Network Effects: An Introduction to Broadband Technology & Regulation

A study commissioned by the U.S. Chamber of Commerce

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A REPORT TO THE U.S. CHAMBER OF COMMERCE

NETWORK EFFECTS:
AN INTRODUCTION TO BROADBAND TECHNOLOGY & REGULATION

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The Advanced Communications Law & Policy Institute ("ACLP") at New York Law School is a public policy program that focuses on identifying and analyzing key legal, policy, and regulatory issues facing the advanced communications sector. ACLP's mission is to promote robust and solution-focused dialogues amongst state and federal policy makers, industry, academe, the financial community, and consumers concerning changes to the state and federal regulatory regimes governing wireline, wireless, broadband, and IP platforms.

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1. EXECUTIVE SUMMARY

Less than a decade ago, the dial-up modem was the primary means of getting online, enabling Internet connection speeds upwards of 56,000 bits per second, or 56 kilobits per second. Such speeds, slow by today's standards, were adequate for an Internet that was dominated by text-based sites, correspondences, and file transfers. However, the number of Internet users, the sophistication of content, and demand for advanced applications increased exponentially in the mid-1990s, highlighting the need for more high-capacity bandwidth to accommodate the rise in network traffic. This demand, along with cheaper network equipment, drove the development and deployment of broadband in the late 1990s.[1]

By 1999, broadband was being heralded as an economic and social catalyst, a technology that was poised to "increase our nation's productivity, create jobs…[and] meaningfully improve our educational, social, and health care services."[2] Over the last few years, broadband has replaced the dial-up modem as the primary Internet connection for the vast majority of consumers and businesses because it can deliver robust voice, video, and data services more quickly and reliably than its narrowband predecessor. Indeed, only 10 percent of American households still use a dial-up connection while over 55 percent have adopted broadband.[3]

As a result of such robust adoption and rapid innovation, broadband is fundamentally changing the way people live their lives. It is being used to spur technological innovations in the areas of health care, education, environmental sustainability, economic development, energy efficiency, personal wellbeing, and government. Broadband brings people closer together, helps consumers save money, makes government more accessible, and creates jobs. Broadband is currently a life-altering tool for many and should be viewed as an indispensable tool for all Americans as the technology is further integrated into daily life. Understanding exactly what broadband is, how it has evolved, and what the regulatory philosophy is that has allowed this vital new technology to flourish is critical to understanding how policy making can and will impact the evolution of networks and content.

Section II discusses two core aspects of broadband. First, it assesses the current broadband market and analyzes the policies that have enabled the market to grow and innovate at such a dramatic pace. Second, this section discusses the many facets of the broadband network and underscores the pivotal role that the network plays in facilitating innovation. Advanced, reliable, and efficient networks are essential to continued deployment and adoption of new technologies and services. Cutting-edge applications increasingly rely on stable broadband connections to deliver flawless and, in many cases, lifesaving services like telemedicine. *Being able to design, construct, and*

manage a network is crucial to creating the proper incentives for deploying physical broadband infrastructure and continuing to encourage and foster innovation.

Section III discusses the growing number of regulatory challenges facing the broadband market. The current regulatory environment, which focuses on promoting facilities-based investment and platform competition, has played a key role in enabling innovation at the network and application levels. The result has been a massive increase in network investment by communications providers. Indeed, it is estimated that companies will have invested upwards of $60 billion in communications infrastructure in 2008.[4] Moving away from a pro-investment model would halt this organic progress and would have a devastating effect on the U.S. economy, investment, and innovation as discussed at length below. Moreover, policies aimed at management practices are unnecessary and would serve only to chill innovation at the network level and at its edges, resulting in net consumer welfare losses.

Public policy should recognize that pro-investment policies have spurred the growth of broadband and that network management plays a critical role in ensuring that consumers realize the full benefits of the technology. Thus, policymakers should be guided by the ***foundational principles*** discussed below:

- The broader advanced communications marketplace, including the broadband and wireless sectors, has responded positively to the pro-investment policies designed by a bipartisan Congress and the FCC to spur innovation, investment, and network build-out.
- Government intervention in the broadband marketplace through the imposition of restrictive policies, such as those that would control how providers price, market, and manage their products and services, would deter innovation, halt competition, and thwart the continued enhancements of broadband networks.
- Network management allows network owners to mange congestion, prevent jitter and latency, ensure a reliable quality of service, and otherwise optimize network performance for all users.
- Consumers would be negatively impacted by efforts to restrict network management. In the short term, the Internet experience of the majority of average users could be negatively impacted by high-capacity users, the actions of which can crash a network or greatly congest it. In the long-term, such policies could impair the effectiveness of lifesaving telemedicine and other applications that ride the network and require connections that are jitter-free.
- The ability of network managers to prioritize emergency and lifesaving data is necessary in order to realize the full potential of many new telemedicine, telehealth, and distance learning services and

applications. Thus, stripping network owners of the ability to effectively manage their networks imperils users and decreases incentives to further innovate in this space.

2. AN OVERVIEW OF BROADBAND DEVELOPMENT, DEPLOYMENT & POLICY MAKING

Throughout the development of the Internet, the federal government, acting through Congress and the Federal Communications Commission ("FCC"), has implemented a regulatory framework designed to rely on technological advancement, competition, and investment, as opposed to one that sough to prop up a monopoly provider, which characterized telecommunications regulation of the past. Support for this policy framework has been largely bipartisan. Even as demand for Internet services and access exploded, regulatory mandates were minimal. This approach has been necessary in order to promote the continued deployment of broadband networks across the country.[5]

In the advanced communications space, narrowly tailored, pro-competition regulation has consistently facilitated competition and innovation. In the broadband sector specifically, deregulatory policies have created consumer welfare gains. Intermodal competition has driven the deployment of next-generation broadband networks to nearly every corner of the country and has similarly spurred innovation among application and content providers. Broadband users now have access to a growing universe of life-enhancing and potentially lifesaving applications and services.

The positive impacts of regulatory policies that support and encourage competition in the broadband sector are multiple. First, the wide availability of robust networks has facilitated the rapid development and consumption of cutting-edge Internet applications like IP video and lifesaving advances like telemedicine and remote monitoring services. Consumers are relying on broadband services more than ever before. Second, increased consumer demand for broadband has spurred further investment and innovation at the network level. Network owners have poured and continue to pour billions of dollars into the physical broadband infrastructure to ensure that consumers have access to the content they most desire.[6] Recent network deployments and announcements of future intentions for investments signal a new primacy for providing consumers with even more robust broadband connections (see Section 2.3.2 for a discussion of these new network offerings).

Third and perhaps most importantly, perceptions regarding the network itself are changing. Long eschewed as just a "dumb" set of pipes used to transmit simple data packets, advanced broadband networks are fast becoming a critical cog in the machine

of innovation. Complex and bandwidth-intensive applications and content require a "smarter" and more robust network to provide reliable service. *To this end, the advent of real-time voice, video, telepresence, and other broadband-enabled services has necessitated the development of protocols for efficiently managing data traffic and congestion on networks.* Without ample latitude to manage this traffic, broadband networks, no matter how robust, will fail to perform at the highest possible levels.

2.1 *The Evolution of Policy Making in the Broadband Sector: Less is More*

In 1996, a bipartisan Congress made clear its intent to rely on policies that limited government intervention on the Internet. In its overhaul of the 1934 Communications Act, Congress explicitly stated that "[i]t is the policy of the United States…to preserve the vibrant and competitive free market that presently exists for the Internet and other interactive computer services, unfettered by Federal or State regulation."[7] Regulatory authority for the Internet was delegated to the FCC, which outlined a goal of "ubiquitous availability of broadband to all Americans."[8] To reach this objective, the FCC has fostered a "minimal regulatory environment" for Internet access technologies, especially those that deliver broadband service.[9]

With phone, cable, wireless, satellite, and other companies aggressively competing for broadband consumers, the FCC has worked to create regulatory parity among broadband platforms. This policy has provided the marketplace with certainty, which has in turn helped spur competition, network deployments, price and service competition, and increased subscribership.[10]

SNAPSHOT 1
Examples of Subsidizing Competition:
The 1996 Telecom Act

- From March 2000 to July 2004, market capitalization in the telecom sector plummeted from $1,135 billion to $375 billion.
- Some 380,500 jobs were lost between March 2001 and May 2004 in telecom service, Internet service, and equipment manufacturing.
- The communications equipment-manufacturing sector experienced a 74% decline in market capitalization for the same period.
- The telecom industry lost 193,000 jobs between 2000 and 2003.

Unfortunately, many other aspects of the 1996 Act proved to be ineffective because they were too proscriptive. A number of provisions in the Act sought to dictate the market forces of and create artificial competition in a very dynamic and fluid sector. As a result of regulatory arbitrage, a large influx of competitors flooded the local telephone market, helping to inflate a technology "bubble" that eventually exploded in spectacular fashion around the turn of the century (see Snapshot 1).[11]

In diametric opposition, a pro-competitive approach has been successful in the wireless sector. When the Commission revised its rules in the mid-1990s to allow more than two carriers to serve each local market, the wireless industry experienced explosive growth and consumers realized enormous consumer welfare gains, including lower costs and innovative services (see Snapshot 2). Wireless providers invest billions of dollars each year in their networks in order to provide more ubiquitous and reliable service.[12] In addition, as described in more detail below, intermodal competition in both the voice and broadband markets have pushed wireless providers to speed the deployment of third- and fourth-generation networks in order to provider users with a robust mobile broadband experience.

SNAPSHOT 2
The Success of Open Markets & Network Competition:
The National Framework for Wireless

The adoption and implementation of a deregulatory national framework for wireless in the 1990s has had a profound and lasting impact on the sector:

- There are currently over 262 million wireless subscribers in the U.S., up from 44 million in 1996 and 28 million in 1995.
- The penetration rate is currently 84 percent. In 1995, it was 11 percent.
- Nearly 16 percent of households have "cut the cord" and use only wireless for phone calls.
- Prices continue to decline as consumers are offered a growing universe of tailored service options.
- Ovum estimates that mobile service produces annual productivity gains in the hundreds of billions.

Similarly, the Internet was developed under an analogous regulatory rubric that was minimalist in nature. Although initially a government-funded project, the Internet was eventually spun off into a private endeavor that was guided by the efforts of scientists, researchers, academics, and others who were provided with the freedom to tinker with the foundations of the web.[13] These innovations did not come about by government diktat but rather through collaboration. Network engineers, computer scientists, and others belonging to the initial cadre of experts who helped design the Internet were free to act in the best interests of web users.[14] Government did not attempt to micromanage innovation.

Consumers across every demographic have enjoyed the enormous welfare gains that have resulted from a consistently pro-competitive approach to regulation in the advanced communications market. As set forth below, the broadband market in particular has greatly benefited from an approach that has been focused on platform competition and investment.

2.2 *The Current Broadband Market*

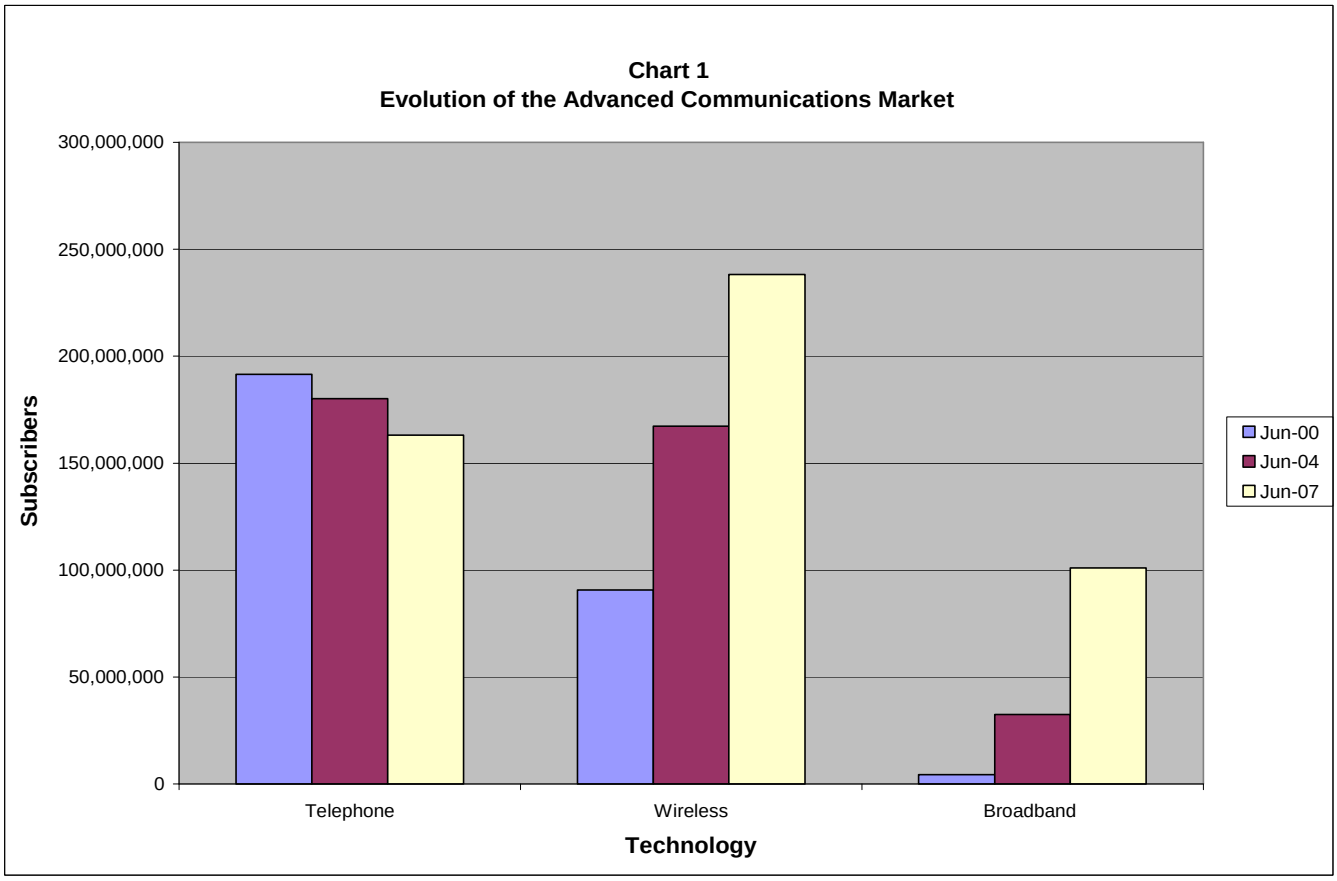
The emergence of broadband as a mainstream method of communication has been remarkable. Since June 2000 the number of broadband lines in the United States has increased by 2,360 percent.[15] Broadband is widely available; indeed, according to the FCC, *only 0.1 percent of zip codes in the U.S. reported no broadband in June 2007.*[16] Moreover, much of the population lives in areas with multiple service providers; nearly 90 percent live in areas with competition and choice of broadband services.[17] Competition among network owners has led to decreased prices for consumers[18] and increased choice for getting online. Across the U.S. there are some 1,360 different broadband providers.[19] Consumers have a number of options for obtaining broadband Internet service. These include digital subscriber line ("DSL"), cable modem, third-generation ("3G") wireless service, fiber-optic networks, and more. With such a diversity of choice, more and more consumers are accessing the Internet via non-traditional means. For example, over 40 million wireless subscribers regularly access the Internet via their mobile phones.[20] The emergence of broadband has stirred intermodal competition and has fundamentally altered the landscape of the advanced communications market (see Chart 1 on the next page).

SNAPSHOT 3
Key Broadband Statistics

- Over 100 million broadband lines in service across the U.S., up from 4 million in June 2000.
- Broadband is available in 99.9 percent of all zip codes.
- 90 percent of the population lives in areas with 4 or more broadband providers.
- The number of fiber-optic connections doubled between 2006 and 2007, and continues to rise.
- 40 million consumers access the Internet on their mobile phones, enabled by next-generation networks.

Sources: FCC; Nielsen Mobile

Current pro-investment policies have allowed for innovation and investment in all facets of the broadband market. Network owners responded to increased consumer demand for advanced applications and faster Internet connections by developing and deploying next-generation broadband networks. The first wave of innovation leveraged existing infrastructure – the copper-based telephone network, coaxial cable networks, and wireless spectrum – to provide the first iteration of broadband service. Over the last several years, however, network owners, including telecommunications firms, cable companies, and wireless providers, have invested billions of dollars in order to build out next-generation broadband networks that are largely based on fiber-optic cables and more advanced spectrum management technologies. These newer networks provide end-users with faster upload and download speeds and more reliable connections (see Section 2.3.2 for further discussion).



Source: FCC

Companies vying for broadband consumers are integrating Internet Protocol ("IP") technology into their products and services. Such convergence of technologies encourages further innovation, allows for a wide range of new products to be deployed, and spurs new types of competition. For example, wireless companies are bolstering their networks with next-generation equipment to enhance the end-user experience and enable cutting-edge handsets like the iPhone. These types of Smartphones are able to access the Internet at broadband speeds, allowing consumers to watch videos on their handsets, download music, and otherwise enjoy a nearly seamless mobile broadband experience. Such diverse functionality, which is enhanced by a wireless broadband connection, provides consumers with the ability to purchase one device for many different uses and thus save money.[21]

2.3 Network Effects: The Shifting Paradigm & Increasing Importance of the Broadband Network in the Modern Digital Age

At the dawn of the Internet age, the underlying physical network of wires and routers was tasked with transporting traffic that consisted mostly of text. Indeed, before the development of "commercial" Internet service offerings like AOL, the Internet was used

mostly by hobbyists, researchers, and academicians for email and file transfers.[22] However, demand grew as soon as the Internet became publicly available in the early 1990s. In 1995 and 1996, Internet traffic grew at an annual rate of 1,000 percent.[23] Traffic continued to grow at a rate of 100 percent per year in 1997 and 1998.[24] *Fortunately, network engineers had the flexibility to adapt the network in order to accommodate the growth in size and scope of the Internet.*[25] Similarly, network providers responded to increasing consumer demand for a more robust online experience by deploying more advanced networks and implementing "new ways of network budgeting and engineering" to accommodate increased traffic and congestion.[26]

Over the last few years, however, the Internet has transitioned to its "third phase," characterized by the ability to transmit rich content like VoIP, video, and a growing array of real-time services that depend on a broadband connection to be reliably delivered.[27] Consumer demand for these types of services has sharply increased and is poised to further expand as faster broadband networks are deployed.

As a result, there have been three fundamental changes within the broadband market, each of which is tied to the evolving nature of the broadband network.

2.3.1 Increasing Consumer Consumption of Internet Services & Applications

First, there has been a dramatic shift in the way people are using their broadband connections. Consumption of online services and content has steadily increased over the last few years. Perhaps the most illustrative example of how consumer use of the Internet has evolved is consumption of online video.

The advent of fast broadband networks facilitates the rapid transmission of very large video files to end users. Depending on their length and quality, video files may contain many gigabits (i.e. billions of bits) of data. Consumers can view or obtain video in a number of ways, including by downloading it directly from a website, downloading it via a peer-to-peer network[28], or streaming[29] it. Streamed video is perhaps the most popular video application and can be found on websites like YouTube and Hulu. YouTube is by far the most popular video site with over 40 percent market share.[30] To get a sense of how popular Internet video is, consider that in December 2007 U.S. users viewed 10 billion videos online, then a new record.[31] By July 2008, that number rose to 11.4 billion.[32] And the amount of bandwidth consumed just by You Tube alone is staggering. It uses as much bandwidth as the entire Internet did in 2000[33] and currently accounts for approximately seven percent of all U.S. Internet traffic.[34] Chart 2 illustrates how very popular streaming video has become in just the last three years.

CHART 2 – U.S. Online Streaming Video Viewing Habits: 2005-2008

	June 2005	July 2007	July 2008
# of U.S. consumers who watched streaming video online	94 million	134 million	142 million
% of U.S. Internet population that watched streaming online video	56	75	75
Avg. # of minutes of video viewed per month by U.S. users	73	180	235

Source: comScore

However, while three quarters of American Internet users have viewed videos online, very few are considered "heavy users." These users consume an average of 841 minutes (or 14 hours) of video viewing per month, compared to just 7 minutes for "light users."[35] Even as more people view videos online, there continues to be a wide disparity between casual viewers who watch only a couple of minutes per day versus a minority of users who consume the vast majority of minutes. Over the past year, the number of videos being uploaded or downloaded online has increased 1,000 percent.[36] Across the board broadband customers are using 40 percent more bandwidth each year.[37] Yet according to Time Warner Cable, only five percent of its users account for more than 50 percent of bandwidth usage.[38] As a result, one study predicts that by 2011, the amount of data on the Internet will have increased tenfold since 2005.[39] By pushing the network to the edge, these extreme users may raise the cost of Internet access for all customers as providers are forced to invest in network upgrades at a faster pace than 95 percent of the marketplace would require.

In addition to video, however, broadband networks have also facilitated the development of services and applications that can be used to enhance an individual's health and, in a growing number of cases, save lives. As discussed in the four companion papers to this study, broadband has had and will continue to have a profound impact on the healthcare and medical services industry, on education, on people with special needs, and on senior citizens. Moreover, consumers are using their broadband-enabled VoIP phones to make emergency calls in addition to low-cost personal calls. *While these types of life-enhancing and lifesaving applications vary in their bandwidth requirements, they often require a secure network connection.*

Rapidly growing use of bandwidth-intensive applications has increased the amount of traffic being sent over broadband networks. At times, networks become overwhelmed with traffic and can become clogged and congested, which in turn slows the transmission of all data packets. As described in further detail below, network operators are currently confronted with a unique problem: managing a network that

transmits a large variety of data, some of which may be purely for entertainment and some of which may be for voice communications or emergency or lifesaving purposes. *Thus, the network – its infrastructure and ability to manage different types of traffic – has fast become a critical factor in enabling further innovation at its edges.*

2.3.2 Innovation at the Network Level

The second change in the broadband market is the amount of innovation at the network level. While network owners have always invested large amounts of money and resources into their infrastructure, recent developments have signaled a new primacy for even more robust networks (see Snapshot 4).

Wire-based network owners – i.e. telephone and cable companies – for example, are currently upgrading their respective networks to provide consumers with voice, video, and broadband services. Verizon, for example, is spending at least $23 billion dollars on its new FiOS system, which replaces its old copper-wire phone with fiber-optic lines capable of delivering double-digit megabit per second broadband speeds.[40] Similarly, AT&T is deploying a fiber-optic system – U-Verse – across its entire service territory.[41] Both plan to have their networks completed in the next few years. Cable providers – e.g., Comcast – are also upgrading their networks with a new technology – DOCSIS 3.0 – which will boost broadband speeds that are comparable to fiber-optic speeds.[42]

SNAPSHOT 4
Broadband Network Innovation

- *Fiber-optic networks.* Fiber-optic cables provide much faster and more symmetrical broadband service.
- *Advanced cable systems.* New delivery methods provide end-users with even faster Internet access.
- *Third-generation (3G) Wireless Networks.* Most major carriers have already deployed these networks, which enable a wide range of mobile applications.
- *WiMAX*. One of the leading 4G wireless technologies, this as-yet deployed service promises broadband-level speeds.
- *Long-term Evolution*. An alternative to WiMAX, these networks will be deployed in the next few years by AT&T and Verizon.

Wireless providers are also deploying next generation networks to provide users with more broadband-enabled applications like email, faster web access, and a host of new location-based services (e.g., GPS directions). For example, most major national mobile operators have already launched, or are in the processing of launching, third-generation

("3G") networks that are capable of delivering broadband-level Internet access and that enable a wide-range of broadband tools. To date, over 64 million wireless users have 3G-capable devices.[43] Additional deployments are expected later this year by carriers like T-Mobile.[44] The next generation of wireless networks is also in the process of being deployed. WiMAX, one fourth-generation ("4G") standard, will be deployed nationwide by a consortium led by Sprint Nextel and Clearwire.[45] Long-term Evolution ("LTE"), another 4G standard, will also be deployed in the next few years by Verizon and AT&T.[46]

In general, innovation at the network level provides applications developers with a reliable and fast infrastructure, thus encouraging further innovation at the edges of the network. However, as discussed in the next section, perceptions regarding the network itself are changing in important ways. Innovation at the edges of the network has populated the Internet with a rich and dizzying collection of information and applications. Yet it is innovation within the network that promises to facilitate further innovation and to ensure that all users have ready and reliable access to the information and applications they demand.

2.3.3 The Network as an Enabler of Innovation

The third change in the broadband market regards the shifting perceptions associated with the network. The physical infrastructure of the Internet – wires, routers, etc. – has been described by some as a "dumb" network that blindly transfers content from user to user.[47] In other words, the network is viewed here as nothing more than a conduit through which both harmful and "safe" content could pass.[48] However, the wide availability and adoption of broadband has changed this dynamic. Increased bandwidth allows for the transmission of much larger amounts of data than older narrowband networks. As a result, the user experience is impacted by not only an individual's actions but by the actions of other users and the actions of the network owner, which must ensure a reliable quality of service to its customers by efficiently managing the exploding amount of traffic flowing over its wires.

The exponential increase in data traversing the Internet infrastructure has challenged the capacity of networks and has necessitated the development and implementation of more effective "network engineering" tools and protocols to manage traffic by nearly every Internet stakeholder. To ensure that their customers have the best Internet experience possible, these companies need the flexibility to quickly and adeptly maximize the reliability, security, and speed of their networks. For example, application provider Google collects enormous amounts of information each day and systematically organizes it to make it useful for consumers.[49] Its primary tool for organizing information is an algorithm that analyzes web pages and ranks them using a subjective set of data.[50] Similarly, Akamai, a company that provides services to facilitate

the transmission of content over the Internet, actively monitors network traffic in order to assure the timely and safe delivery of its clients' data.[51]

The ability to implement similar methods by network owners, however, has recently been questioned. Some argue that the original perception of the network – i.e. a "dumb" set of wires – should still apply in order to preserve the sanctity of the Internet.[52] Yet as described above, this view is no longer tenable at a time *when unmanaged Internet traffic has the potential to overwhelm and potentially crash a network or unduly impair the Internet experience for a majority of users.*

The Internet remains a powerful medium for the transmission of data from user to user. Yet due to the advent of broadband Internet access, the rise in data traffic, and the increasing complexity of online services and applications, the original perceptions associated with the network are shifting. The network is now a critical enabler of continued innovation at its edges. But for robust and reliable broadband connections, consumers would not be able to enjoy the cutting-edge innovations described above and in the companion papers to this study. Indeed, innovation and creativity would likely be stifled if networks became too congested to be useful to consumers or valuable to content and service providers.

3. TURNING POINT: POLICY CHALLENGES & THE 21ST-CENTURY BROADBAND MARKET

> *A small number of wireless sensors blanket the house of a senior citizen, monitoring her movements in a real-timer manner and uploading data wirelessly to a server that is accessible by her family and primary care givers. If the sensors detect an anomaly – a disruption in her movement, e.g., a fall or the inability to get out of bed – an alert is sent over the network to her primary care giver, to her family and, potentially, to emergency medical personnel. However, at the moment when this alert is about to be sent, a small contingent of users on the same broadband network are busy downloading full-length high-definition movies via a peer-to-peer file transfer network.*

High-definition video transfer and other data-intensive applications require tremendous amounts of bandwidth and have, on occasion, caused networks to crash or slow considerably in order to accommodate the large amount of traffic their actions produce. Under the traditional view of the network, each of these data packets – those associated with the movies being downloaded and those associated with the emergency alert regarding the senior citizen – has the same inherent value. In other words, each set of data is assigned the same level of priority when flowing over the network even though those associated with the movies may crash the network and delay the transmission of the emergency alert.

This type of situation, while rare, was nothing more than a hypothetical occurrence only a few years ago. Innovation at the network level and at its edges has facilitated the development, deployment, and adoption of a growing number of broadband-enabled services like real-time health monitoring and the rapid downloading or streaming of video. The original perception of the network as a "dumb" conduit is thus challenged by these new uses. *Of particular importance is the ability of the network owner to manage the increased traffic flowing over its network in order to provide all its customers with a consistent, reliable connection – and to insure, as needed, that traffic like real-time voice communications or real-time health monitoring is not degraded.*

Some would argue that the ability to manage a network should be regulated even though such might degrade the quality of service for all users or crash a network outright and thus jeopardize the transmission of emergency communications. The debate, then, is about whether 20th-century notions of the network ought to still apply in a 21st-cenutry market. As discussed in this section, policy makers should adhere to pro-competitive tenets when carefully considering whether new regulations are needed for the broadband market. Enacting laws or implementing policies that restrict the ability of stakeholders to innovate will decrease the value of broadband for all users. Most critically, such policies would likely have a disproportionate impact on the services and users described in the papers accompanying this study.

3.1 Calls to Regulate Broadband & the Internet Must be Resisted

Internet use and broadband deployment have surged in the United States because of the government's pro-investment policies. This approach must not be reversed. However, a variety of proposals have been put forward to regulate the broadband sector under the guise of making the physical infrastructure more "neutral" to the data flowing over it.

An increase in adoption and use of broadband over the last several years has resulted in a rise in the amount of content flowing through the network. While most use the Internet for emailing, reading the news, etc., a much smaller yet more avid contingent of consumers use their connections to upload and download huge amounts of information, ranging from full-length movies to entire music libraries. *It has been estimated that, at any one time, only five percent of users consume nearly 90 percent of available bandwidth.*[53] These extreme users can damage a network if it crashes or is clogged with traffic, thus raising the cost of Internet access for all customers.

Net neutrality proposals center on limiting the ability of network owners to manage the content that flows over their infrastructure, thus curtailing their power to ensure that all users, from the average senior citizen checking health information online to the college student downloading movies in her dorm room, have the same ability to enjoy the Internet. But, with more and more data migrating online, including telephone service

and video, the amount of bandwidth needed to seamlessly transport these and other services will increase exponentially.[54] *As a result, imposing regulations that limit the ability of a network owner to manage their network would have three negative impacts on consumers in the broadband market*.

First, the adoption of regulation aimed at network owners would hinder the market forces that have driven the development and deployment of advanced broadband infrastructure across the country. Competition in the sector has spurred broadband providers to upgrade their networks to provide users with faster, more reliable service. Upgrading is continuing. Network owners have taken the financial risk of investing hundreds of billions of dollars in their infrastructure based on almost a decade's worth of policy decisions that have determined that limited government intervention is the best way to spur broadband growth.

Altering the pro-competitive framework by adopting network regulation could chill these deployment efforts and ultimately lead to welfare losses for all consumers. For example, the price of broadband could increase if regulatory compliance costs are passed on to the consumer. Moreover, companies might decide to limit investments in network upgrades because of the prospect of having to redesign their networks to comply with future regulations. The dynamic nature of the Internet requires providers to have the flexibility to respond to market demands without fearing that their engineering choices will be subject to second-guessing or censure by the government.

Second, regulation that chills investment and innovation at the network level would trickle down to the application level, depriving consumers of new services. Network upgrades and innovations spur application and content developers to develop new services. If developers of broadband-enabled applications face a stagnant broadband sector, then they, too, will have little incentive to innovate. Innovative bandwidth-intensive applications that provide lifesaving services (e.g., telemedicine) will only be developed and deployed if advanced network infrastructure is in place. Moreover, at-risk users like seniors and people with special needs can only adopt these services if broadband connections are readily available. *Network regulation would serve only to slow innovation and discourage continued network deployment by increasing regulatory uncertainty and decreasing financial incentives to deploy advanced infrastructure.*

Third, regulations that impair network management and data prioritization would ignore the realities of the network. Network management and data prioritization are necessary practices employed daily by network owners (see Snapshot 5). The idea that network owners should be precluded from offering customers prioritized data fails to take into account current techniques used to alleviate congestion on networks. E911 VoIP calls, for example, are usually given priority over regular calls in order to overcome issues like "jitter." Jitter refers to a "variation in the delay of received packets. At the sending side, packets are sent in a continuous stream with the packets spaced evenly apart. Due to network congestion, improper queuing, or configuration errors, this steady stream can become lumpy, or the delay between each packet can vary instead of remaining constant."[55] Jitter can degrade the service of real-time services like VoIP and health monitoring.

SNAPSHOT 5
The Scope of Network Management

Network management allows network owners to:

- Improve network performance for all users.
- Manage network congestion.
- Prevent jitter and latency, which degrade real-time services.
- Identify opportunities for optimizing network performance (e.g., working with P2P providers to increase transmission speeds).
- Ensure that emergency and potentially lifesaving data packets are safely and rapidly transmitted.

Similarly, bandwidth-intensive, real-time applications like streaming video are often given priority over less time-sensitive applications like e-mail[56] in order to preclude "latency". Latency is a measure of how fast a network is running[57] and occurs when too much traffic congests the network, thus slowing speeds for all users.[58] These and other network management decisions are reflective of end-user demand and, in the case of e911 and other calls, of public policy. *An inefficiently managed network, which would likely result if network owners were not allowed to decongest traffic, would jeopardize the quality of service for all consumers and undermine the efficacy of emergency services.*

For those who seek more capacity, the market has been responsive. More active users, like gamers, have the option of purchasing more capacity to suit their needs while more casual users, such as those who use the Internet just for email, have the option of purchasing a baseline plan at prices so low they were unimaginable a few years ago. These types of offerings reflect a healthy market that is considerate of diverse consumer demand.

3.2 *Enhancing Pro-Competitive and Pro-Investment Policies in the Broadband Market*

The four companion papers being issued in this study highlight the profound and life-altering impacts of broadband on senior citizens, telemedicine, people with special needs, and education. In addition to broadband being a critical and necessary tool for each segment and industry, a common theme among the papers is the importance of government implementing pro-investment policies that promote the deployment of advanced broadband networks to every corner of the country and that bolster efforts to increase the use and adoption of broadband. While each paper identifies a number of sector-specific guiding principles for ensuring that all U.S. consumers have access to broadband and broadband-enabled tools, there are a number of meaningful, overarching policy tools that policy makers should pursue:

- *Government funding allocated to support the broadband industry via an economic stimulus package should be carefully targeted and deliberately disbursed.* Should a portion of a larger stimulus package be earmarked for use in spurring broadband network deployment,[59] funding could be allotted via a number of effective vehicles in order to create a spectrum of incentives for a wide variety of stakeholders. For example, tax breaks could be provided to network owners that deploy advanced infrastructure to unserved areas. In addition, funding could support grants to training programs, community centers, and similar efforts that provide users with computer and broadband access.
- *A full embrace of public-private partnerships will ensure that broadband deployment and adoption efforts are targeted at the most local levels.* A number of public-private approaches – e.g., Connected Nation – have succeeded in devising local and statewide deployment strategies that provide network owners and consumers with incentives to build out and adopt broadband. Federal support of these types of endeavors would enhance their effectiveness at the state level. Support should also be provided to ensure that new federal measures regarding broadband data collection are successful in identifying those parts of the country that are most in need.[60]
- *Rational reform of the Universal Service Fund ("USF") could support federal efforts to spur broadband deployment and could provide critical support in bringing broadband to unserved rural areas.* The USF was created to ensure that all Americans had telephone service. Recent discussions regarding USF reform have centered on recasting its mission to support broadband deployment to unserved areas.[61] Rational reform of the fund that shifts its focus to supporting the deployment of

broadband and advanced wireless networks to unserved areas could supplement other federal efforts to spur network build out.

- *Government efforts should be considerate of the high levels of healthy intermodal competition in the marketplace and policies should thus be tailored that do not threaten to chill these organic efforts.* As discussed in the previous section, there are a number of areas in the broadband sector where the government should not act. Organic competition among a diverse array of broadband providers has increased consumer choice, increased availability, and decreased prices. Going forward, government policies should seek to further these gains by implementing pro-competitive and pro-investment policies.

4. CONCLUSION

The regulatory certainty that has prevailed in the broadband market over the last decade has recently been put in doubt. While the FCC, in theory, provides network owners with the freedom to implement "reasonable network management" methods,[62] in practice it is unclear whether and to what extent they can manage the information flowing over their networks.[63] As discussed above, innovation across the entire broadband sector depends on the availability of advanced network infrastructure. The deployment of such has been "reasonable and timely" to date and has been driven by a regulatory paradigm that allows stakeholders to innovate without the threat of unnecessary government intervention.[64]

In addition, the FCC has adopted four principles "to encourage broadband deployment to encourage broadband deployment and preserve and promote the open and interconnected nature of public Internet: (1) consumers are entitled to access the lawful Internet content of their choice; (2) consumers are entitled to run applications and services of their choice, subject to the needs of law enforcement; (3) consumers are entitled to connect their choice of legal devices that do not harm the network; and (4) consumers are entitled to competition among network providers, application and service providers, and content providers."[65] These principles are working to promote widespread broadband deployment, adoption, and consumer choice. In the context of the dynamic and highly innovative broadband sector, efforts to curtail the ability of network engineers to efficiently manage their networks in real time will harm consumers and hinder innovation. The judgment of network engineers and of consumers should not be replaced with a one-size-fits-all policy.

Each of the four companion papers to this study assesses the impacts of broadband on a discrete segment of the market. Broadband has already had an enormous impact on senior citizens and people with special needs by providing them with an interactive

outlet for realizing economic, social, and healthcare gains. Similarly, broadband has facilitated the development and deployment of a wide range of telemedicine and distance learning services that are currently being used to drive down health care costs, increase access to educational opportunities, and otherwise enhance personal well-being. Broadband is poised to play an even more indispensable role in the lives of seniors and people with special needs and in the further development and adoption of telemedicine and distance learning services. But long-term success for each relies on the present actions of policy makers.

Cutting-edge innovations in the telemedicine and distance learning industries rely on stable and reliable broadband connections. In the case of telemedicine, for example, real-time health monitoring services are increasingly popular among older users and could well become the norm for a large percentage of patients. These services can only be effective if their broadband connection is free of congestion. Similarly, the sophistication of distance learning services runs parallel to the bandwidth of their broadband connections.

Without the ability to design and implement network-specific protocols for the management of traffic, network owners will be limited in their ability to manage traffic, ensure reliability, and otherwise provide consumers with the optimal user experience. Without the availability of robust and reliable broadband infrastructure, innovation at the edges will slow. Without optimal innovation at the edges, the availability of services to seniors, people with special needs, those wishing to decrease the cost of healthcare by using telemedicine services or those wanting to enhance their education remotely will be jeopardized.

It is thus incumbent upon policy makers and all stakeholders to realize that the broadband market is operating efficiently and providing consumers with an array of life-enhancing welfare gains. Regulation of the network is unnecessary and, if imposed, would serve only to halt the many advances described in the accompanying papers. When policy makers ask whether the value of imposing regulation outweighs the many benefits described herein, it should be clear that less regulation, not more, is the key to enabling further innovation across the entire broadband sector.

ENDNOTES

[1] *See, e.g.,* Robert W. Crandall, Competition and Chaos: U.S. Telecommunications Policy Since the 1996 Telecom Act, p. 110 (Brookings Inst. Press 2005).

[2] *See In the Matter of Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996*, First Report, CC Docket No. 98-146, para. 2 (rel. Feb. 2, 1999).

[3] *See,* John Horrigan, *Home Broadband Adoption 2008*, Pew Internet & American Life Project, at p. 2 (July 2008), *available at* http://www.pewinternet.org/pdfs/PIP_Broadband_2008.pdf ("*Home Broadband Adoption 2008*").

[4] *See Statement of Jonathan Banks to the Subcommittee on Telecommunications and the Internet, Committee on Energy and Commerce, U.S. House of Representatives*, p. 2, July 22, 2008, *available at* http://energycommerce.house.gov/images/stories/Documents/Hearings/PDF/Testimony/TI/110-ti-hrg.072208.Banks-testimony.pdf (quoting a projection made by Yankee Group).

[5] *See, e.g.,* FCC, *Connecting the Globe: A Regulator's Guide to Building a Global Information Community*, at Section IX, (June 1999), available at http://www.fcc.gov/connectglobe/sec9.html.

[6] Since 2000, spending on services in support of broadband network infrastructure equipment has totaled nearly $100 billion. It is estimated that spending will top $18 billion in 2008, up from just $3.2 billion in 2000. *See Networked Nation: Broadband in America 2007*, p. 33, Report of the National Telecommunications and Information Administration (Jan. 2008), *available at* http://www.ntia.doc.gov/reports/2008/NetworkedNationBroadbandinAmerica2007.pdf.

[7] 47 U.S.C. 230(b)(2).

[8] *See, e.g., In the Matter of Appropriate Regulatory Treatment for Broadband Access to the Internet Over Wireless Networks*, para. 2, 22 F.C.C.R. 5901 (2007) ("*Wireless Broadband Order*").

[9] *Id.*

[10] The primary tool that the Commission has used to facilitate continued innovation and build out has been the classification of broadband transmission technologies as "information services" an approach that has created a "consistent regulatory framework across broadband platforms by regulating like services in [a] similar manner." *Wireless Broadband Order*. According to the Communications Act, an "information service" is defined as "the offering of a capability for generating, acquiring, storing, transforming, processing, retrieving, utilizing, or making available information via telecommunications, and includes electronic publishing, but does not include any use of any such capability for the management, control, or operation of a telecommunications system or the management of a telecommunications service." 47 U.S.C. 153 (20). Classifying a technology as an "information service" exempts it from common carrier regulation and places it under the FCC's Title I ancillary jurisdiction. *See Nat'l Cable & Telecomm. Ass'n v. Brand X Internet Serv.*, 545 U.S. 967, 968-969 (2005) (upholding the FCC's classification of broadband cable modem service as an "information service"). Over the past few years, the FCC has classified broadband cable modem service, *Id.*, DSL broadband service, *In the Matter of Appropriate Framework for Broadband Access to the Internet over Wireline Facilities*, CC Docket No. 02-33, Report and Order and Notice of Proposed Rulemaking (rel. Sept. 23, 2005), broadband over power lines, *Classification of Broadband Over Power Line Internet Access Service as an Information Service*, 21 F.C.C.R. 13281 (2006), and wireless broadband, *Wireless Broadband Order*, as "information services."

[11] Sources for material in the box on the 1996 Act are: Thomas Hazlett, Coleman Bazelon, John Rutledge & Deborah Allen Hewitt, *Sending the Right Signals: Promoting Competition Through Commerce*, Report of the U.S. Chamber of Commerce (Oct. 2004), *available at*

http://www.uschamber.com/NR/rdonlyres/ewsytfmufpiofdr3r753gtgufvfe7dm7ma4gjz73wwwuwpym3uyxyh3gmtvjzvgxwkqmuyq6tkycnbwn7i7liwbdsbd/0410_telecommstudy.pdf; Stephen B. Pociask, *The Effects of Bargain Wholesale Prices on Local Telephone Competition: Does Helping Competitors Help Consumers?* Joint Study of the New Millennium Research Council & the Competitive Enterprise Institute (June 2003), *available at* http://www.newmillenniumresearch.org/archive/wholesalereport061603.pdf; Stephen B. Pociask, A Failure to Communicate Reforming Public Policy in the Telecommunications Industry (Econ. Policy Inst. 2004).

[12] In the year ending June 2008, wireless carriers invested $21 billion in capital expenditures. *See* CTIA – The Wireless Association, Wireless Quick Facts (Mid-year Figures), http://www.ctia.org/advocacy/research/index.cfm/AID/10323.

[13] *See, e.g.*, Debora L. Spar, Ruling the Waves: From the Compass to the Internet, a History of Business and Politics along the Technological Frontier, p. 258 (2001); Lawrence Lessig, The Future of Ideas, p. 36-41 (2001); Jonathan E. Nuechterlein & Philip J. Weiser, Digital Crossroads: American Telecommunications Policy in the Internet Age, p. 103-131 (2005) ("*Digital Crossroads*"); Jonathan Zittrain, The Future of the Internet, p. 31-32 (2008) ("*Future of the Internet*").

[14] However, up until the early part of the 1990s, many of these stakeholders were funded by various arms of the federal government (e.g., the Defense Department and the National Science Foundation). The Internet was formally privatized in the early 1990s. *Digital Crossroads* at p. 130-131.

[15] *See High-Speed Services for Internet Access: Status as of June 30, 2007,* FCC Wireless Competition Bureau Report, Table 10.

[16] *See* FCC, *In the Matter of Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, Fifth Report, FCC 08-88* (rel. June 12, 2008), para. 35 ("*5th 706 Report*").

[17] *Id*. ("The percent of zip codes reporting four or more providers of high-speed lines also has increased, from 46.3 percent in December 2003 to 88.5 percent in June 2007.").

[18] Prices have dropped four percent since 2005, *Home Broadband Adoption 2008* at p. 7.

[19] *See High-Speed Services for Internet Access: Status as of June 30, 2007,* FCC Wireless Competition Bureau Report, Table 7.

[20] *See* Nielsen Mobile, *Critical Mass: The Worldwide State of the Mobile Web*, p. 3 (July 2008), *available at* http://www.nielsenmobile.com/documents/CriticalMass.pdf.

[21] It was recently reported that a growing number of lower income mobile users have turned to the iPhone as a primary Internet and entertainment device. *See* Press Release, *In Tough Economy, Lower Income Mobile Consumers Turn to iPhone as Internet & Entertainment Device*, Oct. 27, 2008, COMSCORE, *available at* http://www.comscore.com/press/release.asp?press=2545.

[22] *Digital Crossroads* at p. 130.

[23] *See* Andrew Odlyzko, *The Current State and Likely Evolution of the Internet*, p. 2, PROC. GLOBECOM'99, IEEE (1999), *available at* http://www.dtc.umn.edu/~odlyzko/doc/globecom99.pdf.

[24] *Id.*

[25] *See* Robert M. McDowell, *Who Should Solve This Internet Crisis?*, WASH. POST, July 28, 2008 (noting that the "Internet has flourished because it has operated under the principle that engineers, not politicians or bureaucrats, should solve engineering problems") ("*Who Should Solve*").

[26] *See* Andrew Odlyzko, *Internet Growth: Myth and Reality, Use and Abuse*, p. 1, iMP: INFORMATION IMPACTS MAGAZINE, Nov. 2000 (pre-print), *available at* http://www.dtc.umn.edu/~odlyzko/doc/internet.growth.myth.pdf.

[27] *See* Bret Swanson & George Gilder, *Estimating the Exaflood*, p. 4, Discovery Institute (Jan. 2008), *available at* http://www.discovery.org/scripts/viewDB/filesDB-download.php?command=download&id=1475 ("*Exaflood*").

[28] A peer-to-peer ("P2P") network "uses diverse connectivity between participants in a network and the cumulative bandwidth of network participants rather than conventional centralized resources where a relatively low number of servers provide the core value to a service or application." *See* Wikipedia: Peer-to-Peer, http://en.wikipedia.org/wiki/Peer-to-peer. In other words, a P2P network is a decentralized way of sharing files among groups of end-users and differs substantially from the traditional, centralized system of data transfer. Under a centralized system, each user downloads a file from the same source (e.g., a website), where under a P2P system, users download bits and pieces of a file from a number of end users.

[29] Streaming media allows an end user to enjoy content "live" by transmitting content in real time. Popular streaming media sites include You Tube (for videos) and Pandora (for music). The more traditional (but increasingly unpopular) method for viewing such content is by downloading the entire media file first and then viewing it.

[30] *See* Press Release, *YouTube Draws 5 Billion U.S. Online Video Views in July 2008,* COMSCORE, Sept. 10, 2008, available at http://www.comscore.com/press/release.asp?press=2444 ("*July 2008 Video Data*").

[31] *See* Press Release, *U.S. Internet Users Viewed 10 Billion Videos Online in Record-Breaking Month of December,* COMSCORE, Feb. 8, 2008, *available at* http://www.comscore.com/press/release.asp?press=2051.

[32] *July 2008 Video Data.*

[33] *See* FCC Commissioner Robert M. McDowell, *Text of Luncheon Address at the Broadband Policy Summit III,* at 13, June 7, 2007, *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-273742A1.pdf ("*McDowell Speech*").

[34] *Exaflood* at p. 4.

[35] *See* Press Release, *comScore and Media Contacts Study Highlights Behavioral Differences Among Online Video Viewer Segments*, COMSCORE, Feb. 14, 2008, *available at* http://www.comscore.com/press/release.asp?press=2063.

[36] *McDowell Speech* at p. 13.

[37] *See* Amy Schatz, Dionne Searcey & Vishesh Kumar, *Officials Step up Net-Neutrality Efforts*, WALL ST. J., Feb. 13, 2008.

[38] *Id.*

[39] *See* John F. Gantz et al., *The Diverse and Exploding Digital Universe*: *An Updated Forecast of Worldwide Information Growth Through 2011,* p. 3, White Paper of IDC (Mar. 2008), *available at* http://www.emc.com/collateral/analyst-reports/diverse-exploding-digital-universe.pdf.

[40] Verizon will invest upwards of $18 billion over the next few years to deploy FiOS throughout its service territory. *See* Peter Grant and Dionne Searcey, *Verizon's FiOS Challenges Cable's Clout*, WALL. ST. J., Oct. 24, 2007; *see also* Wikipedia: Verizon FiOS, http://en.wikipedia.org/wiki/Verizon_FiOS.

[41] AT&T will have spent approximately $5 billion by the end of 2008 to deploy U-Verse. *See* Todd Spangler, *AT&T Ups U-verse Spending Estimates by $500 Million,* MULTICHANNEL NEWS, Nov. 6, 2007,

available at http://www.multichannel.com/article/CA6497700.html; *see also* Wikipedia, U-Verse, http://en.wikipedia.org/wiki/U-verse.

[42] *See* Bob Wallace, *Comcast Details its First DOCSIS 3.0 Deployment*, XCHANGE, April 4, 2008, *available at* http://www.xchangemag.com/hotnews/comcast-details-its-first-docsis-3-0-deployme.html.

[43] *See* Tricia Duryee, *3G Adoption in the U.S. Exceeds Western Europe: Report*, WASH. POST, Sept. 4, 2008, *available at* http://www.washingtonpost.com/wp-dyn/content/article/2008/09/04/AR2008090400776.html.

[44] *See* Press Release, *T-Mobile USA Begins Commercial 3G Network Rollout*, T-MOBILE, May 5, 2008, *available at* http://www.t-mobile.com/company/PressReleases_Article.aspx?assetName=Prs_Prs_20080505&title=T-Mobile%20USA%20Begins%20Commercial%203G%20Network%20Rollout.

[45] *See* Cliff Edwards, *Putting WiMAX on the Fast Track,* BUSINESS WEEK, May 7, 2008, *available at* http://www.businessweek.com/technology/content/may2008/tc2008057_480955.htm.

[46] *See* W. David Gardner, *AT&T Plans Fast 4G Wireless Rollout*, INFORMATION WEEK, April 4, 2008, *available at* http://www.informationweek.com/news/mobility/3G/showArticle.jhtml?articleID=207001878; Press Release, *Verizon Selects LTE as 4G Wireless Broadband Direction*, VERIZON WIRELESS, Nov. 29, 2007, *available at* http://news.vzw.com/news/2007/11/pr2007-11-29.html.

[47] This perception stemmed from the "end-to-end" argument, which was originally conceived by a team of network engineers. *See* Jerome H. Saltzer, David Clark & David Reed, *End-to-End Arguments in System Design,* in Integrated Broadband Networks (Amit Bhargava, ed.) (Artech House 1991). Under the end-to-end conception, complexity is pushed to the edge of the network, relegating the "core" or physical network as a "dumb" conduit, much like the traditional telephone system. *See, e.g.,* Lawrence Lessig, Code, Version 2.0, p. 44 (2006).

[48] *Future of the Internet* at p. 164.

[49] Indeed, the company's stated goal is to "organize the world's information and make it universally accessible and useful." *See* Google, Company Overview, http://www.google.com/intl/en/corporate/; *see also* Randall Stross, Planet Google: One Company's Audacious Plan to Organize Everything we Know 21-22 (2008) (noting that "information is a commercially valuable asset, to be hoarded, not shared" and that "Google's search engine needs access to the entire Internet, not merely the patches that remain outside the walled gardens of social networking sites. The company's very existence depends upon advocates of an open online environment holding at bay the threat of encroachment by their opponents.").

[50] *See, e.g.,* John Battelle, The Search: How Google and its Rivals Rewrote the Rules of Business and Transformed our Culture 22 (2005) (describing Google's Page Rank algorithm: "it looks at the links on a page, the anchor text around those links, and the popularity of the pages that link to another page and factors them together to determine the ultimate relevance of a particular page to [a user's] query.").

[51] *See* Akamai, About, http://www.akamai.com/html/about/index.html; *see also The State of the Internet*, p. 4, Vol. 1, No. 1, Akamai (1st Quarter 2008).

[52] This argument has been made by numerous commentators. A brief bibliography of some of the more thoughtful academic pieces includes *Future of the Internet;* Tim Wu, *Network Neutrality, Broadband Discrimination*, 2 J. Telecomm. & High Tech. L. 141(2003); Mark Lemley & Lawrence Lessig, *The End of End-to-End: Preserving the Architecture of the Internet in the Broadband Era*, 48 UCLA L. Rev. 925 (2001).

[53] *Who Should Solve.*

[54] *Exaflood* at p. 4.

[55] *See Understanding Jitter in Packet Voice Networks,* p. 1-2, Cisco, Document ID: 18902 (Feb. 2006), *available at* http://www.cisco.com/application/pdf/paws/18902/jitter_packet_voice.pdf;

[56] *See, e.g.*, Microsoft, Web Server vs. Streaming Server, http://www.microsoft.com/windows/windowsmedia/compare/webservvstreamserv.aspx (explaining how data sent via a streaming server is given priority over data sent via a web server).

[57] *See* Javvin, Network Latency, http://www.javvin.com/etraffic/network-latency.html.

[58] *See* About.com, Latency in Networking, http://compnetworking.about.com/od/speedtests/a/network_latency.htm.

[59] *See* Cecilia Kang, *For the Web, Change All Sides Can Believe In*, WASH. POST, Dec. 17, 2008, *available at* http://www.washingtonpost.com/wp-dyn/content/article/2008/12/16/AR2008121602930.html.

[60] A Broadband Data Collection law was enacted in October 2008. This law "requires Internet service providers to give the FCC more detailed reports so the FCC can identify the actual numbers of broadband connections by customer type and geographic area." *See* Stephanie Condon, *President Signs Broadband Data Collection Bill*, Oct. 10, 2008, CNET NEWS.COM, *available at* http://news.cnet.com/8301-13578_3-10063734-38.html.

[61] *See, e.g., Federal-State Joint Board on Universal Service*, Recommended Decision, FCC 07J-4, WC Docket No. 05-337, CC Docket No. 96-45 (rel. Nov. 20, 2007).

[62] *See* FCC, *In re Appropriate Framework for Broadband Access to the Internet over Wireline Facilities*, Policy Statement, fn. 15, 20 FCC Rcd. 14986 (2005) ("*Broadband Policy Statement*").

[63] The FCC recently ruled that Comcast's network management practices vis-à-vis peer-to-peer traffic were not reasonable. *See* FCC, *Memorandum Opinion & Order from the FCC, In the Matters of Formal Complaint of Free Press and Public Knowledge Against Comcast Corporation for Secretly Degrading Peer-to-Peer Applications and Broadband Industry Practices Petition of Free Press et al. for Declaratory Ruling that Degrading an Internet Application Violates the FCC's Internet Policy Statement and Does Not Meet an Exception for "Reasonable Network Management,"* WC Docket No. 07-52, FCC 08-183 (rel. Aug. 20, 2008), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-08-183A1.pdf.

[64] *5th 706 Report* at para. 59.

[65] *Broadband Policy Statement.*

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