Before the Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Preserving the Open Internet	)	GN Docket No. 09-191
	)	
Broadband Industry Practices	)	WC Docket No. 07-52

Reply Comments of Bret T. Swanson[1]

The network of networks known as the Internet is growing in power, vibrancy, complexity, and openness. So is the content flowing through it. The Internet has grown so fast, in part, because of the simple (and few) rules that govern the space.

The technologies that power the Net are exacting – yet flexible enough to accommodate new networks and new content. The Net has always evolved, rarely in predictable fashion. This suggests simple principles, not complex new rules. It suggests cooperative creativity across the Internet ecosystem, not a centralized bureaucratic regime in a fundamentally unbureaucratic realm.

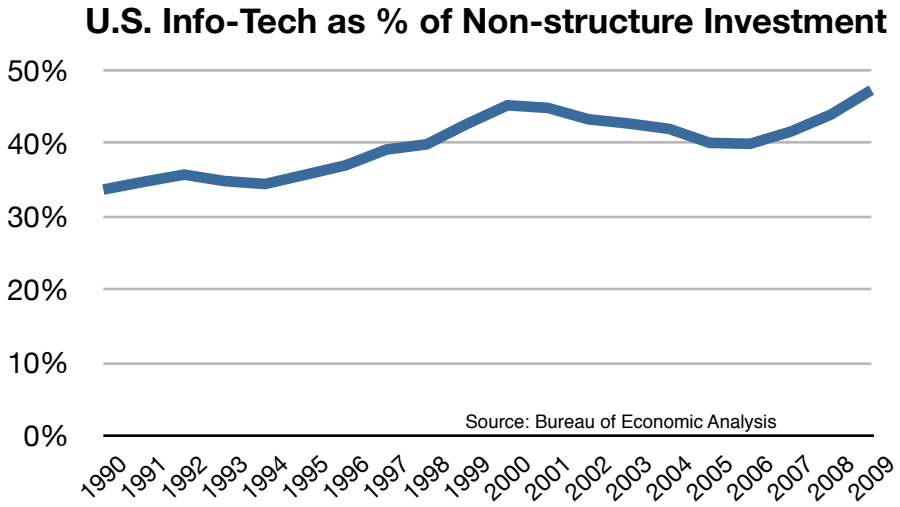
The most important considerations in this proceeding are maintaining incentives for innovation and investment. Because innovation and investment propel and expand the Net into new geographic, virtual, and economic arenas, bringing an ever wider array of people, businesses, content, and and devices onto this common global platform, these goals are also the keys to achieving the objective of this proceeding – preserving the Internet's openness.

Having predicted in 2004 that Net Neutrality would become the next great Internet policy debate, and having followed and participated in this discussion every step of the way since, I submit these comments as a summary of the facts and arguments I find most important and compelling. The topics I will address are investment in communications networks; the state of the U.S. Internet ecosystem; innovation; capital expenditures and jobs; wireless; the definition of "discrimination"; the economics of Net Neutrality; the lack of any empirical data or facts to support an intrusive *ex ante* regulatory regime; and a growing consensus pointing toward cooperation among industry players and a focus on potential consumer harm rather than a proscriptive "nondiscrimination" rule.

Investment

In the last five years (2005-09), U.S. companies invested $576 billion in communications equipment and structures. Adding computers and software, U.S. capital expenditures on

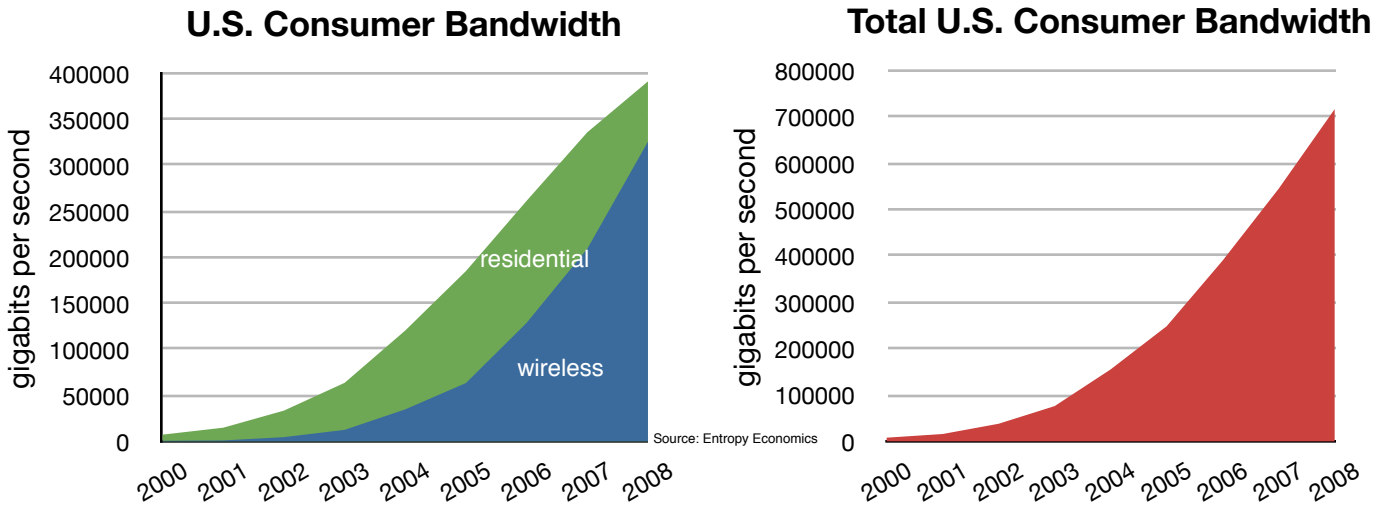
information technologies (ICT) since 2005 totaled $2.2 trillion. Today, info-tech investment accounts for a record 47.3% of all U.S. non-structure capital investment (see chart).

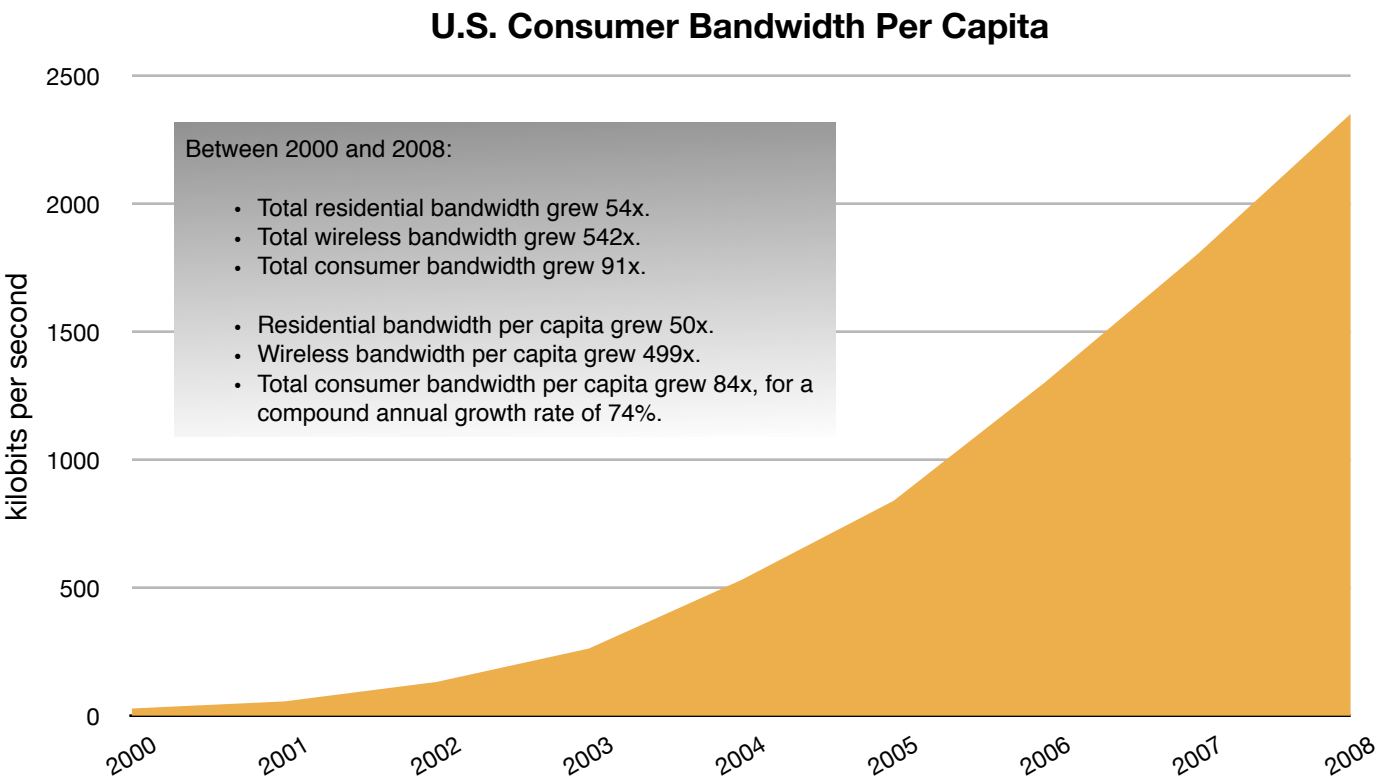


Updating a previous study from last decade that estimated investment levels if harmful regulations were relaxed, economists Robert Crandall and Hal Singer counted large investments in specific broadband technologies – far more investment than their previous paper projected. They found actual annualized investment from 2003 to 2009 was[2]:

- $4.3 billion in cable modem networks;
- $11.7 billion in DSL and fiber optic networks;
- $11.6 billion in 3G wireless and satellite technologies.

The deployment of these new networks yielded a bandwidth boom. We estimate that between 2000 and 2008, total U.S. consumer bandwidth grew from just 7.9 terabits per second to 717 terabits per second.[3] On a per capita basis, consumer bandwidth grew to almost 3 megabits per second in 2009 from just 28 kilobits per second in 2000.





Innovation

This bandwidth boom, combined with the creativity of thousands of technologists and content creators led to a flurry of activity across the broadband network and content landscape.

As we wrote in *The Wall Street Journal* in October 2009:

> In 2004, Wi-Fi was embryonic, the Motorola Razr was the hot phone, the BlackBerry was a CEO's email device, and Apple's most recognizable product was an orange-sicle laptop. But then the industry turned upside-down in a flurry of dynamism. Both Motorola and Palm plummeted in popularity and only now are attempting real comebacks. BlackBerry and Apple vaulted to smart-phone supremacy from out of nowhere, Nokia became the world's largest camera company, and a new wireless reading device rekindled Amazon's fortunes.
>
> Wireless carriers invested $100 billion in just the past three years, and the U.S. vaulted past Europe in fast 3G mobile networks. Americans enjoy mobile voice prices 60% cheaper than foreign peers. And the once closed mobile ecosystem is more open, modular and dynamic than ever.
>
> All this occurred without net neutrality regulation.

> My research suggests that U.S. Internet traffic will continue to rise 50% annually through 2015. Cisco estimates wireless data traffic will rise 131% per year through 2013. Hundreds of billions of dollars in fiber optics, data centers, and fourth-generation mobile networks will be needed. But if network service providers can't design their own networks, offer creative services, or make fair business transactions with vendors, will they invest these massive sums to meet (and drive) demand?[4]

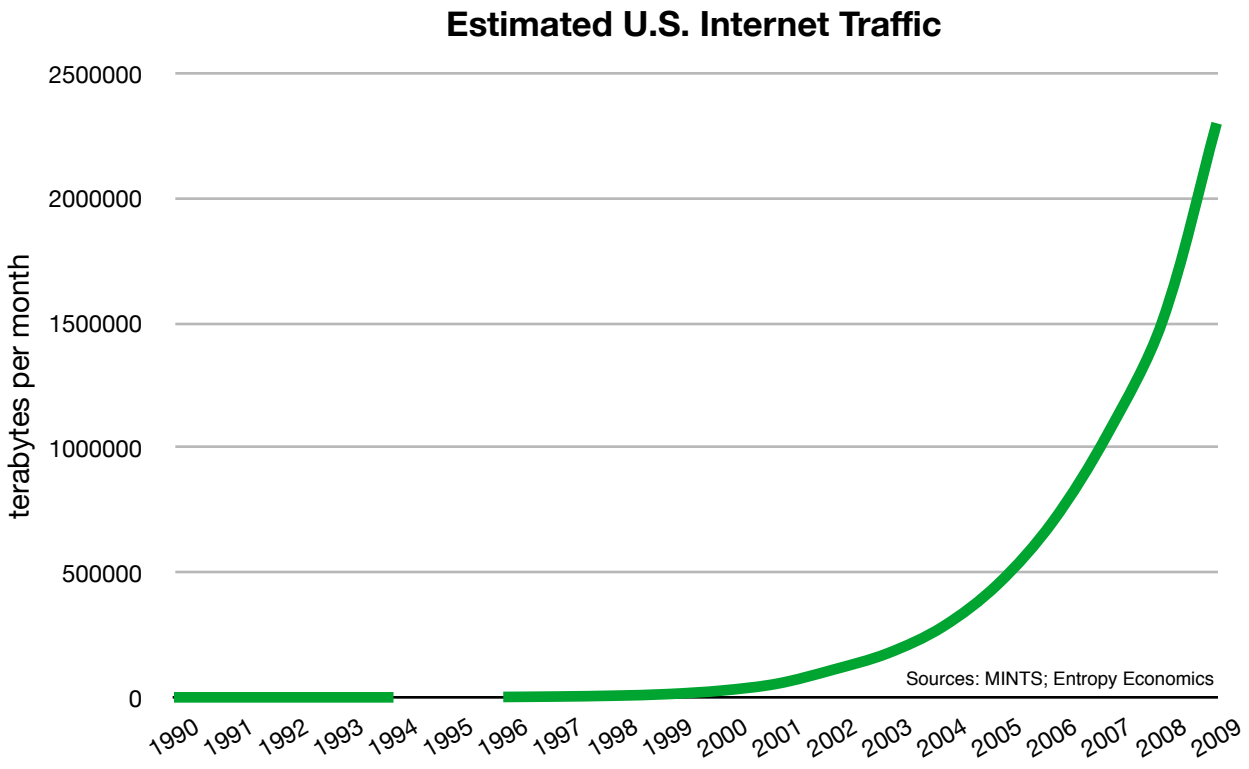
Founded only in 2005, when broadband was just starting to gain critical mass, YouTube now receives uploads to its servers of 24 hours of video . . . *every minute*. That is almost 35,000 hours of video each day. YouTube reports it streams more than one billion videos to users each day. We estimate YouTube streams around seven terabytes every minute. Every *hour*, therefore, YouTube streams nearly the *monthly* traffic of the entire Internet of 1998.

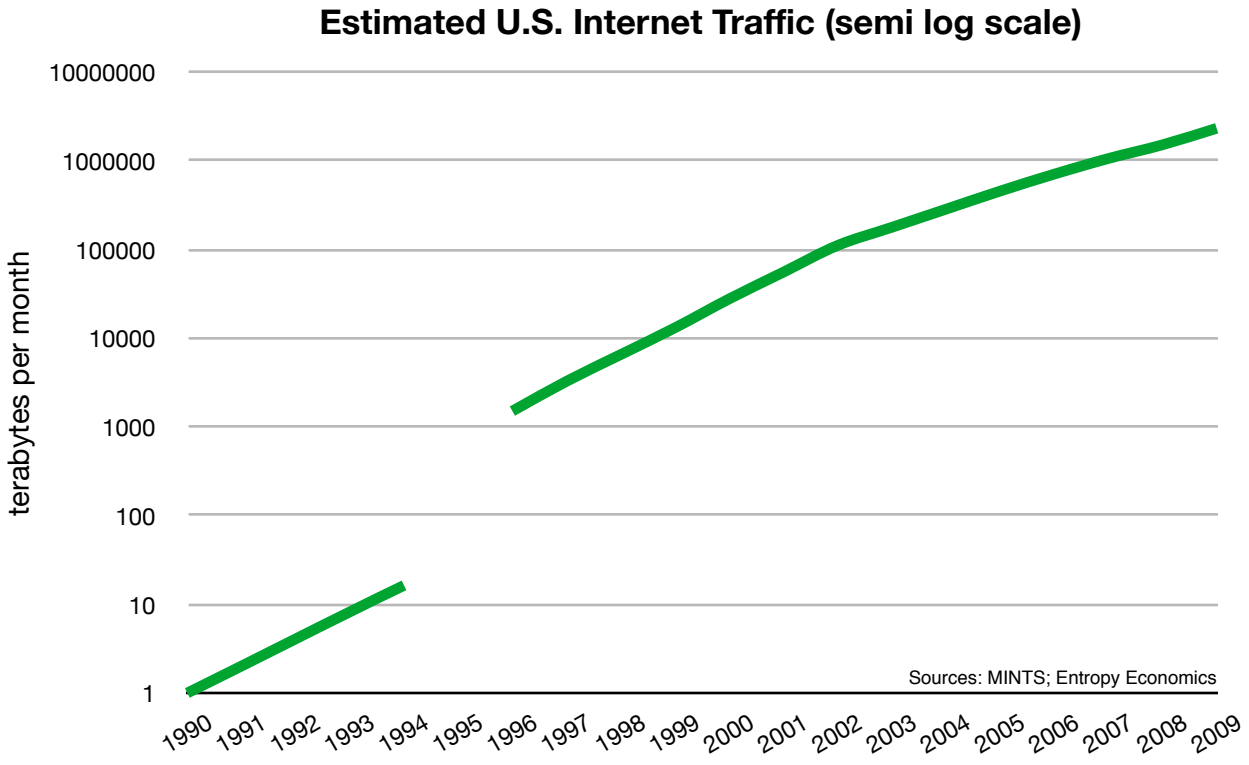
Fast-Changing Web

Internet traffic is growing, and its nature is changing. Once upon a time, almost all traffic was voice calls. Then the Internet came, and simple data entered the mix: Web pages, file transfers, email. But now we are moving far beyond simple data and voice calls to include streamed video, peer-to-peer video, video conferencing, blogs, cloud computing, software-as-a-service, social networks, gaming, virtual worlds, super-high-resolution photos, remote back-up, machine-to-machine communication, wireless texting, mobile video, and many more. The types of data, and the network requirements thus imposed, are proliferating with the number and diversity of applications and network endpoints and channels.

U.S. Internet traffic continues to grow at an annual rate of 50-60%, requiring large capacity increases. But as important as the capacity increases are the technologies and architectures needed to get specific traffic to the right place at the right time. Some data (email) can wait hundreds of milliseconds, or even seconds. Other data (voice calls and real-time video) cannot tolerate more than a tiny fraction of a second. Some data can be stored close to end users. Other real-time and transactional data must travel long distances. Our research suggests Internet traffic will continue to grow at a 50-60% annual rate for at least the next five years. Cisco estimates wireless data traffic will grow faster than 100% per year through 2014.

A new two-year study by Arbor Networks analyzed 264 exabytes of network traffic.[5] Arbor found rapid data traffic growth and fast-changing Web architectures. Streaming Web video now accounts for 52% of Internet traffic, while peer-to-peer (P2P) video, although declining as a percentage of Net traffic, still accounts for perhaps another 30-35%. Content delivery networks like Akamai and Limelight, which cache content closer to end-users to cut latency and improve the consumer experience, now account for 10% of Internet traffic. Google, which runs its own vast networks and data centers, now carries 6% of Internet traffic and has quickly become the third largest network operator on the planet. Arbor found there are “increasingly blurred lines between content, consumer ISP, transit, CDN, etc.” “The Internet is at an inflection point,” and these “[c]hanges mean significant new commercial, security, and engineering challenges.”


Estimated U.S. Internet Traffic
terabytes per month
2500000
2000000
1500000
1000000
500000
0
Sources: MINTS; Entropy Economics
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009


Estimated U.S. Internet Traffic (semi log scale)
terabytes per month
10000000
1000000
100000
10000
1000
100
10
1
Sources: MINTS; Entropy Economics
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009

Exacloud

The rise of multimedia content delivered over the Web is a fundamental departure from the early days of email, data exchange, and simple websites.

We are intrigued by one particular innovation just around the corner. Call it online gaming. Call it cloud streaming. We call it the "exacloud." It is cloud computing but of a scope and scale never seen before. Imagine a supercomputer built not of microprocessors (CPUs) but of thousands of graphics processors (GPUs). The world's most powerful supercomputer is IBM's one-petaflops Roadrunner at Los Alamos National Labs. But in 1% of the space and for 3% of the cost, we can build a graphics supercomputer that delivers three times Roadrunner's performance – three petaflops.

Connect this computer to the Internet, and you can stream any real-time interactive 3D video experience at any resolution to thousands of people using any browser on any device, from a home-theater to an iPhone. This exacloud will transform video games, movies, virtual worlds, business software, and most other media. Piracy goes away. So do DVDs, game boxes, and maybe even expensive personal computers. New content and software subscription models open up. Based in the cloud instead of on your device, interactivity thrives.

This new paradigm generates enormous amounts of Internet traffic. High-definition video requires big bandwidth, and real-time applications tolerate very little delay. UC-San Diego estimates that 55% of total American information consumption, or 1,991 exabytes per year, is (brace yourself) video games.[6] If just 10% of these games moved online, they would generate twice the worldwide Internet traffic of 2008. Video is not always the most important content on the Web, but it defines the architecture and capacity of (and often pays for) the networks, data centers, and software that make all the Web's wonders possible.

Strict Net Neutrality could easily kill this tremendously exciting new cloud streaming paradigm.

The Proposed Rules

In light of the vast evidence of the health, vibrancy, and dynamism of the U.S. broadband market, we next examine some of the particulars of the Commission's NPRM.

We can find no data and no facts in evidence to support the case for Net Neutrality regulation. Only a few arguable anecdotes and some conjecture about what business practices a few companies might or might not engage in in the future.

Many Net Neutrality advocates propose complex (although ever-changing and hard-to-pin-down) rules for a vaguely defined and hypothetical set of problems. This is just the opposite of what we need: simple principles that can be applied to specific violations that cause real consumer harm.

What If?

Depending on the letter of the rules and the spirit of its implementation, a Net Neutrality regime could have prohibited some of the Net's most important recent innovations:

- Content Delivery Networks, which now support around 10% of all Internet traffic[7], might never have appeared or grown so fast had service and content providers been blocked or discouraged from charging for robust performance enhancements. YouTube was just one of many innovations that made fundamental use of CDNs.

- Paid Peering, similar to Content Delivery Networks, enhances performance – at a price. Many content, application, and service providers today use Paid Peering instead of the traditional Tier One Transit services that dominated from the mid-1990s until the mid-2000s.

- The Apple iPhone may never have emerged if we had blocked or discouraged the type of "exclusive," "discriminatory" deals like the one Apple (a new entrant to the mobile market) struck with AT&T. Apple's entry was a move fraught with uncertainty, and the partnership with AT&T allowed both sides to make the investments of time and money necessary to execute a monumental project. The iPhone unleashed wave after wave of innovation in the mobile arena – like "app stores" – thus pushing all competitors at many layers of the wireless value chain towards more dynamism and openness than ever before.

- Quality of Service could have been blocked, thus slowing the Voice over IP and mobile revolutions. Its emerging sibling Quality of Experience will enable a compelling online video experience. But will we ban it before it happens?

It is easy to look back at such important (and, with hindsight, obvious) innovations and insist: *But those were good things. We would never have prohibited or discouraged such practices, technologies, or business models. Our new rules will only block bad things.*

But as the above examples show, it is not so easy in practice to write and implement complex rules to govern a complex environment. Better to stick with simple principles. CDNs, for example, discriminated among bits and applications. They favored the bits of the application providers who paid. But they helped consumers enjoy a faster Web experience and were of great value to the content companies paying for the service. Discrimination? Yes. Harm? No.

It is easy to think of services that will require some measure of helpful network "discrimination": video conferencing, online gaming, high-end business services, real-time health and educational services. Just as important, there will be many applications, devices, and network technologies we have not anticipated. The proposed rules would threaten not only existing network technologies, services, and business practices; not just the crucial new services emerging now; but also the unknown innovations of the future.

Definition of Discrimination

The Commission's proposed rules turn the accepted definition of "discrimination" on its head – in both the legal and economic realms. Perfectly common and acceptable transactions could be banned, while potentially troubling instances of real discrimination would be ignored.

As George Ford and Lawrence Spiwak concluded:

> [T]he FCC's proposed rule permits discriminatory pricing – that is, the FCC permits different prices for exactly the same service offered at the same cost and under the same market conditions. But, the FCC's proposed rule also blocks pricing practices that are non-discriminatory under any established or meaningful standard – specifically, the FCC prohibits different prices for different services. In essence, the FCC has concluded that it is discriminatory if a gallon of water has a different price than a gallon of milk. It is clear that the FCC's proposal is a puzzling implementation of a "non-discrimination" rule in that it has no ties to accepted theories of discrimination.[8]

To prohibit "discrimination" in the technical realm is to completely ignore the fundamental workings of the network itself. Here, many trillions of bits ride on millions of miles of optical fiber and nearly infinite numbers of silicon transistors, whose very job it is to discriminate among data packets, flows, applications, codes, IP addresses, and user access profiles. Data flies through the air over wireless networks where it encounters remorseless resistance from buildings, mountains, trees, moving objects, and electromagnetic and intersymbol interference.[9] Discrimination among signals, noise, applications, cell sites, frequencies, and the correct codes and symbols is paramount. In wireless, especially, the mandate is clear: discriminate or die.

Economics of Net Neutrality

To the extent any economic modeling of Net Neutrality exists, it is sparse, highly theoretical, and equivocal. Although the theoretical work is in its infancy and the empirical work almost non-existent, a group of 21 economists and network experts, including Nobel laureate Vernon Smith, noted in reply comments that even the few theoretical attempts show ambiguous results – except in the one case that should be of most concern to the FCC and other federal agencies: Net Neutrality's potential effect on consumers. "It is remarkable," wrote the economists, "that the only robust result of the Economides and Tåg model – the only result that applies under all parameter values – is that consumers are *always* made worse off by net neutrality regulation."[10] (emphasis in original)

This troubling result follows logically from the Commission's proposed definition of "discrimination," which curiously applies to upstream content, application, and service providers but not to downstream consumers.

Hahn, Litan, and Singer insightfully conclude: "The guiding principle behind a blanket rule proscribing any agreement between as BSP and a content provider is not nondiscrimination in its standard sense, but is instead 'equality of outcome.' Government interventions that foster

equality of *outcome* (rather than equality of *opportunity*) reduce economic efficiency by prohibiting firms and consumers from entering into mutually beneficial agreements."[11] (emphasis in original)

Economists George Ford and Michael Stern make the compelling case that Net Neutrality regulation will *increase* the incentives for monopolization, exclusion, and, I would add, stagnation in the content market.[12] Broadband service providers are not likely to be the best sources of the highly diverse, creative, and risky content across the global Web. They may find niches where they can contribute content or value-added products from within. But the vast majority of content will be provided by end-users, unaffiliated CAS providers around the world, and, in some cases, through partnerships with affiliated CAS providers. A prohibition of the voluntary partnerships that are likely to add so much value to all sides of the market – service provider, content creator, and consumer – would incentivize the service provider to close greater portions of its networks to outside content, acquire more content for internal distribution, create more closely held "managed services" that meet the standards of the government's "exclusions," and build a new generation of larger, more exclusive "walled gardens" than would otherwise be the case. The result would be to frustrate the objective of the proceeding. The result would be a less open Internet.

Most economists find scant evidence of market power. They find no evidence of market failure. They find no empirical evidence that consumers have been harmed. More importantly, *the Commission itself has not found these things*. The Commission alludes to potential market power, failure, or consumer harm but falls far short of marshaling any suggestive evidence, let alone making any such findings.

The Economy and Jobs

Because the Internet is of such increasing importance to the overall economy, these proceedings are central to U.S. economic growth and employment.

Crandall and Singer found that from 2003 to 2009, broadband investments directly created 431,000 jobs. They estimate continuing broadband investments from 2010 to 2015 will, if not discouraged by bad policy, create 509,000 jobs.[13] These direct effects do not even begin to match the productivity enhancements that ripple throughout the economy with the proliferation of information technologies.[14]

Practically speaking, we examined the comments, as of February 5, filed by companies in this proceeding. Companies who oppose Net Neutrality employ 1,440,021 workers.[15] Companies in favor of Net Neutrality employ just 148,936. Excluding the large cable and telecom service providers, we found Net Neutrality opponents still far outpaced advocates in employment: 570,316 to the aforementioned 148,936. These non-service provider opponents are key American technology companies like Qualcomm, Corning, and Cisco.

We then looked at capital investments and found a similar 10-1 ratio. On a rolling three-year basis, from 2006 to 2009, Net Neutrality opponents made capital investments of $189 billion, while Net Neutrality advocates invested just $18 billion.

As we noted, this analysis of company FCC filings is, of course, not dispositive. The efficacy of Net Neutrality regulation is not determined solely by who submits FCC comments nor only by its impact on near-term job creation or capital investment. Regardless of one's view of long-term effects, however, there is little chance Net Neutrality regulations could improve the near-term jobs picture. There is, on the other hand, a substantial possibility for harm. This analysis does show that many U.S. companies employing large numbers of American workers oppose a major increase in regulation of perhaps the nation's most important high-growth industry. An industry that today is healthy, growing, and dynamic.

New Consensus

Contrary to the zero-sum rhetoric often heard, Amazon.com, long sympathetic to Net Neutrality, correctly concludes, "A win-win-win outcome is possible." In arguing for a cooperative and flexible relationship among service and content providers, Amazon's Paul Misener made a crucial distinction:

> [B]roadband Internet access service providers would have the regulatory certainty to pursue new business models with users and content providers, while content providers would have opportunities to better serve their customers by using the network operators' new services . . . . [C]onsistent with the principle of maintaining an open Internet, Amazon respectfully suggests that the FCC's proposed rules be extended to allow broadband Internet access service providers to favor some content so long as no harm is done to other content . . . . [W]e note that the Internet has long been interconnected with private networks and edge caches that enhance the performance of some Internet content in comparison with other Internet content, and that these performance improvements are paid for by some but not all providers of content. The reason why these arrangements are acceptable from a public policy perspective is simple: the performance of other content is not disfavored, i.e., other content is not harmed.[16]

"Openness"

A Net Neutrality regime will not make the Internet more "open." The Internet is already very open. More people create and access more content and applications than ever before. And with the existing Four Principles in place, the Internet will remain open. In fact, a Net Neutrality regime could close off large portions of the Internet for many consumers. By intruding in technical infrastructure decisions and discouraging investment, Net Neutrality could decrease network capacity, connectivity, and robustness; it could increase prices; it could slow the cycle of innovation; and thus shut the window to the Web on millions of consumers. Net Neutrality is not about openness. It is far more accurate to say it is about closing off experimentation, innovation, and opportunity.

If Net Neutrality is not about openness, neither is it even about neutrality. This is a supreme irony of the proposal.

If Net Neutrality applies neutrally to all players in the Web ecosystem, then it would regulate every component and entrepreneur in a vast and unknowable future. If Neutrality applies selectively (oxymoron alert) to only one sliver of the network, then it is merely a political tool of one set of companies to cripple its competitors. But even if a Neutrality law initially targets just a few companies, it will eventually spread to all corners of the Net because of the "increasingly blurred lines" among network competitors, collaborators, and components. Along the way, we will likely endure a decade or more of expensive and wasteful litigation that will promote uncertainty and discourage investment. This is a recipe for either far-reaching micromanagement of the fast-changing Web, or for endless permission-seeking and litigation among network and content companies who find it impossible to operate their networks. Or more likely, both.

Burden of Proof

The economy remains in a parlous state. At 9.7%, unemployment is still brutally high. Small businesses find credit difficult to obtain. Historically important sectors like automobiles and finance are wounded.

But the Internet is healthy, growing, vibrant. Unlike so many other U.S. industries, the Internet is not only surviving but thriving. Internet companies are investing hundreds of billions of dollars in American infrastructure. The Internet is our best chance to vault out of the current rut and bring jobs to millions of out-of-work Americans. It is the best platform for entrepreneurship and low-cost education. It holds the possibility of helping to transform our health care problem into a high-growth opportunity. It can provide the large productivity gains and entirely new products, services – even whole new sectors of the economy – that can help overcome long-term social and budgetary challenges.

With all the Internet's current prosperity and future promise, the burden of proof falls heavily on those who would make a dramatic change to current policy. Because the Internet is already "open," a Net Neutrality law offers no discernible benefits but many potential pitfalls. The U.S. should not toy with its successful model of Internet innovation. Our economy, and the Internet, cannot afford it.

---

[1] Bret Swanson is president of the technology research firm Entropy Economics LLC. http://entropyeconomics.com

[2] Crandall, Robert, and Hal Singer. "The Economic Impact of Broadband Investment." Broadband for America. February 23, 2010. p. 2. http://www.empiris.com/docs/broadbandforamerica_crandall_singer_final.pdf

[3] Swanson, Bret. "Bandwidth Boom: Measuring U.S. Communications Capacity from 2000 to 2008." Entropy Economics. June 24, 2009. http://entropyeconomics.com/wp-content/uploads/2009/07/bandwidth-boom-measuring-us-comm-capacity-2000-08-062409c.pdf

[4] Swanson, Bret. "Google and the Problem with 'Net Neutrality.'" *The Wall Street Journal*. October 4, 2009. http://online.wsj.com/article/SB10001424052748703628304574452951795911162.html

[5] Labovitz, Craig, et al. "2009 Annual Report." Atlas Internet Observatory / Arbor Networks. October 2009. http://www.nanog.org/meetings/nanog47/presentations/Monday/Labovitz_ObserveReport_N47_Mon.pdf

[6] Bohn, Roger E., and James E. Short. "How Much Information? 2009" UC-San Diego. December 2009. http://hmi.ucsd.edu/pdf/HMI_2009_ConsumerReport_Dec9_2009.pdf

[7] Labovitz, Craig, et al. "2009 Annual Report." Atlas Internet Observatory / Arbor Networks. October 2009. http://www.nanog.org/meetings/nanog47/presentations/Monday/Labovitz_ObserveReport_N47_Mon.pdf

[8] Ford, George S., and Lawrence J. Spiwak. "Non-Discrimination or Just Non-Sense." Phoenix Center for Advanced Legal and Economic Public Policy Studies. March 24, 2010. p. 4. http://www.phoenix-center.org/perspectives/Perspective10-03Final.pdf

[9] In its Comments in this proceeding, Qualcomm, perhaps the world's most important mobile innovator for two decades, nicely summarizes the lethal threat Net Neutrality could pose to wireless. Brenner, Dean R. "Comments of Qualcomm Incorporated." In the matter of "Preserving the Open Internet." GN Docket No. 09-191. January 14, 2010. http://fjallfoss.fcc.gov/ecfs/document/view?id=7020378228

[10] Eisenach, Jeffrey A., et al. "Net Neutrality Regulation: The Economic Evidence." FCC Reply Comments in the matter of "Preserving the Open Internet." GN Docket No. 09-191. April 12, 2010. pp. 18-19. http://fjallfoss.fcc.gov/ecfs/document/view?id=7020408754

[11] Hahn, Robert, Robert Litan, and Hal Singer. "Addressing the Next Wave of Internet Regulation: A Case for Equal Opportunity." The Georgetown Center for Business and Public Policy. p. 7. http://www.gcbpp.org/files/Academic_Papers/Hahn_Papers/AP_Hahn_NextWaveInternet_012010.pdf

[12] Ford, George S., and Michael Stern. "Sabotaging Content Competition." Phoenix Center for Advanced Legal and Economic Public Policy Studies. March 4, 2010. http://www.phoenix-center.org/perspectives/Perspective10-02Final.pdf

[13] Crandall and Singer. pp. 2-3.

[14] See, for example, Jorgenson, Dale W, Mun S. Ho, and Kevin J. Stiroh. *Productivity, Volume 3: Information Technology and the American Growth Resurgence*. The MIT Press. October 2005.

[15] Swanson, Bret. "What Would Net Neutrality Mean for U.S. Jobs?" Entropy Economics. February 5, 2010. http://entropyeconomics.com/wp-content/uploads/2010/02/what-would-net-neutrality-mean-for-jobs-020510.pdf

[16] Misener, Paul. Comments of Amazon.com. In the matter of "Preserving the Open Internet." GN Docket No. 09-191. January 14, 2010. http://fjallfoss.fcc.gov/ecfs/document/view?id=7020373635