hearing impairments. Those figures compare to 75% of respondents in the same age range who reported none of those disabilities (U.S. Department of Commerce, 2002, Table 7-3, p. 67).

Looking at children and youth, the same study found a majority of individuals between the ages of 3 and 24 used the Internet. Among those with disabilities, the proportions ranged from a low of 46% who reported difficulty walking to a high of 56% of those who reported deafness or severe hearing impairments. Those figures compare to 57% of same-aged children and youth who reported no disabilities. The proportions are much closer than are those among adults. In its report, A Nation Online, the U. S. Department of Commerce speculated that the narrowed gap may be attributable, in large part, to the fact that many children and youth use the Internet at school (U. S. Department of Commerce, 2002, Table 7-2, p. 67).

This study that formed the basis for this report is the **only** one to date to ask people with disabilities about their use of broadband. Sadly, A Nation Online does not break out type of Internet connection for persons with disabilities. I worked with the Census Bureau to review the raw data upon which the report was based. *This analysis reveals that of persons with disabilities who have an Internet connection, 84% have dial-up connections, 11% have cable-modem connections, and 5% have DSL connections. Those proportions are virtually indistinguishable from those obtained among persons with no disabilities.*

Because this is the only study to date to ask about broadband use of Americans with disabilities, disaggregation in future Commerce reports on the Computer and Internet Use Supplement is important. I have asked the Commerce Department and the Census Bureau to do so.

A Nation Online represents an important development: the addition of disability questions to a non-March Current Population Survey (CPS) study. It draws upon a September, 2001 Computer and Internet Use supplement to the CPS, which interviewed 57,000 households containing 137,000 individuals across the United States. The U. S. Census Bureau is committed to continuing that supplement, including the disability questions (below), at least through 2005. The supplement includes two questions about disability:

> **Do you have any of the following long-lasting physical conditions** (*Asked of everyone in the household age 3 and above*):
>
> A. Blindness or a severe vision impairment even with glasses or contact lenses?
>
> B. Deafness or a severe hearing impairment even with a hearing aid?
>
> B. A physical condition that substantially limits your ability to walk or climb stairs?
>
> C. A condition that makes it difficult to type on an ordinary typewriter or traditional computer keyboard?

Do you have difficulty going outside the home alone, for example, to shop or visit a doctor's office, because of a physical or mental health condition lasting six months or longer? (*Asked of everyone in the household age 15 and above*)

MAY/JUNE 2001 HARRIS/NOD SURVEY

In May and June 2001, the Louis Harris polling firm interviewed 2,024 individuals throughout the nation (National Organization on Disability, 2002a). The survey was conducted by phone. Questions about disability were modeled after those used by the U. S. Census Bureau in the 2000 Census (e.g., "a health problem or disability which prevents them from working or which limits the amount or kind of work they can do"). The researchers found that 38% of adults with disabilities used the Internet at home. This compared to a 56% rate of use by non-disabled adults. Internet use was particularly strong among individuals with vision or hearing impairments (43%), followed by people with learning disabilities or mental retardation (39%), and persons with mobility limitations (35%). The National Organization on Disability (NOD), which sponsored the study, noted that the proportions using the Internet were much higher than were the percentages found by the Harris firm in a similar study five years earlier: 7% of those with disabilities and 26% of those with no disabilities. Thus, over five years, use by persons with disabilities increased five-fold and that by people with no disabilities doubled.

DECEMBER 1998/MARCH 1999 COMPUTER AND INTERNET USE SUPPLEMENT AND CPS DISABILITY SUPPLEMENT

The 1998 Computer and Internet Use Supplement was conducted by the U. S. Bureau of the Census in December, 1998. This study was the foundation for the widely publicized "Digital Divide" report of the U. S. Department of Commerce's National Telecommunications and Information Administration (1999). Four months later, the Census Bureau conducted its regular March disability supplement as part of the Annual Demographic Survey. Disability was defined as "a health problem or disability which prevents them from working or which limits the amount or kind of work they can do" (note that this definition is different from the one used in the September 2001 CPS).

Discovering that 2,196 records of persons with disabilities were common to both studies, University of California at San Francisco (UCSF) researcher Steve Kaye produced a data analysis that did what neither study alone had done: report on computer and Internet use by Americans with disabilities (Kaye, 2000). Kaye found that 10% of persons aged 15 and over who had work disabilities used the Internet. Just 7% did so at home; another 4% used the Internet from other locations, notably work or school. By comparison, Kaye reported that same-aged adults with no disabilities used the Internet at a 38% rate. Some 26% of them used it at home and 21% at other locations.

The studies reviewed here raise obvious questions. The most important of these seem to be: What are the factors that contribute to lower rates of use of the Internet among persons with disabilities as opposed to people with no disabilities? We turn to that question now.

CONSUMER CONCERNS

As we have just seen, use of the Internet by Americans with disabilities has been rising more rapidly than has the very-fast rate among Americans with no disabilities. Even with this recent surge, the proportion of persons with disabilities online remains lower than that of people without disabilities. We need to understand why this is so. A number of factors appear to be at cause. These include considerations of personal/family income, employment, accessibility, speed, and geographical location.

1. **Cost Concerns**. Americans with disabilities tend to have lower incomes than do Americans with no disabilities. The most recent Census Bureau data (2002e) show that even in the so-called "peak earning years" of 45 to 54, workers with disabilities averaged just $35,000 per year even when they worked full-time, year-round in 2000. Of those with jobs, far more worked part-time and/or part-year. The mean earnings for workers with disabilities in that age range, considering both full-time/year-round and part-time/part-year workers, was $23,000. Earnings of workers with disabilities who were in other age ranges were even lower. These low levels of earned income are a factor because broadband typically costs $50/month on top of **internet service provider** (ISP) fees of $10/month to $23/month *and* basic phone service costs of some $25/month to $50/month. A Nation Online (U. S. Department of Commerce, 2002) illustrated how cost concerns act disproportionately upon lower-income families, causing many to forego Internet service and some who signed up with an ISP to discontinue the service. For purposes of comparison, the Census Bureau report indicated that average earnings of full-time, year-round workers aged 45-54 with no disabilities was $49,000 and that for part-time/part-year workers was $44,000. Thus, adults without disabilities generally are more able than are those with disabilities to afford advanced telecommunications services.

2. **Employment Concerns**. Some American adults have broadband connections to the Internet at their places of work, whether or not they also have broadband at home. Because adults with disabilities are employed much less often, they are far less likely to enjoy work-provided broadband connections. A Nation Online, for example, reported that people with disabilities were "much less likely to be Internet users" (p. 68) than were people with no disabilities, in large part because the latter are employed at much higher rates than the former. The U. S. Census Bureau (2002b), reporting on work disability status of noninstitutionalized adults aged 16 to 74 in March 2001, found that 75% of those with disabilities were *out of the labor force*--neither working nor actively looking for employment. In sharp contrast, just 22% of same-aged adults with no disabilities were out of the labor force. Stated differently, 25% of 16-74 year-old adults with disabilities and 78% of those with no disabilities were either working or were actively pursuing employment.

3. **Accessibility Concerns**. Many Americans with disabilities remain unaware of assistive technologies (AT) that could help them to use the Internet. A mid-2001 study found that *most* adults with disabilities knew little or nothing about AT (Carlson, Ehrlich, Berland, & Bailey, 2001). The National Task Force on Technology and Disability, in its forthcoming report, "Within Our Reach," is expected to refer to this as a problem of "category awareness" (to be posted at http://www.ntftd.org). That is, people who need AT tend not to be aware that devices that meet the needs they experience because of disabilities are "out there," available to assist them.

   People using personal computers (PCs) to receive, manipulate, and send information in a broadband environment can use the thousands of alternative input and output devices that are available to help people with vision, hearing, and fine-motor-control limitations to surf the Internet (http://www.abledata.com and http://www.assistivetech.net). They can only do so if they know about, and can afford, these products.

4. **Speed Concerns**. The FCC has defined "high-speed" and "advanced" telecommunications services as featuring at least 200 kbps speed. The Committee on Broadband Last Mile Technology (2002) found that 200 kbps is too low for many important purposes. TechNet, a consortium of such companies as Cisco, Intel, Hewlett Packard, and Microsoft, estimated that about 2 Mbps (with more speed being desirable) is needed for telework, distance learning, home shopping, video on demand, and other applications. The International Telecommunication Union (ITU) defined broadband as transmission capacity in the 2 Mbps range. That is what I estimate is needed to support applications needed by many Americans with disabilities.

   While 2 Mbps speed is clearly within reach--both cable and telecommunications providers can deliver such speeds--it is beyond what is currently offered to American residential and small-business customers. Accordingly, the speeds now available--which range from 56 kbps for dial-up connections to 500 kbps for DSL and cable modem connections--are insufficient to support key uses. That fact dampens demand.

5. **Rural Concerns**. Americans with disabilities are more likely than are Americans with no disabilities to reside in rural areas. This is so for several reasons. One, individuals with low levels of education attainment tend to be rural residents more than is the case with people who have high levels of education attainment. Lower education, in turn, is associated with physical-labor jobs which expose workers to higher risks of on-the-job injuries than do office-based jobs that people with higher levels of education tend to fill. Such injuries may lead to disabilities. In addition, access to medical care in rural areas tends to be more problematic, both because of distance to a medical facility and because of low incomes and lack of health insurance that are more common in rural than in urban and suburban areas (Enders & Seekins, 1999).

Internet connections in general, and broadband ones in particular, are less common in rural than in urban and suburban areas (Federal Communications Commission, 2002b; U. S. Department of Commerce, 2002). The Committee on Broadband Last Mile Technology (2002) explained that expenditures to deliver high-speed connections are far higher in rural areas, largely because of labor costs. Wireless and satellite technologies are appealing for cost reasons in rural areas. However, speeds tend to be well under what I believe many people with disabilities need, e.g., ostensibly 144 kbps for 3G wireless but in actuality 40 kbps to 60 kbps (e.g. Brewin, 2002).

POLICY ISSUES

Three (3) policy issues emerge from the data presented in this paper. They are: (1) rapid and nation-wide deployment of broadband, as soon as practicable; (2) subsidies for special-needs equipment; and (3) accessibility of content and end-user devices. These are discussed in this section.

Making broadband widely available, fast, will entail a major public commitment. So will equipment subsidies and enforcement of accessibility. The benefits of a ubiquitous, affordable, and robust public broadband network that is useable by and useful to all Americans far outweigh the potential costs, in my judgment.

During the early development of information services, the idea of accessibility was often explained by use of the term "electronic curb cuts." Just as concrete curb cuts eliminate the "lip" between streets and sidewalks, so too do electronic curb cuts eradicate disability-related barriers to information technologies. And just as concrete curb cuts quickly became valued by mothers pushing baby carriages, movers delivering heavy equipment, and bicycle riders, among many others who never advocated for curb cuts, so too do electronic curb cuts add value to people who do not have disabilities. This holds, as well, for broadband infrastructure and systems. Telepresence, telemedicine, and other broadband applications all could dramatically enhance the lives of all Americans, not just those with disabilities.

The need for ubiquity of broadband is unique among people with disabilities. To continue with the example of curb cuts: imagine a world in which curb cuts were installed in 90% of a city's street intersections. In the "world" of broadband, that would not do it. The barriers posed by the 10% non-cut "intersections" would be insurmountable. It is the nature of broadband that it must be in place *both* at the point of origin (sending point) *and* at the receiving point (end-user point) -- wherever those points may be.

Some observers claim that end-user adaptive devices make such ubiquity unnecessary. They miss the point. Such products will offer accessibility *only if the bandwidth is available*. So the facts are exactly in the other direction: we need ubiquitous bandwidth in order to provide adaptive solutions. Potentially vital work to develop portable access devices is being done at the Trace R&D Center in Wisconsin and at the Wireless Rehabilitation Engineering and Research Center in Georgia. Broadband is a *sine qua non* for such adaptive equipment to work.

Broadband potentially can reach the needed 100% penetration level. Vint Cerf, in his recent FCC presentation, reported that access modifications can be user-controlled. Both creator/sender and recipient of content may dictate the protocol to be used. I might elect to send and receive in captioned video or text, while my friend Paul Schroeder of the American Foundation for the Blind might choose to send and receive in voice. Giving us these options is a network with the computing power and the bandwidth to deliver any and every communication in whatever form senders and receivers deem appropriate. Something else is needed, too. Product designers need to plan *consciously* to make end-user products support our choices. What accessibility now exists in content and in end-user devices is largely a by-product of features designed for other purposes. Market forces have not yet sufficed to make broadband services, nor broadband-ready end-user products, accessible to and usable by people with disabilities.

1. **Rapid deployment**.

   Americans with disabilities have much to gain if broadband becomes widely available, quickly, and at affordable rates. As shown, convincingly, by the Committee on Broadband Last Mile Technology (2002), this is at bottom a policy issue. The technology is available to deliver broadband to much of the nation. Costs are falling. Further cost reductions and broader deployment loom – waiting only for policies that encourage them.

   The policy need is to help the nation achieve ubiquity, at the earliest practical moment. The life-changing applications for people with disabilities that were reviewed in "Killer Apps" in this paper will not work unless the services and capabilities are available to all. The issue, moreover, is not about "subscription rates" because when a new broadband blanket covers this nation, every location and every product or service will have the potential to be "lit up" and therefore both useful and accessible.

   What is needed is a national broadband policy that encourages rapid and widespread deployment as being in the national interest. The President should lead the effort. Congress, the FCC, and state regulatory agencies all have important roles to play. Some steps may be taken without new legislation. The FCC and state agencies may act under section 706, for example, to eliminate regulations where it is clear that increased competition would foster deployment. Congress should act this year to pass pending bills which include incentives to deploy broadband widely and quickly: tax credits, regulatory relief and flexibility, grant and subsidy programs for rural and disadvantaged areas, and assurances for universal deployment. Of course, whatever is done in Congress must include assurances of accessibility (see below).

2. **Equipment subsidies**.

   Even if we had comprehensive deployment today, there would still be barriers to access for people with disabilities. Many states have offered, some for several decades, subsidies allowing people with disabilities to obtain telecommunications products they need in order to use the network. This includes TTY devices, ring signalers, large-button dialers, and the like. These equipment-distribution programs typically are linked to the dual-party relay services required under title IV of the Americans with Disabilities Act. Now that broadband is arriving, we need something similar so that persons with disabilities, whose incomes tend to be lower than that of other Americans, can afford the end-user devices they need. The "Show Me" state of Missouri offers an outstanding model.

Recognizing that for many people, the Internet has become the preferred means of interpersonal communications, Missouri offers free hardware and software to residents with disabilities, including speech-recognition systems, screen readers, speech synthesis products and the like, while individuals with disabilities purchase their own end-user equipment (PC's, etc.) and pay for basic phone service and for service from their Internet Service Provider (ISP) of choice. This is equivalent to traditional TRS equipment-distribution programs which offer free TTY's but require persons with disabilities to buy their own phones and pay for basic phone service. Earlier this year, the American Foundation for the Blind recognized the Missouri model with an award for innovation, an honor I believe was richly deserved. What happened in Missouri is a good example of what could occur nationwide were subsidies to be directed, via a mechanism such as that used for TRS equipment distribution programs, toward meeting accessibility needs of people with disabilities.

3. Accessibility

Federal telecommunications policy provides that narrowband products and services should be accessible to and usable by Americans with disabilities, if readily achievable. If those cannot readily be made to be accessible, they are to be compatible with adaptive devices. Current law (section 255 of the Communications Act of 1934, as amended by the Telecommunications Act of 1996) covers "telecommunications products and services". An unambiguous statement that accessibility is required in broadband will serve the nation's interests.

Because broadband is a transmission medium offering content that people access through end-user products, accessibility is required *both* of content and of products. Compatibility will be necessary, as well. The need is parallel to that in section 255, which requires accessibility of products and services and, at minimum, compatibility with consumer adaptive devices.

To illustrate, consider speech recognition. Broadband-transmitted content may be made accessible to me and others who are deaf or hard of hearing through speech recognition systems attached to the switches in central offices and switching stations. In the absence of such network attachments, the content must be compatible with speech-recognition systems that end users install on their own equipment. Or consider the frustration of many people who are blind with interactive menus on digital cell phones. Again, accessibility requires that the content and the cell phones themselves be accessible to and usable by people who cannot see the menus or, at minimum, that the phones be compatible with commercially available adaptive devices.

Current FCC proceedings suggest that the Federal Communications Commission (FCC) plans to rule that broadband services are information services. One effect of such a ruling, if it were made, is to firmly and unequivocally to exclude broadband services from the requirements contained in section 255. Given that one objective of the Telecommunications Act of 1996 was to assure Americans with disabilities access to and benefits from telecommunications, at the then-current state-of-the-art, the FCC needs to require that today's state-of-the-art, broadband services and the end-user devices people use to create, send and receive broadband, be accessible to and usable by people with disabilities. Absent such coverage in rule-making, legislation appears to be necessary to assure accessibility.

SUMMARY

Broadband communications offer exhilarating possibilities for Americans with disabilities, including those who develop conditions as they age. Speeds of 2 to 3 Mbps appear to be necessary for these potentials to be realized. Fortunately, such speeds are within our reach.

Already, Americans with disabilities are beginning to recognize the contributions broadband can make in their lives. The most recent data suggest that as high a proportion of persons with disabilities as of people with no disabilities who have any kind of Internet connection have a broadband one. That is revealing, given that concerns related to costs, accessibility, and rural residence, among others, might be expected to depress demand among Americans with disabilities.

The most intriguing broadband applications (the so-called “Killer Apps”) are, I believe, in the areas of remote interpreting, peer-to-peer signing, telepresence, telemedicine, and protocol conversion. Bringing two or more of these together (what the industry calls “convergence”) could render distance learning and civic participation more meaningful and richer than is possible through any other technology.

Getting from here to there will require policy decisions that support full accessibility of broadband. We need to support accessibility in both its incarnations: affordability and usability. Universal-service policies need to be applied to broadband, perhaps following the model that Missouri has given to us. As for usability, both the content and the end-user devices need to be accessible or, failing that, compatible with adaptive equipment. Federal regulations will be required and legislation probably will be, as well.

I have been excited about broadband for 13 years. After a long wait, necessitated by the fact that the vast bulk of wireline communications remains narrowband in nature, I can finally see the dawning of the day I have long awaited: the day when all Americans with disabilities can enjoy the liberating benefits of broadband communications.

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GLOSSARY

ADSL is asymmetric Digital Subscriber Line (DSL, below). It offers high speeds in one direction, typically downstream (see below) but much slower speeds upstream (below). Some applications require high speeds in both directions, for which SDSL may be preferable.

Advanced telecommunications services, according to the Federal Communications Commission (FCC), provide speeds greater than 200 kbps over the last mile (near the user) in both directions. It is thus distinguished by the FCC from "high-speed" services," below.

Always on. In this report, we distinguish between the "always on" nature of broadband and the "dial-up" (below) nature of narrowband (below). The fact that broadband connections are always on changes user expectations (Anderson & McClard, 1998). With always-on, people tend to regard the Internet as an instantly available resource, much as they do an encyclopedia in the home. With dial-up, by contrast, people tend to view the Internet as a resource that is reachable only with effort and after a waiting period.

Analog. Contrasted to digital (below), analog refers here to communications that are not in 1's and 0's.

Broadband is high-speed communications that is capable of carrying voice, video and data simultaneously. According to the International Telecommunication Union (http://www.itu.int), broadband comprises communications of 1.5 to 2 megabits per second (1.5 Mbps to 2 Mbps) or faster. See "narrowband," below. In the long run, as the Committee on Broadband Last Mile Technology (2002) noted, the definition of broadband should be a flexible one. We should not seek to limit it to any particular level of speed. While 2 Mbps appears fast as of this writing (March, 2002), because it is well above the speed now available to residential customers, it could and probably will appear slow in the near future. Experience shows that as speeds increase, applications using higher speeds become widely used, thus "hogging the available bandwidth" and increasing consumer desire for even faster speeds.

Dial-up refers to use of 56 kilobits per second (kbps) modems by telephone customers who "dial up" an internet service provider (ISP). Dial-up services make use of the traditional switches at telephone company central offices and switching stations. Designed for voice telephone use, those switches allocate 64 kbps to any voice signal (of which 56 kbps is available). Depending on the time of connection, the quality of the line, crosstalk, and other factors, speed may be as slow as 40 to 45 kbps in everyday use.

Digital. Contrasted to analog, digital communications use 1's and 0's. This fact opens the door for "protocol conversion" (below).

DSL is digital subscriber line. DSL offers speeds in excess of dial-up, despite the fact that it uses twisted-pair copper wires. According to the FCC (2002a), today's DSL provides speeds of less than 500 kbps to 7 Mbps. DSL achieves these speeds both because the DSL modems used by customers are faster than are dial-up modems and because the signal bypasses traditional phone switches at telephone company central offices. DSL transmissions use software that is incompatible with those switches and is handled, instead, by DSLAM switches (below). DSL has another feature: "always on" (no dial-up is required). Typically, DSL means "ADSL," or asymmetric DSL, which offers much higher speeds in one direction than in the other. Symmetric DSL (SDSL), which provides high speeds in both directions, is more expensive than is ADSL and is less widely available.

DSLAM. At the telephone company's central office or switching station, sophisticated modems are used to receive and process DSL signals. These Digital Subscriber Line Access Multiplexers (DSLAMs) have the software required to process DSL signals.

Downstream is from a telephone company central office or from a cable company head end down to the customer. See "upstream," below. ADSL, for example, can offer speeds as high as 8 Mbps downstream.

Fiber to the home (FTTH) was once regarded as necessary for broadband to reach residential customers. An ideal, it may cost as much as $100 billion to achieve in the United States (Committee on Broadband Last Mile Technology, 2002). However, experience has shown that a much less expensive alternative, fiber to the curb (FTTC), probably will suffice for most near-term applications.

High-speed telecommunications services, according to the FCC, provide speeds greater than 200 kbps over the last mile (close to the user) in one direction and under that level in the other direction. See "advanced telecommunications services," above.

Instant messaging services, such as those offered by America Online (AOL) and by Microsoft Network (MSN), tell users which of their friends, family members, and business colleagues are online and, if the users wish, connect them to those friends, family members and colleagues for real-time, two-way text messaging.

ISDN. Integrated Services Digital Network is a 1990s technology featuring two 64 kbps channels. It was faster than dial-up (op. cit.) but failed in the marketplace, largely because of installation problems.

ISP. Internet service provider. Examples are America Online, Earthlink, NetZero, and the like. Consumers pay a fee, typically $10 to $25 per month, to the ISP for Internet connections. Those fees are in addition to fees consumers pay to basic service providers (cable, local phone service) and costs consumers incur for in-home equipment (TV, PC, modem).

Narrowband. Telecommunications characterized by speeds under that of broadband (op.cit.) and not by always-on.

Packet switching is a transmission technique that sends data in packets. Those packets do not necessarily traverse the same phone lines. In this way, packet switching differs from traditional voice telephony. The techniques reflect their bases: packet switching is a digital technology and voice telephony has its roots in analog.

Peer-to-peer communications is Internet-enabled communications between two subscribers. Thus, a residential customer may communicate with her local library over the Internet. Peer-to-peer communications, if they continue to proliferate, may upset industry models that anticipate different consumer behavior.

Protocol conversion is a change in the format of digital information. Thus, information that is sent as digital text could be converted, at the user's request, to digitized voice.

SDSL is symmetric DSL. It offers high speeds in both directions, upstream as well as downstream.

T1 is dedicated commercial high-speed communications service reaching speeds as high as 45 Mbps (International Telecommunication Union, 2002). One might term it "wideband". Costs range from $500 to $2,000/month (Federal Communications Commission, 2002b), making T1 economically unattractive for residential customers.

Technology neutral, as used in this report, refers to the fact that broadband may be delivered in a variety of ways. Today, DSL and cable modem are the most common vehicles. However, wireless and satellite technologies may also be used.

3G is third-generation wireless. 3G was introduced in the United States early in 2002. Announcing the service for some areas, Verizon Wireless said speeds could reach 144 kbps but that most customers probably would experience about 40 kbps to 44 kbps, or much the same speed that dial-up modems offer over phone lines (e.g., Brewin, 2002). At such speeds, 3G does not deliver broadband services as discussed in this paper.

Upstream is the term used to characterize communications from the customer's devices up to the telephone company's switching stations or the cable company's head end. Typically, upstream speeds are much slower than are downstream speeds. With ADSL, for example, speeds upstream seldom exceed 1.5 Mbps (v. up to 8 Mbps downstream).

VDSL. Very high-data-rate DSL can transmit at speeds up to 60 Mbps. It is the fastest DSL service now available.

Video streaming is the transmission of full-motion video over the Internet. It "hogs bandwidth" on today's networks.

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