Washington Internships for Students of Engineering

Federal Strategies Encouraging Rural Broadband Access:

Intelligent Options to Minimize the Digital Divide

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Executive Summary

The fast-paced growth of broadband technologies represents a significant shift in the way that Americans will communicate. Where users once accessed the Internet using traditional voice telephone lines, new broadband technologies boast download speeds that are four to forty times as fast with the convenience of an "always-on" connection. While the narrowband Internet represented a crucial proof of concept, broadband is the next-generation enabling infrastructure for a genuinely interactive multimedia Internet. Experts anticipate broadband connectivity to drive innovation in personal communications, education, business, government, and even medicine.

Lawmakers, regulators, and public interest groups are concerned that the high costs associated with serving rural customers will lead to an uneven distribution of broadband access across the United States. The ubiquity of the traditional public telephone network, made possible by federal commitment to Universal Service policies, allowed rural areas to close the narrowband access gap without significant infrastructure investment. However, the unique technical constraints on broadband access technologies and the high cost of wire-based infrastructure deployment threaten to leave parts of rural America unconnected.

Infrastructure investment in high-density markets led to significant broadband access deficiencies in rural areas, yet wireless technologies will soon provide high-speed services to even the most remote parts of the country. While urban and suburban consumers may already have high-speed Internet access over the traditional telephone network via DSL, the cable television network via cable modem, and the airwaves via satellite and fixed wireless, rural customers' choices are severely limited. Technical and economic considerations limit the potential for DSL and cable modem deployment in sparsely populated rural areas, but fixed wireless and next-generation satellite technologies have enormous potential to bring broadband to those geographically isolated. Investors are pouring billions into satellite ventures because satellites provide nationwide coverage, including the most remote areas, without the expense of laying fiber optic and copper infrastructure. Fixed wireless systems can serve a small town with a single radio tower, similarly avoiding copper and fiber deployment.

Federal proposals to facilitate rural broadband connectivity either change the regulatory framework for specific technologies or provide financial incentives for deployment. Experts, including FCC Chairman Michael Powell, maintain that appropriate federal action should encourage fair competition and discourage one-size-fits all solutions, and lawmakers have met this challenge with varying degrees of success.

The Internet Freedom and Broadband Deployment Act of 2001, cosponsored by Reps. Billy Tauzin (R-LA) and John Dingell (D-MI), is a high-profile example of one-size-fits-all legislation that does little to encourage rural access. The bill, as amended, forces the four Bell operating companies to deploy rural DSL service on an enforced five-year timetable in exchange for interstate data transmission privileges. However, the bill's language ignores technical limitations of DSL technology while undermining the pro-competitive provisions of the Telecommunications Act of 1996. By assuming that DSL is an appropriate technology for all rural users, the bill offers little real relief.

Financial assistance proposals include incentives like tax credits, loan guarantees, grants, and research funding. New tax credits, loan guarantees, and grants mirror several existing assistance programs and, if unchecked, may encourage inefficient investments based on one-size-fits-all solutions. Since there is general agreement that rural wire-based infrastructure deployment is uneconomical, it may be more cost effective to ease wire-based infrastructure subsidies and promote next-generation broadband satellite, an inherently location-neutral technology, and fixed-wireless systems. Federal financial support is most appropriate for research efforts in low-cost optics and satellite technology, which will facilitate continuing improvement in rural access technologies. Senator Clinton's Broadband Rural Research Investment Act of 2001 (S. 430) authorizes $25 million for NSF-administered rural broadband research and should be adopted.

To meet the long-term telecommunications needs of Americans, the FCC should adopt 1.5 Mbps (million bits per second) bi-directional capability as a new definition of "broadband" access. The current definition of 200 kbps (thousand bits per second) allows certain technologies to be officially considered "broadband" despite their inability to deliver many anticipated broadband services including high-quality video. To discourage the deployment of inferior infrastructure with limited upgrade potential and hedge against obsolescence, the FCC should proactively direct broadband technology development by raising the official standard for "broadband" technology.

Successful rural broadband deployment relies on solutions designed to meet individual communities' needs. Effective legislation and regulation rest on the principle of fair competition and reject one-size-fits-all approaches. Bills like Tauzin-Dingell will do little to improve rural connectivity and should be opposed, but Clinton's research authorization bill will promote long-term improvement of rural broadband services at a reasonable cost to taxpayers. Furthermore, raising the FCC standard for broadband access will encourage the development of technologies appropriate to serve future needs.

Broadband Access and the Digital Divide

"Internet access is no longer a luxury item, but a resource used by many."
-- United States Department of Commerce: Falling Through the Net: Toward Digital Inclusion-[1]

Broadband technology deployment, allowing Internet access at speeds of four to forty times that of a dial-up modem[2], is the subject of widespread excitement, uncertainty, and regulatory debate. Over 100 million Americans use the Internet, and 12 percent of those users have a broadband connection.[3] Broadband technology enables the high-speed transmission of high-quality multimedia content, including audio, video, and interactive applications. The "always-on" feature of broadband frees users from the dial-up delay inherent in telephone modems, and enables remote access applications for users away from home. Proponents of broadband expect the technology to revolutionize electronic learning, communication, entertainment, and even medicine[4] while adding up to $500 billion to the U.S. economy.[5]

Though broadband deployment is just beginning in many parts of the country, rural consumers, businesses, and governments see value in high-speed Internet access. Rural towns hope to use broadband to improve the quality of medical care, enable

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[1]United States. Department of Commerce. Falling Through the Net: Toward Digital Inclusion. Washington: GPO, October 2000 at xviii.
[2] There is no accepted standard definition of "broadband" access. While the FCC uses a 200 kbps standard, (four times the speed of a standard telephone line), many broadband technologies offer far faster speeds. Legislators are beginning to use a stricter standard, 1.5 Mbps, in an attempt to hedge against the rapid obsolescence of low speed "broadband" technologies.
[3] United States. General Accounting Office. Characteristics and Choices of Internet Users. Washington: GPO, February 2001 at 14.
[4] Corporate trainers are also anticipating the benefits of high-speed access. *See* DeVreaux, Paul. "Broadband: Will it solve e-learning's dilemma?" e-learning 2.3 (March 2001), p. 20-22. One author foresees a virtual video store where every existing movie is available for download. *See* Platt, Charles. "The Future Will Be Fast But Not Free." Wired 9.5 at 127.
[5] According to a Verizon-commissioned study by Brookings Institution economist Robert Crandall and engineering consultant Charles Jackson, broadband services will add $200 billion to the economy if half the country has broadband Internet access or $400 billion if the entire country is appropriately wired. An additional $50-100 billion stimulus will come from higher consumer demand for computers, software, and entertainment products. *See* USA: "Broadband could add $500 bln to U.S. economy -study." Reuters via Dow Jones Interactive (http://www.djnr.com), 16 July 2001.

participation in advanced distance learning programs, and attract businesses.[6] Rural users involved with agriculture have unique forces driving their broadband demand: farmers need the most current weather forecasts and commodity pricing information to ensure the viability of their business.[7]

The most significant statutory law covering broadband access technologies is contained in the modifications to the Federal Communications Act of 1934[8] known as the Telecommunications Act of 1996[9] (hereafter, the 1996 Act). The 1996 Act contains a regulatory framework for telecommunications services, broadcast services, and cable services, while requiring the FCC to, on a regular basis, report whether "advanced telecommunications capability is being deployed to all Americans in a reasonable and timely fashion."[10] The FCC has regulatory jurisdiction over broadband technologies, and is expected to tend toward market-oriented solutions under the leadership of Chairman Michael Powell.[11] To understand current problems with rural broadband deployment, it is valuable to examine the transition from narrowband to broadband.

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[6] The Kentucky Commonwealth Virtual University uses broadband to increase college-level educational opportunities in all parts of the state. *See* Perlman, Ellen. "Bridging the Digital Divide Requires Imagination." Governing 14.2 (October 2000) at 78. Canadian rural communities in Newfoundland and Labrador use satellite broadband for remote medical consultations, bail hearings, and government services. *See* Industry Canada. The New National Dream: Networking the Nation for Broadband Access. Ottawa: Industry Canada, 2001 at 30. According to Claiborn Crain of the Agriculture Department's Rural Utilities Service: "For a community to provide this kind of [broadband] service … is no guarantee that you're going to have economic development. However, if you don't have it, you're guaranteed those prospects are going to go somewhere else." *See* Landers, Jim. "Nation's Rural Areas Seek Competitive Edge through Fast Internet Service." The Dallas Morning News via Dow Jones Interactive, 21 Feb. 2001.

[7] *See* Diwata, *supra* Note 10.

[8] Codified at 47 U.S.C., as amended.

[9] Codified at 47 U.S.C. The portion known as the Communications Decency Act (Title V) was declared unconstitutional in 1997.

[10] 47 U.S.C. § 706.

[11] *See* Srinivasan, Kalpana. "Powell Touts Move to Digital World." AP Online 31 May 2001. Lexis-Nexis 5 July 2001. "While Powell favors marketplace solutions over government intervention, he said the commission won't ignore the changes happening in these markets."

Narrowband and the Beginnings of the "Digital Divide"

The early development of the narrowband[12] Internet was not uniform across demographic lines, which prompted fears of a "digital divide". Before commercialization changed the essence of the Internet in the 1990s, users were almost exclusively affiliated with universities, research labs, or the federal government. As Internet adoption levels soared into the tens of millions, the demographics of the Internet population began to resemble society as a whole, except for notable deficiencies in low income, poorly educated, and rural users. As a result, controversy erupted over the perceived "digital divide" between information technology "haves" and "have-nots".[13]

The "digital divide" can be defined as the quantifiable gap in access to information technology along several demographic lines, including socioeconomic status, age, level of education, and geography (i.e., urban, suburban, or rural). Although there has been some disagreement over the existence or magnitude of a digital divide[14], FCC Chairman Michael Powell sees the divide as an "important social issue"[15] and Congress has held several related hearings.[16] The sociological forces[17] behind the digital divide are beyond the scope of this report, which will concern technical and financial approaches for improving rural broadband deployment.

[1212] The FCC designates access at speeds lower than 200 kilobits per second as "narrowband" and all faster access as "broadband".

[13] Falling Through The Net, supra Note 1 at xv.

[14] Thierer, Adam D. "Is the 'digital divide' a virtual reality?" Consumers' Research Magazine. 83.7: 16-20.

[15] Powell's now famous comparison of the digital divide to a "Mercedes divide" was toned down in a Washington Post profile: "I think it's an important social issue – but it shouldn't be used to justify the notion of, essentially, the socialization of deployment of the infrastructure."
See Ahrens, Frank. "The Great Deregulator." The Washington Post 18 June 2001: C1+.

[16] The House Small Business Subcommittee, House Judiciary Committee, House Energy and Commerce Committee, and Senate Commerce, Science, and Transportation Committee have held hearings on digital divide and broadband issues.

[17] Sociological forces may include socioeconomic status, educational background (IT literacy), and cultural issues.

The Transition to Broadband Access

Low levels of narrowband access were once common in rural areas, but a Department of Commerce study suggests improvement, noting that rural access levels are only 2.6 percentage points below the national average.[18] Federal telecommunications policies, including Universal Service, promoted the near ubiquity of the telephone network in the United States, leading to huge growth in the ISP industry and narrowband access levels.[19] However, narrowband Internet connections used existing phone lines as transmission infrastructure, thereby avoiding the costly deployment of additional wires in rural areas. Upgrading infrastructure is an expensive proposition: cable companies have spent $48 billion since 1996 to deploy broadband to many of their 68 million cable television customers.[20]

Recent data suggests that as much of the country begins a transition to high-speed broadband access, rural areas are particularly vulnerable to exclusion for technical and economic reasons.[21] A Department of Commerce study shows that 7.3% of rural Internet subscribers use broadband, compared to 11.8% of urban subscribers.[22] The gap in subscriber levels can be traced to a lack of access, where data indicate a strong bias against rural deployment for wire-based (cable and DSL) technologies. Although cable modem service is available to residents in half of cities with populations above 100,000, less than one percent of towns with populations below 2,500 had access.[23] Deployment of

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[18] Falling Through the Net: Toward Digital Inclusion *supra* Note 1.
[19] See United States. General Accounting Office. Technical and Regulatory Factors Affecting Consumer Choice of Internet Providers. Washington: GPO, October 2000 at 51.
[20] Stern, Christopher. "Cable's Long Reach." The Washington Post 15 July 2001, H1.
[21] United States. Department of Agriculture. Advanced Telecommunications in Rural America: The Challenge of Bringing Broadband Service to All Americans. Washington: GPO, April 2000 at iii.
[22] *Id*. at xviii.
[23] United States. Department of Agriculture. Advanced Telecommunications in Rural America: The Challenge of Bringing Broadband Service to All Americans. Washington: GPO, April 2000 at 19.

DSL is similarly skewed: RBOCs served two-thirds of cities with populations exceeding 100,000 while ignoring all but .1% of towns with fewer than 2,500 people.[24] While it is true that some rural telephone cooperatives are expecting to make broadband services available to small towns, they do not have the resources to reach suburban or urban levels of penetration.[25]

To encourage rural broadband growth, FCC Chairman Michael Powell wants to promote "the growth of a wide variety of technologies that can compete with each other for the delivery of content … [and] redirect our focus onto innovation and investment."[26] The low levels of rural deployment for wire-based technologies may reveal a fundamental economic and technical incompatibility between those technologies and the environments where broadband deficiencies exist. Therefore, it is useful to examine the current technical, regulatory, and economic limitations of current and future broadband access technologies.

Broadband Access Technologies and Regulatory Structures

From a technological perspective, narrowband data communications technologies and related Internet applications[27] represented a significant proof-of-concept, foreshadowing the impact of broadband communications and its associated Internet

[24] *Id.* at 21. Forrester Research analyst Jay Kolko concurs: "The reason that adoption is different is because of availability, not demand." *See* Fonte, Diwata. "Speed the Plow – and Broadband, Too…." BusinessWeek Online via Dow Jones Interactive (http://www.djnr.com), 11 July 2001.
[25] *See* United States. Department of Agriculture. Advanced Telecommunications in Rural America: The Challenge of Bringing Broadband Service to All Americans. Washington: GPO, April 2000 at 23.
[26] Powell, Michael. Testimony Before the Subcommittee on Commerce, Justice, State, and the Judiciary… On the Federal Communications Commission's Fiscal Year 2002 Budget Estimates. 28 June 2001 at 5.
[27] Narrowband Internet applications include e-mail, basic World Wide Web browsing, text messaging, and other low-bandwidth applications.

applications[28]. The promotion of nationwide broadband access presents a significantly different set of challenges from narrowband because broadband relies heavily on the construction and heavy upgrading of telecommunications infrastructure. Capital investment is no longer required to support the bulk of the U.S. telephone network, but the construction of a national broadband infrastructure requires significant new capital.

Five technologies are regarded as the most promising Internet access methods: DSL, cable, satellite, fixed terrestrial wireless, and direct fiber optics.[29] Of these technologies, cable and DSL are the current leaders in the U.S., together accounting for 95% of residential broadband access.[30] However, these wire-based technologies have seen limited rural deployment due to technical, economic, and possibly regulatory restrictions. Satellite and fixed wireless services, which serve under 3% of broadband customers, represent promising access technologies in rural areas that are not served by DSL- or cable modem-capable wires. Next generation broadband satellites, scheduled to begin service as early as 2002, may provide performance at or above the level offered by cable and DSL. Fiber optics, the high-bandwidth medium of the Internet's backbone, serve the remaining broadband customers, but high start-up costs make it currently unfeasible in most urban areas, let alone rural communities.[31]

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[28] Broadband applications may include voice and video messaging, distributed computing, IP telephony, and digital distribution of software, audio, and video.
[29] See McAdams et al. "The Evolution of US telecommunications infrastructure." Info 2.2 (April 2000) at 108.
[30] *See* Infotechtrends.com 1 March 2001.
[31] *See* "The role of optical fibre in future networks." Info 2.2 (April 2000) at 121.

Cable and DSL: The prominent physical media technologies

Cable and DSL have dominated current broadband deployment in urban and suburban areas because they are able to reuse parts of existing copper-based networks and have the financial support of giant telephone and cable television providers. Of the 8.75 million Americans households with broadband Internet access, 38% have DSL service and 57% have cable service.[32] Although the two services provide customers with comparable experiences, their deployment is governed by distinct technical and regulatory constraints.

Cable companies provide high-speed data service through preexisting cable television networks[33], which allow data traffic to coexist with video signals on a coaxial cable brought into the home. In the upgraded "Hybrid Fiber Coaxial" (HFC) cable infrastructure that is necessary for data transmission, data and video signals are sent from the cable operator over fiber optics to "fiber nodes" that transfer signals to the coaxial wire connected to each residence. Each node, capable of serving lines as long as 16,000 feet[34], shares a fixed amount of bandwidth between 500 to 2000 homes, depending on the service provider's plans. Upgrade cost estimates for cable broadband range from $200 to $600 per household passed, regardless of how many are customers.[35] By one estimate, capital expenditures (including CPE) total about $1000 per subscriber.[36] High fixed costs must be spread over an appropriately sized customer base, which is generally not available in low-density areas.

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[32] *See* Infotechtrends.com, *supra* Note 30.
[33] The United States has about 65 million cable subscribers, and the cable network passes 97% of Americans. *See* "The potential for hybrid fibre coax technology." Info 2.2 (April 2000) at 125.
[34] Advanced Telecommunications in Rural America, *supra* Note _ at 28.
[35] *See* United States. Congressional Research Service. Broadband Internet Access: Background and Issues. Washington, CRS, 1 June 2001.
[36] *See* Abe, George. Residential Broadband. Indianapolis: Cisco Press, 2000.

Cable services enjoy a lighter regulatory load than their DSL counterparts. The FCC does not view cable operators as common carriers, and thereby shields them from the "open access" obligation of allowing competitors the use of their infrastructure to provide retail services. A U.S. Court of Appeals for the Ninth Circuit[37], however, found that cable modem service is a "telecommunications" service instead of a "cable" service, which made possible federal mandates for open access under the common carrier provisions of the 1996 Act.[38] As a result, the FCC issued a September 2000 Notice of Inquiry to resolve the question of whether cable should be subject to open access requirements.[39] While open access would increase competition within the cable technology itself, cable providers argue that such provisions will undermine investment in infrastructure, and add uncertainty to expansion plans.[40]

Cable modem service provides high-speed Internet access through an upgraded version of its existing network, much like competing DSL technology. However, DSL is regulated in an entirely different fashion, which may affect its ability to serve rural areas.

Digital Subscriber Line (DSL) service is made available by local telephone companies through preexisting voice telephone networks, on which data and voice are transmitted in distinct frequency ranges. Like cable, DSL requires costly physical upgrades to the existing infrastructure, resulting in a fiber-copper hybrid network. In this way, DSL infrastructure deployment costs are roughly comparable to HFC, although connections between the fiber interface and the home are handled differently. DSL, like

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[37] *See AT&T Corp. v. City of Portland*, 216 F.3d 871 (9th Cir. 2000).
[38] *See* Technical and Regulatory Factors… *supra* note 13 at 57.
[39] *See* Broadband Internet Access: Background and Issues *supra* note 14 at 11.
[40] *See* Technical and Regulatory Factors… *supra* note 13 at 56.

the voice telephone system, is based on a series of dedicated connections[41] that avoid shared resource problems like those experienced by cable operators.

Under the 1996 Act, DSL is treated as a Title I "telecommunications service"[42] and is therefore subject to the unbundling and interconnection requirements of a common carrier service.[43] As a result of this provision, DSL experienced the most substantial competition of the broadband access technologies, sprouting competing data providers like Covad, Rythms, and Northpoint Communications. Competing providers made attempts to serve small communities, but often failed to get the requisite 85 customers to justify infrastructure deployment.[44] Due to a variety of circumstances, including bad business planning, these competitors were substantially weakened in the 2000-2001 technology slowdown, and several were forced to file for bankruptcy protection.[45] These competitors were notorious for long delays in service installation, which some observers blame on a lack of RBOC responsiveness to connection requests.[46] While critics want the FCC's enforcement tools (i.e., fines) to be strengthened by Congress[47], the RBOCs are begging Congress to release them from their common carrier obligations.

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[41] These dedicated copper connections, called "local loops", cover the distance between the optical network unit and the home. Short local loops are able to transmit data at very high speeds, while sufficiently long loops (>18,000 ft.) are incapable of supporting broadband access.

[42] 47 U.S.C. § 251 et seq.

[43] "Unbundling" requires the Incumbent Local Exchange Carriers (ILECs), typically Regional Bell Operating Companies (RBOCs), to lease physical portions of the telephone network to Competing Local Exchange Carriers (CLECs). This provision was adopted to encourage local retail competition against the -monopoly previously held by the RBOCs. "Interconnection" requires ILECs to connect their networks to competitors' networks.

[44] *See* Thiessen, Mark. "Demand must meet willingness to pay for rural Internet connections." Associated Press Newswires via Dow Jones Interactive, 12 March 2001.

[45] *See* MacMillan, Robert. "Baby Bells Not Responsible For Telecom Troubles – Study." Newsbytes.com 27 June 2001.

[46] Wired reports: "[W]hen customers wanted DSL from other companies, Pac Bell wouldn't process the orders electronically; instead, DSL providers had to fax them in. Pac Bell workers then retyped them, inevitably making a few errors." *See* Rose, Frank. "Telechasm." Wired 9.5 (May 2001) at 131.

[47] *See* Holland, Royce J. Statement of Royce J. Holland, Chairman and CEO, Allegiance Telecom, Inc., Hearing on State of Local Competition before the Senate Committee on Commerce, Science, and Transportation. 19 June 2001.

Like their cable counterparts, DSL providers argue that open access hinders rural infrastructure investment. RBOCs argue that unbundling and resale requirements are disincentives for network upgrades, because they will be forced to effectively subsidize competitors' access to advanced data capabilities via unbundling.[48] Such debates involving the geographic location of infrastructure necessitate consideration of technologies that are less location-dependent, like satellite and fixed wireless.

Satellite and Fixed Wireless: Lower-cost wide area coverage

Next-generation satellite and fixed wireless technologies represent the best hope for broadband access in rural and remote regions of the United States.[49] Satellite technology offers a direct line-of-sight, and therefore offers access, to almost every location in the United States.[50] Fixed wireless systems like MMDS (Multipoint Multichannel Distribution System) use microwaves to reach almost 4000 square miles with a single antenna and represent a feasible access method for low-density areas.[51]

Next-generation satellite technologies will deliver broadband access with performance levels approaching or exceeding those of cable or DSL. DirecPC, the most prominent first-generation satellite data system suffered from a lack of bandwidth (12Mbps of shared bandwidth for all customers in the U.S.) and a telephone-based 33.6

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[48] *See* United States. Congressional Research Service. Broadband Internet Access: Background and Issues. Washington, CRS, 1 June 2001.

[49] This notion has been supported by former FCC commissioner Susan Ness: "Different high-speed access technologies work better in different locations and circumstances. For example, wireless and satellite services on the horizon may be particularly well-suited to reach consumers in remote areas." *See* "Separate Staetment of Commissioner Susan Ness" in Deployment of Advanced Telecommunications Capability, *supra* Note _ at 2.

[50] Advanced Telecommunications in Rural America, *supra* Note _ at 28.

[51] Advanced Telecommunications in Rural America, *supra* Note _ at 26.

kbps return path[52]. Satellite systems like WildBlue (operational in 2002) and Teledesic (operational in 2004) will provide high-speed bi-directional service across America without additional terrestrial infrastructure.[53]

Latency, used to describe the delay inherent in communicating with a satellite hundreds or thousands of miles away, is a problem minimized in Low Earth Orbit satellite systems like SkyBridge and Teledesic. An inevitable result of the distance covered by the signal, propagation delay has been noticeable to the general public as brief pauses in live-via-satellite interviews. Traditional geosynchronous satellites require almost half a second for a signal to travel a 71,000 km round trip, which limits data throughput and makes such systems unable to handle real-time traffic.[54] Using Low Earth Orbit (LEO) satellites, however, travel time is reduced to a mere 12 milliseconds for a 2000 km round trip.[55] Three geosynchronous satellites can provide global coverage, but lower orbits require a constellation of 80-300 satellites for global coverage, raising the fixed start-up costs of LEO systems.[56]

The cost of launching a satellite represents a significant barrier to entry[57], and the catastrophic financial failure of major satellite investments like Iridium[58] provides a

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[52] *See* Abe, *supra* Note _ at 250. The dial-up return (upload) path can cause additional problems because users in areas without local access to a DirectPC dial-up telephone number will be forced to pay long distance or 800-number fees to use the DirectPC service.
[53] Each satellite has a unique broadcast "footprint that defines its signal strength in various geographic areas. The footprints of current data satellites cover the 48 contiguous states, but leave Alaska and Hawaii disconnected.
[54] *See* Choi, Hyoung-Kee et al. "Interactive Web Service via Satellite to the Home." IEEE Communications Magazine (March 2001) at 189.
[55] *See* Abe, *supra* Note _, at 253.
[56] Hu, Yurong and Victor Lee. "Satellite-Based Internet: A Tutorial." IEEE Communications Magazine (March 2001) at 154, 157.
[57] The original cost estimate for the Teledesic program, bankrolled by Microsoft's Bill Gates and Craig McCaw, was $9 billion for the satellites and launch alone. *See* Abe *supra* note 15 at 255. Because satellite operates on line-of-sight principles, ground-based relays must also be used at additional expense where a direct and continuous line-of-sight is not possible (e.g., dense urban areas).

strong warning for those who will make significant investments in space-based access. However, Teledesic will cost $9 billion to provide global coverage, compared to the $63 billion already invested by cable companies for infrastructure upgrades. Since terrestrial infrastructure upgrades have even higher cost per user in rural areas, it may be more efficient to use satellite technologies to serve such users. Additional research is required to improve data traffic control through satellite networks and minimize the effects of latency[59], which may require federal funding.

Satellite technology is a reasonably high-performance access alternative for rural customers, and competition will exist within the satellite access industry between systems like Astrolink, Skybridge, Spaceway, and Teledesic.[60] In towns and other rural areas where population density is higher, fixed wireless access may emerge as a competitor to satellite.

Fixed wireless access has the potential to connect communities of sufficiently low density that DSL and cable are uneconomical options due to long wire lengths. Multichannel Multipoint Distribution Service (MMDS), the most promising technology for rural areas, operates in the 2.5 GHz range with the ability to transmit up to a 35 mile radius (3,848 square miles)[61]. Equipment, tower, and antenna costs are under $1.5 million, which may be reduced by up to $1 million if a sufficient tower already exists.[62] One entrepreneur agreed to provide town governments with broadband service in

[58] Iridium was the first LEO system to offer global voice service. Due to bulky equipment and outrageous pricing, demand for the service was extremely limited and Iridium filed for bankruptcy. *See* Abe *supra* note 15 at 256.
[59] *See* Hu and Lee, *supra* Note _, at 162.
[60] *See* Hu and Lee, *supra* Note _, at 157.
[61] *See* Advanced Telecommunications in Rural America, *supra* Note _, at 26.
[62] These cost levels are low enough to justify MMDS deployment in towns as small as 6,000 people. *See* Advanced Telecommunications in Rural America, *supra* Note _, at 26.

exchange for access to the water tower for the antenna.[63] The wireless nature of the technology allows providers to support subscribers at any location within the service, no matter how far they are from the nearest wire-based infrastructure.

In summary, satellite and fixed wireless technologies are the best way to provide broadband to rural America. Technical and economic constraints prevent the widespread deployment of cable and DSL, especially outside of towns. Satellite providers provide a location-neutral broadband service as a reasonable substitute for wire-based technologies, and fixed wireless may soon provide broadband access competition to rural towns. The flexibility offered by satellite and wireless access should be considered in creative public policymaking decisions.

Analysis of Recent Policy Proposals

This section is still a mess and is omitted here. It will be finalized in time for the dry-run presentations on Wednesday.

H.R. 1542: Internet Freedom and Broadband Deployment Act of 2001 (Tauzin-Dingell)

S.88 (Rockefeller), H.R. 267 (English), and other Assistance Programs

S. 430: Broadband Rural Research Investment Act of 2001 (Clinton)

Improving the FCC Definition of "Broadband"

Industry Canada, in a survey of 14 developed countries, found that the official national government definitions for "broadband" varied dramatically from 200 kpbs to 30 Mbps.

Recommendations

The following recommendations follow from the analysis above:

[63] *See* Landers, *supra* Note _.

Recommendation 1: Policy seeking to address rural Internet access should be based on the principle of competition and avoid one-size-fits-all solutions. Competition should be encouraged both within a specific technology and between technologies.

Recommendation 2: Wireless access technologies like satellite and fixed wireless should not be overlooked as access alternatives for rural areas. Regulatory changes and financial assistance based on assumptions of a cable and DSL future are misguided and inefficient.

Recommendation 3: Promote research in technologies that will serve rural Americans, particularly wireless and satellite technology. The high fixed costs of wire-based and wireless infrastructure make necessary long-term research a low corporate priority.

Recommendation 4: The FCC should adopt a higher standard for its definition of broadband access. The current 200 kbps definition is set too low, and a higher-speed standard would promote forward-thinking investment.

Broadband connectivity is clearly an important part of our nation's digital future. Although access deficiencies currently exist in rural areas, new technologies and creative business plans can be used to capitalize on the opportunity to serve 65 million rural Americans. Regulatory changes and additional assistance programs are not needed to spur this innovation, but policies should be reviewed to ensure that they promote competition. By recognizing the importance of emerging access technologies, these recommendations encourage a pro-competitive, creative framework for rural broadband policy and promote long-term competitiveness in the digital economy.

Appendix A: Comparison of Broadband Access Technologies

Access Technology		Typical Speed	Infrastructure Highlights	Technical Limitations	Level of Deployment	Regulatory Applicability	Representative Providers
XDSL	VDSL	13-52 Mbps up 1.5-3 Mbps down	Fiber to neighborhood, twisted pair to customer, Voice/data splitters on site	Loop length < 3000 ft (<1000 ft for highest speed)	2.8 million xDSL subscribers (Q1 2001). Phone lines have near 100% penetration, but many lines not DSL-ready	Telecom service under 1996 Act, subject to unbundling	RBOCs (Verizon, SBC, BellSouth, Qwest) Competitive Data Providers (Covad, Rhythms)
	G.lite	512 kbps up 2 Mbps down	Fiber to neighborhood, twisted pair to customer, No voice/data splitters needed	Loop length < 18,000 ft			
HFC (Cable)		320kbps-10Mbps up 27 Mbps down (shared access between 500-2000 homes passed)	Fiber to neighborhood, amplifier upgrades required, coax to customer ($1000/subscriber)	Shared media path causes noise, bandwidth concerns, 3 mile range	4.3 million subscribers (Q1 2001). Cable reaches 64 million households, but many lines not HFC ready	**Data:** Telecom service (US 9th Circuit Appeals) **Video:** Cable service	AT&T Broadband, Comcast
Fixed Wireless		155 Mpbs up 155 Mbps down (shared access)	Broadcast towers, radio equipment	Interference, 35 mile range for MMDS	Rollout limited to metropolitan areas, few rural areas	Broadcast service subject to spectrum management provisions	MCI Worldcom, Sprint, Nextlink, Winstar
Satellite		64 Mbps up 2 Mbps down	Satellite launches. Lower orbits require more satellites	Line-of-sight to satellite(s), rainfall –based interruptions	National (or global) coverage by multiple systems within three years	Broadcast service subject to spectrum management provisions	Teledesic, WildBlue, SkyBridge, Spaceway

Sources: *Residential Broadband, Technical and Regulatory Factors Affecting Consumer Choice of Internet Providers, Teledesic (www.teledesic.com), Jupiter Research*

Works Cited

Abe, George. Residential Broadband. Indianapolis: Cisco Press, 2000.

Ahrens, Frank. "The Great Deregulator." The Washington Post 18 June 2001: C1+.

Akin, David. "Task force misses the mark on investment, technological issues." National Post (Toronto) 19 June 2001: C3.

Bettelheim, Adriel. "Fate of House 'Broadband' Bill Handed to Rules by Judiciary." CQ Weekly 16 June 2001: 1434-1435.

Brent, Paul. "Who pays the broadband piper?" National Post (Toronto) 19 June 2001: C2.

"Broadband Blues." The Economist 23 June 2001: 62.

Industry Canada. The New National Dream: Networking the Nation for Broadband Access. Ottawa: Industry Canada, 2001.

Corcoran, Terrence. "Broadband Socialism." National Post (Toronto) 19 June 2001: C15.

Crandall, Robert. "Bridging the Divide – Naturally." Brookings Review 19.1 (2001): 38- 43.

Dawson, Emily L. "Universal Service High-Cost Subsidy Reform: Hindering Cable-Telephony and Other Technological Advancements in Rural and Insular Regions." Federal Communications Law Journal 53.1 (2000): 117-135.

Dodd, Annabel Z. The Essential Guide to Telecommunications. Upper Saddle River: Prentice-Hall, 2000.

"EU agrees to bring Net to all homes." MSNBC 27 June 2001 http://www.msnbc.com/news/593207.asp (5 July 2001).

Holland, Royce J. Statement of Royce J. Holland, Chairman and CEO, Allegiance Telecom, Inc., Hearing on State of Local Competition before the Senate Committee on Commerce, Science, and Transportation. 19 June 2001.

Hollings, Senator Ernest F. Hollings Opening Statement for Senate Commerce, Science, and Transportation Hearing Competition in the Local Phone Market. 19 June 2001.

IEEE-USA Committee on Communications & Information Policy. Position Statements. Washington: IEEE-USA, 2000.

Irving, Larry. "Michael Powell's 'Mercedes Divide'." The Washington Post. 30 June 2001: A30.

MacMillan, Robert. "Baby Bells Not Responsible For Telecom Troubles – Study." newsbytes.com. (28 June 2001).

McCain, Senator John. Statement of John McCain, Ranking Member, Committee on Commerce, Science, and Transportation Hearing on Local Competition for Telephone Service. 19 June 2001.

National Research Council. The Internet's Coming of Age. Washington: National Academies Press, 2001.

Pew Internet and American Life Project. Who's Not Online. http://www.pewinternet.org/reports/pdfs/Pew_Those_Not_Online_Report.pdf (5 July 2001).

Solomon, Lawrence. "Coast-to-coast subsidies trap rural Canada." National Post (Toronto) 19 June 2001: C15.

Srinivasan, Kalpana. "Powell Touts Move to Digital World." AP Online 31 May 2001. Lexis-Nexis 5 July 2001.

Thierer, Adam D. "Is the 'digital divide' a virtual reality?" Consumers' Research Magazine. 83.7 (July 2000): 16-20.

United States. House Committee on Energy and Commerce. Internet Freedom and Broadband Deployment Act of 2001: Report. Washington: GPO, 24 May 2001.

United States. House Committee on the Judiciary. Internet Freedom and Broadband Deployment Act of 2001: Adverse Report. Washington: GPO, 18 June 2001.

United States. Congressional Research Service. Broadband Internet Access: Background and Issues. Washington, CRS, 1 June 2001.

United States. Congressional Research Service. Broadband Internet Access and the Digital Divide: Federal Assistance Programs. Washington, CRS, 10 May 2001.

United States. Department of Commerce. Falling Through the Net: Toward Digital Inclusion. Washington: GPO, 2000.

United States. Federal Communications Commission. Deployment of Advanced Telecommunications Capability: Second Report. http://www.fcc.gov/Bureaus/Common_Carrier/Orders/2000/fcc00290.pdf (5 July 2001).

United States. General Accounting Office. Characteristics and Choices of Internet Users. Washington: GPO, February 2001.

United States. General Accounting Office. Technical and Regulatory Factors Affecting Consumer Choice of Internet Providers. Washington: GPO, October 2000.

Vardy, Jill. "Report kicks off debate on who picks up the bill for broadband." National Post (Toronto) 18 June 2001: C3.

Walker, Jean F. "Paved With Good Intentions: How InterLATA Data Relief Undermines the Competitive Provisions of the 1996 Act." Federal Communications Law Journal 53.3 (2001) 533-556.

Wilhelm, Anthony. "From Crystal Palaces to Silicon Valleys: Market Imperfection and the Enduring Digital Divide." in Access Denied in the Information Age. Location: Pub, 200x.

Winston, Brian. "'Smell the Tulips': the Internet, Neo-liberalism and Millenarian Hype." in Access Denied in the Information Age. Location: Pub, 200x.