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In this issue

Carpool Lanes on the Internet: Effective Network Management

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In recent years, the Federal Communications Commission (FCC) has embarked on a new path of Internet regulation by declaring that it is illegal for network owners to use certain techniques to manage traffic on their networks. We all want a vibrant Internet that both allows a million flowers to bloom now and can technologically evolve to let the next million bloom as well. The question is what path will best get us there, and whether the path the current FCC has set us on is necessarily the right one.[1]

The theme of this essay is twofold. First, even with a finite resource, the most successful communications regulatory policies are those that allow technological flexibility in how that resource is managed and used. With regard to the nation's airwaves, for example, the FCC has frequently followed policies that allow spectrum users substantial flexibility in how to use and manage that spectrum. Although having its roots in government research, the nation's modern broadband Internet network has been built almost entirely through the construction investment of network operators, from backbone to last-mile connections. Notably, then, the technological success stories arising from flexible wireless communications and satellite allocation service rules are particularly compelling when applied to the question of what rules should apply to management of the broadband Internet.

Second, any network management rules should be founded on the understanding that network management is, at bottom, traffic management. There should be reasonable rules of the road for Internet traffic, just as there are for highway traffic. Though decidedly low-tech compared to the Internet, the lessons from how carpool lane and fast-track policies have made traditional highways work better for all travelers should be considered in the Internet network management context. Importantly, both airwaves and highways are closer to being true public resources than the Internet is, yet the FCC appears to have embarked on a path that would regulate the Internet even more tightly then society regulates its roads.

The first part of this article examines the FCC's recent actions in regulating the Internet, focusing on its two initial decisions in the cable and wireless Internet context. The second part looks at FCC regulation of satellite and terrestrial wireless spectrum, as well as models of regulating highway traffic, and considers their applicability to current Internet network management regulatory policy. The final part applies the lessons of the spectrum and highway regulation to the current network management debate and concludes that the current TCP/IP standard may be insufficient to manage future Internet uses. Contrary to recent FCC policy, sound network management policy should allow "application layer controls,"[2] such as deep packet inspection, to ensure the network is managed most effectively for both the current and next generations of Internet communications services.

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FCC Entry into Internet Regulation[3]

The FCC took significant steps to regulate the Internet in 2007 and 2008. These actions have their roots in the FCC's September 2005 statement of policy concerning the Commission's role in Internet governance pursuant to its authority under Title I of the Communications Act.[4] The FCC identified four broad Internet policies in 2005 "designed to encourage broadband deployment and preserve the open and interconnected nature of the public Internet." They are

- Consumers are entitled to access the lawful Internet content of their choice;
- Consumers are entitled to run applications and use services of their choice, subject to the needs of law enforcement;
- Consumers are entitled to connect their choice of legal devices that do not harm the network; and
- Consumers are entitled to competition among network providers, application and service providers, and content providers.

The statement of policy also acknowledged that consumer rights should remain subject to reasonable Internet network management practices.[5]

In 2007, the FCC released a notice of inquiry (NOI) into broadband market practices seeking additional information about how broadband Internet services are provided to consumers and whether additional regulations were necessary.[6] In the NOI, the Commission asked whether enforceable rules should be adopted, noting that the Policy Statement did not contain rules.[7] While the NOI was pending, the FCC's focus on this issue led two parties to make submissions asking the FCC to decide whether "degrading" peer-to-peer traffic was a reasonable network management technique.[8] Seven months later, the FCC released its *BitTorrent Order*[9] granting some of the relief requested in the complaints and reaching a finding that Comcast had violated the agency's Internet policies by discriminating against specific applications (peer-to-peer BitTorrent traffic) in its network management practices. The order discussed four kinds of management techniques: deep packet inspection (DPI) to determine the protocols of traffic; sending reset packets to terminate connections (RST Injection); imposition of bandwidth caps on end users; and transmission speed reduction or "throttling."[10] The first two techniques were found to violate the Internet principles as unlawfully discriminatory. The order has been appealed to the D.C. Circuit.[11]

The FCC's actions with respect to technologies such as deep packet inspection deserve closer examination. Essentially, the FCC found that deep packet inspection was unlawfully discriminatory when used to identify peer-to-peer applications for the purpose of managing bandwidth consumption,[12] reasoning that Comcast's use of packet inspection technology was not "application neutral."[13] While going out of its way to specify that deep packet inspection could be used to block pirated or other illegal content, the *BitTorrent Order* leaves little room for use of deep packet inspection to mitigate network congestion by managing otherwise lawful traffic. Packet inspection, after all, merely allows a network operator to look at packets of data traversing its network in order to determine certain of their characteristics and, if used for network management purposes, to take action based on those characteristics. The question unanswered by the FCC is how would a network owner use deep packet inspection in a way that does not make discriminatory judgments about the technical characteristics of packets?

For purposes of network management, a packet is examined to determine whether it is consuming bandwidth fairly and operating according to data transmission "road rules" of the network. Any network management actions taken based on the information gleaned from such inspection will necessarily be "discriminatory" in the sense of treating those packets differently from others. But merely treating two different entities in a different way is not cognizable "discrimination" unless the two are "like" each other and there is no separate good reason for treating them differently. So implicit in the FCC's ruling appears to be a strong (if unstated) technical judgment that all data packets are entitled to the same priority on a network irrespective of the application of which they are a part or the technology used to direct them. Without the ability to treat like packets alike and different packets differently, the FCC appears to have foreclosed the possibility that packet inspection technology will play a role in network management in the future.

The FCC's foray into network management rules proceeded on a second front with its decision to apply new conditions to a block of vacated analog television spectrum prior to public auction for wireless telecommunications use.[14] The FCC's *C Block Order* restricted the winning bidder for "C Block" licenses—22 MHz blocks of radio spectrum in the 700 MHz band—from prohibiting third-party devices or applications to run over the network, subject to reasonable network management practices. The final rule bans the network operator from denying access to any devices or applications, except "[i]nsofar as such use would not be compliant with published technical standards reasonably necessary for the management or protection of the licensee's network, or [a]s required to comply with statute or applicable government regulation."[15]

This ruling had its precursors and fallout as well. In early 2007, Skype Communications filed a petition for rulemaking asking for the FCC to apply its 1968 *Carterphone* rationale to wireless networks.[16] *Carterphone* required AT&T to allow third-party phones and other equipment to connect to the public switched telephone network as long as they did not harm the network. In May 2008, then FCC Chairman Kevin Martin announced the Commission would not grant Skype's petition, stating that the adoption of open access requirements in the *C Block Order* for the 22 MHz 700 MHz licenses (later won by Verizon) had already established sufficient wireless open access principles such that additional regulation was not necessary.[17] Martin went on to note that, following the adoption of 700 MHz C Block open access conditions, the wireless industry had voluntarily agreed to open their networks to third-party devices and applications, further mooting Skype's petition.[18]

At first glance, the *C Block Order* and the *BitTorrent Order* share some commonalities. Both established that reasonable network management cannot be based solely on how much bandwidth an application or device will consume. The *C Block Order* holds that bandwidth control can only be implemented through "technology-neutral capacity pricing."[19] This is similar to the *BitTorrent Order*'s finding that tiered pricing would be a permissible network management technique.

But the similarities soon end. While the *BitTorrent Order* was notable for what it prohibits in terms of network

management practices, the *C Block Order* is notable for what it permits. Despite the admonition of technology-neutrality, the FCC pointed out other means to manage a network:

> We emphasize that we are not requiring wireless service providers to allow the unrestricted use of any devices or applications on their networks. In particular, we are mindful of the risks network operators face in protecting against harmful devices and malicious software. Wireless service providers may continue to use their own certification standards and processes to approve use of devices and applications on their networks so long as those standards are confined to reasonable network management. For example, providers are free to choose their air interface technology, and to deny service to devices or applications that cannot operate on the same technology, since such a restriction permits significant network efficiencies without significantly reducing consumer access to services and features.[20]

That standard is not technology neutral, but rather it allows a wireless operator to discriminate based on different technologies. The Commission continued:

> We also recognize that wireless providers have legitimate technical reasons to restrict particular non-carrier devices and applications on their networks, specifically to ensure the safety and integrity of their networks. In particular, we believe that it is reasonable for wireless service providers to maintain network control features that permit dynamic management of network operations, including the management of devices operating on the network, and to restrict use of the network to devices compatible with these network control features.[21]

Again, this is not technology neutral. It allows the C Block licensee, Verizon, to discriminate based on technologies that do not comply with its network integrity protocols.

To remove doubt, the FCC went on to set a far more flexible standard than the neutrality condition would suggest by approving a "network degradation" standard for network management: "Standards to ensure that network performance will not be significantly degraded would also be appropriate."[22] If the network management principles articulated in *C Block Order* allow carriers to outright ban devices and applications that do not meet reasonable network management standards, would it not also be reasonable to allow the less draconian technique of offering differing levels of delivery speed to applications based on whether they are designed to function well within the network? This would seem logical, but the *BitTorrent Order* essentially forecloses that option. The question, then, is whether the decision in the *BitTorrent Order* to prohibit packet inspection went too far in support of policies that were initially adopted with reasonable flexibility in the *C Block Order*. The next section examines whether other regulatory regimes can shed light on this question.

Regulatory Analogies—Radio Spectrum and Highways

In other instances of new and growing fields of communications technology, the FCC has employed measures that would both allow technology to flourish and simultaneously meet the goals of the Communications Act. Of particular interest is how the FCC's satellite and terrestrial wireless spectrum policies have allowed for flexible use over the years. While no analogy is exact, from a public policy perspective there are some interesting similarities between the Internet and radio spectrum. Notably, radio spectrum is a resource that must be managed to ensure it is used effectively for the benefit of all Americans.[23] While broadband Internet is built on private investment, it remains a resource of great value to the public for education, political discourse, and economic development.[24]

Another analogy is to the relatively low-tech situation of the nation's highway system. Like the highway system, the Internet functions best when it effectively delivers traffic from point A to point B in the shortest period of time possible. On the highways, we adopt rules to encourage use of the roads in a way that serves its purpose, such as carpool lanes that allow traffic to move faster. The examination of how effective carpool lane policy and technology foster socially desirable behavior through what Lior Strahilevitz calls "charismatic code" is especially applicable to the present network management debate.

Both radio spectrum and highways are nearer to being actual public resources than are broadband Internet networks. Wireless airwaves are essentially owned by the public and leased out by the government for private use. Internet traffic, on the other hand, travels almost entirely over privately built facilities to connect application providers with broadband customers. Nevertheless, the *BitTorrent Order* would regulate Internet traffic more strictly than we regulate either traffic using radio spectrum or physical traffic on the highways. The FCC's new rules attempt to compel use of the Internet for a specific purpose (in this case, peer-to-peer file transfers) through restrictions on how the network can be managed, rather than using a flexible approach as has been applied to airwaves. Similarly, the FCC's rules are so restrictive as to eliminate management practices that are used effectively on the highways, making it harder to legally manage private networks than to manage public roads. Below I explain why that which is good for more public, more heavily regulated resources (like roads and spectrum) is equally good for less public, more private ones (like the broadband Internet network).

The *BitTorrent Order* and other recent FCC actions are not technology neutral.

Flexible Rules Foster Development

When creating the rules for what would evolve into modern satellite television, the Commission avoided both its traditional broadcast and common carrier satellite regulatory structures to allow for flexibility in how the service was deployed. In its initial policy statement on DBS, the Commission decided to abandon a traditional common carrier regulatory structure for satellite allocations in favor of a flexible structure in order to allow the service to grow.[25] The FCC upheld this policy in its final order: "Nothing in the comments has persuaded us to abandon our proposal to apply a flexible regulatory approach for the interim operation of DBS systems. We continue to believe that this approach will allow for the type of technical and economic experimentation that is appropriate prior to the adoption of a permanent regulatory scheme."[26]

In freeing DBS satellite frequencies

from technical service restrictions, the FCC emphasized that it wanted to allow the development of a communications service that would benefit the public through improvement in the kind of television technology available:

> We believe that authorization of DBS service would not only make possible more channels of television service throughout the country, but could result in a *major qualitative improvement in the service available* and in the responsiveness of television to viewers' preferences. As a consequence, its potential benefits to the American people would be very great.[27]

The FCC further recognized that allowing operators of the new DBS allocation to offer services that did not conform to a strict common carrier or broadcast regulatory model was the key to ensuring that new and experimental communications systems would emerge, rather than merely following previous models.[28]

This policy carried forward twenty years later when DBS operators first began to offer data services. In extending flexible DBS usage rules to data services in 2002, the FCC noted the importance of maximizing the value of scarce spectrum and found that regulatory options that allow a network to evolve for new uses are what matter most:

> EchoStar supports eliminating all existing regulatory impediments hindering flexible use of DBS spectrum by DBS licensees. It states that *because DBS spectrum is limited*, spectrum efficiency becomes more important to give providers the ability to offer additional services to consumers. For instance, EchoStar has taken advantage of the existing flexibility afforded to DBS operators by providing data services in combination with video services. . . . [W]e agree that allowing non-conforming satellite use of DBS spectrum is consistent with the Commission's spectrum management policies, which favor greater options and choices for consumers.[29]

The result of this policy is the national satellite service providers Dish and DirecTV, which now provide multichannel video service to a combined 30 million American households.[30] Most would agree that this represents a success story in federal regulation of scarce satellite spectrum for the public benefit.

The evolution of the FCC's licensing of terrestrial wire services follows a similar model: a platform that was originally barely used blossomed into a fertile ground for innovation when service restrictions were lifted. Although it had been moving in this direction for a number of years, the Commission most fully embraced this policy in 1996. In proposing flexible use for wireless spectrum, the FCC observed that a flexible use policy would "eliminate the need for the Commission to initiate a rule making or grant multiple waivers each time a broadband CMRS provider or new entrant to a market wishes to adjust its operational mode to evolve for changing technological possibilities."[31] Unfortunately, by contrast, the *BitTorrent Order* appears to create a regime where the agency must initiate a rule making any time a new service requires new network management rules to operate. Under the *BitTorrent Order* regime, before traffic can be managed in any way different from the TCP/IP-based rules the Commission must approve it, and anything that is not explicitly approved is deemed prohibited.

Later in 1996, concluding that a flexible technology regime worked best for terrestrial wireless spectrum, the FCC stated:

> In light of the dynamic, evolving nature of the wireless industry, we are concerned that regulatory restrictions on use of the spectrum could impede carriers from anticipating what services customers most need, and could result in inefficient spectrum use and reduced technological innovation. Allowing service providers to offer all types of fixed, mobile, and hybrid services in response to market demand will allow for more flexible responses to consumer demand, a greater diversity of services and combinations of services, and increased competition.[32]

The Commission specifically noted that allowing flexible use would bring the greatest benefit to the public because operators would chose new technology offerings with the input of subscribers who vote with their wallets:

> [N]othing in the record suggests that giving licensees who provide CMRS services the flexibility to offer fixed service would make them less responsive to market demand for mobile service. In fact, the record indicates that most carriers intend to offer consumers integrated packages and combinations of mobile and fixed services. For these reasons, we conclude that licensees should have maximum flexibility to provide fixed or mobile services or combinations of the two over spectrum allocated for CMRS services, including PCS, cellular, and SMR services. We agree with the majority of commenters that limitations on fixed uses are unnecessary because the market is the best predictor of the most desirable division of this spectrum.[33]

Once again, the analogy to *BitTorrent* is clear. There, the FCC did not rely on any analysis of whether flexibility in managing networks would allow Internet providers to be more responsive to evolving technologies and applications. Rather than allow network management policy to be determined by potential new uses, the Commission imposed regulations reminiscent of pre-cellular wireless service restrictions.

Prior to the FCC's wireless flexible use policy, service restrictions were so detailed as to specify whether paging, voice, or data could be provided over a wireless channel, and whether that service could be in analog or digital format, interconnected with the PSTN or dispatch only.[34] The rule changes introduced the concept of flexible allocation—a spectrum license holder could use the spectrum to provide whatever kinds of services became technically possible to provide. The FCC recognized this gradual change in its 2002 Spectrum Policy Task Force Report, which concluded that "[i]n most instances, a flexible use approach is preferable to the Commission's traditional 'command and control' approach to spectrum regulation, in which allowable spectrum uses are limited based on regulatory purpose."[35] Former FCC Chairman Reed Hunt has noted the benefits of eliminating usage restrictions in ensuring that spectrum is put to the highest valued use:

> [A]ll spectrum is not created equal. Some spectrum is very good for use in satellite transmissions, other frequencies are very good for narrow point-to-point transmissions, and other spectrum is very good for wider area mobile use. Consequently, Congress and the FCC

> should make all spectrum available for all possible uses, and thereby permit firms to make the investments that the market will bear, instead of the investments that regulators determine wise.[36]

Flexible use was a significant departure from the traditional command-and-control way of regulating a radio service, but is now standard practice. The result: 260 million individual wireless subscribers in the United States.[37]

A classic example of how flexible service rules allowed network owners to do something beyond what they would have previously been permitted to do is the creation of Nextel. When initially allocating certain mobile radio channels in the 800 MHz band, the FCC required that these airwaves must be used for private walkie-talkie or taxi dispatch services. Nextel began acquiring these licenses and asked the FCC to permit the spectrum to be used for commercial mobile telephone services instead. In a series of decisions,[38] the FCC agreed—leading to the creation of Nextel as a new mobile phone network.

In another example, the FCC eliminated a requirement that a wide swath of spectrum in the 2.5 GHz band be used for wireless cable television transmissions only, allowing the creation a "broadband radio service" in the spectrum.[39] By removing an *a priori* designation of what particular airwaves should be used for, the FCC opened the way for companies like Clearwire to deploy "fourth generation" WiMax wireless mobile broadband services.[40] Unfortunately, in its approach to the Internet, the FCC has gone against these trends, preferring instead to presume the Internet is now and should always be a tool used for peer-to-peer bulk file transfers, and setting detailed, service-level rules in accordance with that predetermined preference.

While the airwaves arguably are a national resource—owned by the public and managed for its benefit—the modern Internet network was paid for essentially entirely by private enterprise. Still, some believe that the role of government research in developing the early suite of protocols that enabled two computers to communicate makes the Internet itself a quasi-national resource, even if broadband Internet home delivery is a creature of the private sector. The point is that even if the Internet were a truly public resource, the best way to protect it is to allow it to evolve, as we have done with the airwaves. In early satellite and terrestrial spectrum regulation, the Commission imposed common carrier models and restricted the kinds of service that could be provided over different blocks of spectrum based on frequency. Modern flexible use policy puts the spectrum in the hands of those who will develop it and create incentives to insure that they will deploy and develop the services that are most valued by the public.

Similarly, wise Internet policy will allow network operators to experiment with different levels of a managed-Internet experience. The Internet could evolve to require stricter technical protocols for levels of integrity and performance needed for delivery of high speed and real-time applications like online gaming, and its still mostly science-fiction cousin, virtual reality. Rather than the FCC dictating an Internet that serves a few specific functions—such as bulk or best-efforts data transfer—to the exclusion of others, the FCC's rules should allow network operators to accommodate the kinds of functions next generation Internet users may want. Although the FCC's *BitTorrent Order* relies heavily on congressional emphasis on user control over the Internet experience,[41] it does so to the exclusion of the directive to promote the development of new technologies.[42] If network management tools are eviscerated to the point that the network is a dumb pipe unable to support services other than file transfer, then such file-transfer services will be the only choice consumers have. This does not comport with the goals of the Communications Act.

In this respect, overly restrictive rules prohibiting the application layer controls that are at the core of effective network management appear no smarter than premodern FCC wireless spectrum rules that mandated that only two-way dispatch services may be offered on certain frequency bands, or satellite service rules allowing only common carrier telecom offerings. Both make *a priori* judgments about what a network should do without any opportunity for experimentation to determine what the network could do.

Network Management and Monitoring Traffic

Network management using packet inspection is based on the premise that it makes perfect sense to have some packets move through the network more quickly and smoothly than others. This is intuitively obvious: it doesn't matter if there is a one- or two-second delay in delivering the packets comprising a large spreadsheet file, as an example, as long as they all get there in the end. But a one- or two-second delay in delivering packets that are part of a VoIP conversation or streaming YouTube video profoundly disrupts the user experience and value of the application. So, it seems logical that a well-managed network would ensure that packets of the most sensitive applications can, when necessary due to congestion or other factors, be given priority handling. Yet some argue that the public interest is not served by permitting network owners like Verizon and Comcast to decide which traffic moves more quickly. Whether the data packets are streaming movies downloaded through Netflix or peer-to-peer files, allowing network owners to determine how data are being sent is considered akin to allowing the post office to open mail and inspect it. This is the well-worn "envelope analogy" that has driven so much of the net neutrality debate, especially at the FCC.[43]

The Internet functions best when it effectively delivers traffic from point A to point B in the shortest time possible.

Some scholars believe the envelope analogy is not suitable to Internet network management and should be abandoned.[44] Indeed, a more apt analogy for Internet traffic is not mail; it is cars moving along a highway. Just as highways must be built and maintained in order to handle expected volumes of traffic (including rush hours), so too must the Internet be built and maintained to carry expected volumes of data. We subject cars and drivers to numerous restrictions to manage the highways, including drivers' licenses and license plates, and for a host of good reasons. Moreover, we allow highway operators to permit certain traffic to move faster than others when drivers carpool, through the use of HOV lanes, or when they invest in technology that allows for more effective management of roadway toll plazas, like RFID tags read by EZ-Pass. By allowing such practices, network

operators can increase speed of traffic delivery based on how much of an effort the traffic itself (cars or Web applications) makes to ease congestion through steps they can take at little cost. This is a highly efficient network management principle and applies fully to the question of Internet network management.

The concept of carpool lanes on the information superhighway is intuitive. Just as we allow faster transit for cars that adhere to beneficial social policies (such as carrying several passengers in the same car), we should allow faster transit for Internet applications that adhere to beneficial network policies. Why do we need fast-track lanes on the information superhighway? Consider one recent telling example that bodes poorly for the future of the Internet: after earning its protection from the FCC for its file-sharing service, BitTorrent has become even more aggressive in its traffic-sending habits and is now essentially falsifying its peer-to-peer transmissions by encoding them with file transfer protocol identifiers designed for VoIP and other time-sensitive transfers.[45] Essentially, BitTorrent is deceiving the network by telling the packet routers, "I am a real-time application and need to be sent immediately," when in fact the transmission is a bulk file transfer that is being downloaded for viewing at a later time, or for storage. This is akin to someone putting one or two inflatable dummies in his car in order to drive in the HOV lanes. Under the FCC's current model for network management, there is relatively little any network operator can do about this. Our current network management regulations, therefore, encourage application providers to practice technological evasion and deceit to get into the fast lanes, at the expense of Internet users who wish to use time-sensitive applications like VoIP or gaming.

There should be reasonable rules of the road for Internet traffic, just as there are for highway traffic.

The same concept applies when one considers the EZPass system. The EZPass system merely requires a driver to purchase an RFID tag linked to a credit card and display it on the car windshield. The reward is faster access through toll booths in the form of lanes designed to read the EZPass tag. The driver gets to travel faster in exchange for adopting a simple technological measure that facilitates payment of tolls and reduces congestion at the same time. The network (highway) operator gets faster-moving traffic, starting a positive feedback loop enabled by technology that allows highways to read what steps drivers have taken to ease their impact on overall congestion.

The analogy of carpool lanes on the Internet has been used to describe the kind of service Akami provides,[46] but the implications of the analogy run much deeper. Lior Strahilevitz explained how San Diego's carpool lane program successfully increased the number of carpoolers and decreased "cheaters" who used the carpool lane illegally by permitting paid use of carpool lanes. This combination of permitted uses of the lanes established a social norm in the consciousness of San Diego highway drivers.[47] Effectively, San Diego merged the concepts of EZPass and HOV lanes to highly beneficial results for traffic. He observes:

> Schreffier's second explanation for the significant drop in violations—that former HOV violators are being converted into ExpressPass users—is particularly noteworthy. A number of former violators who previously would run a small risk of paying a large fine have now decided that paying a regular fee for lawful use of the Express Lanes is preferable. In all likelihood, these individuals are making rational calculations about how to maximize their own welfare. Even if the average monthly payments of an ExpressPass user are higher than the average monthly fines paid by an HOV violator who used the lanes an equal number of times, the reduced stress levels (that is, no concerns over being caught) and lack of guilt associated with lawful behavior may well suffice to tip the balance in favor of compliance.

Because carpoolers were allowed to use the fast lane for free while noncarpoolers could use it for a price, the arrangement had the effect of both increasing carpooling among the general public[48] and decreasing the incidence of cheaters who used the lanes even though they were not carpooling. The lanes became heavily used, and as carpoolers could use them for free, that reward combined with the awareness that more people were carpooling created the virtuous circle that ultimately increased carpooling:

> [T]he program has likely increased the extent to which carpooling is seen as a socially useful activity. By shifting to congestion pricing, the program has reinforced the view (already created by the presence of carpool lanes) that carpoolers are helping society by easing congestion on the roadway. In the minds of some, the size of the toll not charged to carpoolers may correlate with the amount of money the carpoolers' choices are saving the community when they decide to carpool instead of driving solo.[49]

In another essay, Strahilevitz applies his observation of how norms are created in the context of carpool lanes to explain why peer-to-peer site users share content when they could just as easily download others' content without sharing themselves.[50] He explains that this behavior is built in to the way that file-sharing networks are designed:

> The architecture of the networks is such that although many users on the networks do not share, the networks create an appearance that sharing is the norm. This dynamic—the magnified visibility of sharers and the invisibility of nonsharers—exists on every successful file-swapping application I have seen.[51]

By clever use of what Strahilevitz calls "charismatic code," the peer-to-peer site creates an impression of a community where everyone is sharing content, thereby encouraging a normative behavior of sharing ones' own content.

While technologies that encourage peer-to-peer sharing of illegal content do not generally advance the cause of a well-managed Internet, there is an important lesson in the example of peer-to-peer networks that can be applied to network management. Peer-to-peer networks use code to foster greater cooperation among file sharers because their networks are designed to publicize—indeed, champion—the behavior of those who share files, and mask the behavior of those

who download files without sharing. In the realm of network management, if operators can design their networks to encourage application providers to use technology that consumes bandwidth moderately rather than aggressively, there will be an increase in application providers who send traffic in adherence to certain codes and a decrease in application providers who send traffic in ways that exploit the network and cause congestion. Charismatic code built in to the Internet can make the network highly effective for future lawful uses.

Turning back to the highway model, the San Diego FasTrak system simultaneously allowed paying one-passenger drivers and carpoolers to use the carpool lane, which resulted in positive network effects:

> Charismatic code may play an important role in creating and internalizing social norms among people in the other loose-knit environment I have studied in detail. Just as Napster's charismatic code masked the uncooperative behavior of freeloaders, San Diego's FasTrak program masked the behavior of drivers who were using toll carpool lanes without authorization by making it more difficult to determine whether a solo driver was using a carpool lane unlawfully. FasTrak also (unintentionally) utilized drivers who were participating in the program to enforce the program's norms. Charismatic technologies that mask uncooperative behavior and magnify cooperative behavior may therefore help enforce social norms in varied loose-knit environments.[52]

The FCC would do well to consider this lesson. If charismatic code can encourage people to carpool and file downloaders to share their files, surely such code could encourage people to use the network in a way that does not exploit it at the expense of other users. And this is the problem with the FCC's *BitTorrent Order*. In it, the FCC effectively prohibited packet inspection because it allows Internet operators to discriminate against different kinds of applications based on technology. However, as the foregoing examples show, discrimination based on a user's choice to use or not use certain technology can be a very beneficial tool for good traffic management.

Packet inspection allows network operators to make the same kinds of judgments about traffic as the San Diego FasTrak program, or EZPass lanes elsewhere. Allowing highway systems to scan and read cars to determine the steps they have taken to benefit all users of the highway system makes that system work better for everyone. Because the drivers of cars with FastTrak or EZPass tags have taken a technological step to improve the network, they move more quickly through it. Because highway operators may create rules encouraging individual users to improve their own use of the network, the users take advantage of these technological self-help mechanisms.

In the post *BitTorrent Order* environment, the opposite incentives are present: application providers may try to evade standard network protocols, and their own services will benefit from adopting policies in conflict with network management principles instead of in cooperation with them.[53] This is analogous to the San Diego carpool lane program prior to the institution of the FasTrak option, which allows cheaters to become legitimate paying users—the system was unknowingly designed to reward self-interested rule violations. If highway operators were prohibited from performing "packet inspection" of the technology equipped on every car using FasTrak or EZPass lanes, they would be reduced to expensive and time-consuming "filtering" of all the users traveling on these lanes by examining each car based on content to determine whether they are permitted to be in the lane they are driving in. This would slow traffic on the network and further discourage users from adopting technology that improves the integrity and performance of the highway system for its designed purpose—effectively delivering traffic from point A to point B. The FCC's hard rules in the *BitTorrent Order*, if not subsequently revised consistent with the more flexible standards of the *C Block Order*, unnecessarily inhibit network owners' ability to monitor traffic in the same way as we do on our nation's highways with automated FasTrak and EZPass tag readers. For this reason, they should be rethought.

Application Layer Controls as a Supplement to TCP/IP

Net neutrality advocates focus only on preserving equality for the types of applications that can run on the existing network. This focus prevents them from fully considering what new applications can develop in a well-managed Internet. Effective Internet network management is made more difficult without the use of application layer controls like packet inspection, exactly the techniques the FCC found to be unlawfully discriminatory.[54] Certain applications require an effectively managed network to function, including streaming multimedia, online gaming, voice over Internet protocol (VoIP), video teleconferencing, alarm signaling, and safety-critical applications such as remote surgery.[55] With increasing end-user demands for applications like these that are sensitive to delay, the thirty-year-old TCP/IP "first-come, first-served" best effort model is becoming outdated.[56]

The current problem of network congestion is rooted in the TCP/IP protocol, which operates on a principle of "be liberal in what you accept, but conservative in what you send." It was designed in the 1970s for an Internet populated solely by scholars. Today's network congestion problems therefore have their roots in the founding of the Internet, which has now evolved into something that no one ever predicted. TCP/IP was designed for a small group of users known to each other without need to build rules mandating fairness of bandwidth consumption into the network itself because the community was self-policing. It was enough to have the kind of simple, fairness-based rules that only work in small groups: first-come, first-served; consider your neighbor; and be polite.

Now that the Internet is populated by billions of strangers, some level of application control add-on to TCP is needed to ensure not only that all traffic flows, but also that bandwidth is distributed fairly among those who wish to send traffic. In the *BitTorrent Order*, the FCC found such application layer controls to be unlawfully discriminatory, but did so without a thorough examination of the underlying problem. To fix the problem, we need to move away from the strict concept of "fairness among traffic flows" to one that prioritizes fairness among senders of information. As Christopher Yoo explains:

> TCP/IP routes packets anonymously on a "first come, first served" and "best efforts" basis. Thus, it is poorly suited to applications that are less tolerant of variations in throughput rates, such as streaming media and VoIP, and is biased against network-based security features that protect e-commerce and ward off viruses and spam.[57]

To reach back to the spectrum analogy, at our current point in Internet network management policy we are effectively still in the service-usage and common carrier regulatory phase. The FCC began by reflexively micromanaging satellite and terrestrial wireless resources with overspecific regulation. Over time, the Commission adopted more open policies that allowed for flexible use, which led to the development of DBS and wireless telecommunications, both of which flourished due to the absence of traditional stringent regulation. Then as now, the FCC started by overregulating, and eventually found the balance that allowed both effective management of a valuable resource and innovation in services.

If TCP/IP is unable to perform the task it was originally designed for, is DPI-based management a reasonable alternative? Even critics of network management acknowledge packet inspection may have a place. It has long been understood that traffic can be managed by price restrictions by classes of application (service tier for applications requiring more bandwidth or lower latency) or for different kinds of services, and universities have used application layer controls like DPI to monitor and control peer-to-peer file transfers.[58] Network operators have a legitimate need to inspect packets for network management purposes.

The job of network management is not dissimilar to monitoring traffic flow on a highway. We inspect "packets" on the road to determine if they are driving in the EZPass or HOV lanes without authorization. DPI as a network management technique cannot be put aside as quickly as the FCC would like, as inspecting packets is more efficient than pulling all packets over. The task of monitoring the traffic can be made easier by creating rules that the drivers must follow; and the rules will be most effective if users have an incentive to follow them such that doing so makes the network work better for everyone. When such rules are effectively built into the network as code, as with the FasTrak program, the criminals become cops and the social norm of traffic management becomes self-policing.

Conclusion

Google's recent plans to collocate servers directly with network owners to speed the delivery of its content has become widely reported.[59] This growing concept of application providers working with network owners on traffic management and delivery portends more managed networks, not less, in the future. Carefully crafted technology policy in this environment is necessary to fully recognize the investment and creative energy put into making the Internet what it is today. No one wants to see an Internet preserved as an artifact and a permanent tribute to the inventors of the military ARPAnet. The Internet should be an evolving tool for social communications, adapting with technological advances to give people all the choices that twenty-first-century communications technologies will make possible. The next FCC would do well to carefully consider the fundamentals of TCP/IP in an evolving world, and to look to past successful models regulating far more "public" resources—the airwaves and the highway system—in order to determine how Internet network management should be conducted.

Endnotes

1. At the time of this writing, Congress began considering legislation that would specifically empower the NTIA to apply its own notions of "network neutrality" in certain circumstances. As discussed in this article, the FCC previously has been willing to move in that direction even without express statutory authorization to do so. The possible ways the FCC or NTIA could pursue such policies if it chooses or is directed to do so are the subject of this article.

2. Application layer controls can be thought of as tools that allow one to monitor the way a particular application is designed to travel over the Internet. *See*, *e.g.*, Christopher S. Yoo, *Beyond Network Neutrality*, 19:1 Harv. J.L. & Tech. 14 (2005) ("The differences between the layers can be illustrated in terms of the most common Internet application: e-mail. The physical layer consists of the telephone or cable lines, e-mail servers, routers, and backbone facilities needed to convey the e-mail from one location to another. The logical layer consists of the SMTP protocol employed by the network to route the e-mail to its destination. The application layer consists of the e-mail program used, such as Microsoft Outlook. The content layer consists of the particular e-mail message sent.").

3. Parts of this section are adapted from a chapter in the ABA's *Developments in Administrative Law and Regulatory Practice, 2007–2008.*

4. Appropriate Framework for Broadband Access to the Internet over Wireline Facilities; Inquiry Concerning High-Speed Access to the Internet over Cable and Other Facilities, Policy Statement, 20 FCC Rcd 14986 (rel. Sept. 23, 2005) [*Internet Policy Statement*].

5. *Id.* at n.15.

6. *In re* Broadband Industry Practices, Notice of Inquiry, 22 FCC Rcd 7894 (rel. Apr. 16, 2007) (NOI).

7. *Id*. at n.20.

8. Comment Sought on Petition for Declaratory Ruling Regarding Internet Management Policies, DA 08-91, WC Docket No. 07-52 (rel. Jan. 14, 2008); Comment Sought on Petition for Rulemaking to Establish Rules Governing Network Management Practices by Broadband Network Operators, DA 08-92, WC Docket No. 07-52 (rel. Jan. 14, 2008).

9. Formal Complaint of Free Press and Public Knowledge Against Comcast Corporation for Secretly Degrading Peer-to-Peer Applications, 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," Memorandum Opinion & Order, 2008 FCC LEXIS 5898, 45 CR 1159 (rel. Aug. 20, 2008) [hereinafter *BitTorrent Order*].

10. *Id.* ¶¶ 45–46, 49.

11. Critics have argued that the *BitTorrent Order*'s merging of adjudicatory and rulemaking proceedings violates the Administrative Procedures Act by combining the loose evidentiary standards of legislative fact finding with the adjudicatory power to impose judgments and sanctions on past behavior. *See* Barbara Esbin, *The Law Is Whatever the Nobles Do: Undue Process at the FCC* (2009), *available at* http://www.pff.org/issues-pubs/pops/2008/pop15.12undueprocess.pdf. Esbin also argues the FCC acted beyond its jurisdiction since the FCC claims adjudicate network management disputes based on authority ancillary to its Title I ancillary authority—a broader interpretation of its ancillary jurisdiction than has traditionally been applied. *Id.* As noted above, I do not address whether the FCC has the legal authority to regulate operators' network management practices. Instead, I explain why, if the FCC regulates those practices, it should do so sparingly and with technically flexible rules rather than with detailed proscriptions.

12. *BitTorrent Order*, *supra* note 9, at n.217. The Commission clarified that deep packet inspection technology could be used to filter illegal content, stating "providers, consistent with federal policy, may block transmissions of illegal content (*e.g.*, child pornography) or transmissions that violate

copyright law." *Id.* ¶ 50.

13. *Id.* ¶ 50.

14. Service Rules for the 698–746, 747–762 and 777–792 MHz Bands, WT Docket No. 06-150, 42 CR 210, Second Report and Order (rel. Aug. 10, 2007) [hereinafter *C Block Order*].

15. 47 C.F.R. § 27.16(b)(1) and (2).

16. *See In re* Petition to Confirm a Consumer's Right to Use Internet Communications Software and Attach Devices to Wireless Networks, 22 FCC Rcd 5042, ¶ 7 (rel. Mar. 15, 2007) ("In addition, we determine that for one commercial spectrum block in the 700 MHz Band, the Upper 700 MHz Band C Block, licensees will be required to allow customers, device manufacturers, third-party application developers, and others to use devices and applications of their choice, subject to certain conditions.").

17. *See FCC Chairman Denies Skype's* Carterphone *Petition*, Fierce Wireless, Apr. 2, 2008, *available at* http://www.fierce-wireless.com/story/fcc-chairman-denies-skype-s-carterphone-petition/2008-04-02. A Commission order denying the Skype petition was circulated to the Commissioners on April 1, 2008, but has not yet been adopted.

18. *See Skype's Unnecessary FCC Petition for Wireless Neutrality Is Now Dead*, *available at* http://glimfeather.com/Borderless/Blogs/15754334.html. No formal FCC ruling denying the Skype petition has been issued, and with the change in administration (including the departure of Chairman Martin), this issue could resurface.

19. *C Block Order*, *supra* note 14, ¶ 222 ("In addition, C Block licensees cannot exclude applications or devices solely on the basis that such applications or devices would unreasonably increase bandwidth demands. We anticipate that demand can be adequately managed through feasible facility improvements or *technology-neutral capacity pricing* that does not discriminate against subscribers using third-party devices or applications.") (emphasis added).

20. *Id.* ¶ 223.

21. *Id.*

22. *Id.*

23. Principles for Promoting the Efficient Use of Spectrum by Encouraging the Development of Secondary Markets, Policy Statement, 15 FCC Rcd 24178, ¶ 24 (rel. Dec. 1, 2000) ("Because spectrum is a vitally important and scarce public resource, we must maintain authority and administrative control to safeguard the interests of the public and other licensees.").

24. *Internet Policy Statement*, *supra* note 4, ¶ 1 ("The availability of the Internet has had a profound impact on American life. This network of networks has fundamentally changed the way we communicate. It has increased the speed of communication, the range of communicating devices and the variety of platforms over which we can send and receive information. . . . The Internet also represents 'a forum for a true diversity of political discourse, unique opportunities for cultural development, and myriad avenues for intellectual activity.' In addition, the Internet plays an important role in the economy, as an engine for productivity growth and cost savings.") (internal citations omitted).

25. Inquiry into the Development of Regulatory Policy in Regard to Direct Broadcast Satellites for the Period Following the 1983 Regional Administrative Radio Conference, Notice of Proposed Policy Statement and Rulemaking, 86 FCC 2d 719 (rel. June 1, 1981) ("To ensure that we maintain our future flexibility, we have attempted to propose as few rules as possible for experimental systems. For instance, we propose not to classify experimental DBS systems as broadcasters, common carriers, or private radio services. We believe that requiring a change from one regulatory structure to another (for instance, from the experimental structure we propose to a conventional broadcast or common carrier regulatory structure), would not have a major impact on the profitability of the operation. Consequently, we would not hesitate to make such changes if we believed them to be a desirable means of maintaining competition or enhancing program diversity.").

26. Inquiry into the Development of Regulatory Policy in Regard to Direct Broadcast Satellites for the Period Following the 1983 Regional Administrative Radio Conference, Report and Order, 51 RR 2d 1341, ¶ 83 (rel. July 14, 1982) [DBS Order].

27. *Id.* ¶ 21 (emphasis added).

28. *Id.* ¶ 78 ("[T]he public interest would best be served by utilizing a flexible regulatory approach for DBS systems during this interim experimental period. Thus, we proposed to impose minimal regulatory requirements consistent with statutory provisions and international agreements. We proposed not to require applicants to structure their proposals according to any particular regulatory model. We stated that such an approach would allow DBS operators to experiment with service offerings and methods of financing to find those that would be most beneficial to viewers.").

29. Policies and Rules for the Direct Broadcast Satellite Service, Report and Order, 17 FCC Rcd 11331, ¶¶ 147–48 (rel. June 13, 2002).

30. Linda Moss, *DirecTV Adds 129,000 Subs in Q2*, Multichannel News, Aug. 7, 2008; Linda Moss, *Dish Loses 25,000 Subs in Q2*, Multichannel News, Aug. 7, 2008.

31. Amendment of the Commission's Rules to Permit Flexible Service Offerings in the Commercial Mobile Radio Services, Notice of Proposed Rulemaking, 11 FCC Rcd 2445, ¶ 9 (rel. Jan. 25, 1996); *see also id*. ¶ 11 ("A number of early trials under PCS experimental licenses included a variety of technologies and service concepts, including personal communications networks (PCN), private branch exchange (PBX), and wireless local loop . . . . Based upon concepts expressed in comments, the experimental applications granted, and the pioneer preference requests, we concluded in the PCS Second Report and Order that proposed services and devices would likely range from advanced wireless replacements for ordinary telephones to radio communications devices capable of sending and receiving voice and data to and from virtually anywhere.").

32. Amendment of the Commission's Rules to Permit Flexible Service Offerings in the Commercial Mobile Radio Services, First Report and Order and FNPRM, 11 FCC Rcd 8965, ¶ 22 (rel. Aug. 1, 1996) [*Flexible CMRS Order*].

33. *Id*.

34. Jeffrey Silva, *Rules, Regulations Have Been Instrumental in Wireless Industry's Story; The (Sometimes) Invisible Hand of Regulation*, RCR Wireless News, Oct. 14, 2008, *available at* http://www.rcrwireless.com/article/20081014/WIRELESS/810139959/-1/25_YEARS_OF_WIRELESS/25-years-rules-regulations-have-been-instrumental-in-wireless ("Before cellular, the FCC regulated what were permissible uses for a wireless network; cellular introduced flexible-use allocations.").

35. *See* Spectrum Policy Task Force Report, ET Docket No. 02-153, at 16 (Nov. 2002). ("Flexibility enables spectrum users to make fundamental choices about how they will use spectrum (including whether to use it or transfer their usage rights to others), taking into account market factors such as consumer demand, availability of technology, and competition. By leaving these choices to the spectrum user, this approach tends to lead to efficient and highly-valued spectrum uses.")

36. Reed Hunt & Gregory Roston, *Communications Policy for 2006 and Beyond*, 58:1 Fed. Comm. L.J. 12 (2006).

37. *See Few Snags Expected for Verizon Wireless, Alltel*, Cellular News, June 6, 2008, *available a*t http://www.cellular-news.com/story/31640.php.

38. *See*, *e.g.*, Request of Fleet Call,

Inc. for Waiver and Other Relief to Permit Creation of Enhanced Specialized Mobile Radio Systems in Six Markets, Memorandum Opinion & Order, 6 FCC Rcd 1533 (rel. Mar. 14, 1991); *see also* Establishment of Public Service Radio Pool in the Private Mobile Frequencies Below 800 MHz, Report & Order, 15 FCC Rcd 22709, ¶¶ 108–10 (rel. Nov. 20, 2000).

39. *In re* Amendment of Parts 1, 21, 73, 74 and 101 of the Commission's Rules to Facilitate the Provision of Fixed and Mobile Broadband Access, Educational and Other Advanced Services in the 2150–2162 and 2500–2690 MHz Bands, R&O and FNPRM, 19 FCC Rcd 14165 (rel. July 29, 2004) [*BRS Order*].

40. Doug Allen, *Clearwire Begins National 4G Rollout in Portland, Ore.*, Jan. 15, 2009, *available at* http://www.telecommagazine.com/newsglobe/article.asp?HH_ID=AR_4701.

41. *BitTorrent Order*, *supra* note 9, ¶ 12. Of course, that reliance was misplaced even if rhetorically effective: The congressional proscription favoring "user control" is directed at encouraging content filtering technologies that allow users to block pornography, not greater adoption of bulk-data file sharing. *See* 47 U.S.C. § 230(b)(3), (4).

42. 47 U.S.C. § 230(b)(1) (U.S. policy is to "promote the continued development of the Internet and other interactive computer services and other interactive media").

43. *BitTorrent Order*, *supra* note 9, ¶ 41 ("In other words, Comcast determines how it will route some connections based not on their destinations but on their contents; *in laymen's terms, Comcast opens its customers' mail because it wants to deliver mail not based on the address or type of stamp on the envelope but on the type of letter contained therein*."); *id*. ¶ 45 ("Comcast's method of sending RST packets to interrupt and terminate TCP connections thus contravenes the established expectations of users and software developers for seamless and transparent communications across the Internet—this practice, known as RST Injection, '*violate[s] the expectation that the contents of the envelopes are untouched* inside and between Autonomous Systems' and 'potentially disrupt[s] systems and applications that are designed assuming the expected behavior of the Internet.'") (emphases added).

44. Paul Ohm, *The Rise and Fall of Invasive ISP Surveillance*, Univ. of Colorado Law Legal Studies Research Paper No. 08-22, at 32 (2008), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1261344 ("[T]he envelope analogy is at the same time overprotective, underprotective, and gives rise to question begging and difficult line drawing. For these reasons, policymakers should search for an alternative organizing principle.").

45. Richard Bennett, *BitTorrent Declares War on VoIP, Gamers*, Register, Dec. 1, 2008, *available at* http://www.theregister.co.uk/2008/12/01/richard_bennett_utorrent_udp/ ("Upset about Bell Canada's system for allocating bandwidth fairly among internet users, the developers of the uTorrent P2P application have decided to make the UDP protocol the default transport protocol for file transfers. BitTorrent implementations have long used UDP to exchange tracker information—the addresses of the computers where files could be found—but the new release uses it in preference to TCP for the actual transfer of files. The implications of this change are enormous.").

46. Adam Barr, *Peer to Peer: Analyzing the Network Traffic*, Dec. 5, 2000, *available at* http://www.proudlyserving.com/oso/120500a.htm ("Traffic management companies like Akamai and InterNAP are trying to optimize Internet traffic that is flowing to or from a common point, effectively building carpool lanes on the Internet.").

47. Lior Strahilevitz, *How Changes in Property Regime Influence Social Norms: Commodifying California's Carpool Lanes*, 75 Ind. L.J. 1231 (2000).

48. *Id*. at 1223 ("Much to the delight of San Diego city planners, the number of carpoolers on I-15 increased significantly after FasTrak was implemented.").

49. *Id*. at 1261.

50. Lior Strahilevitz, *Charismatic Code, Social Norms, and the Emergence of Cooperation on the File-Swapping Networks*, 89 Va. L. Rev. 505 (2003).

51. *Id.* at 551.

52. *Id*. n.177.

53. *See* Andy Carvell, *Bitorrent to Switch Protocols to Confound Throttlers*, Dec. 3, 2008, *available* at http://www.geek.com/articles/news/bittorrent-to-switch-protocols-to-confound-throttlers-2008123/) ("Bittorrent, Inc, the makers of uTorrent, are apparently annoyed at the throttling measures introduced by many ISPs, including Comcast. In an effort to confound the throttlers and circumvent the restrictions, they have decided to use the UDP protocol—designed to carry urgent, high-priority traffic such as VOIP phone calls—to transfer files between users instead of TCP. Experts fear such a move could seriously affect performance of many applications."); *see also* Strahilevitz, *supra* note 50, at n.46.

54. *BitTorrent Order*, *supra* note 9, ¶¶ 45–46, 49.

55. Robert E. Litan & Hal J. Singer, *Unintended Consequences of Net Neutrality Regulation*, 5 J. Telecomm'ns & High Tech. L. 533 (2007), *available at* http://ssrn.com/abstract=942043.

56. Christopher S. Yoo, *Network Neutrality and the Economics of Congestion*, 94 Geo. L.J. 1861–63 (2006).

57. Yoo, *supra* note 2, at 8.

58. Tim Wu, *Network Neutrality, Broadband Discrimination*, 2 J. Telecom & High Tech Law 141, 153–55, 165 (2003).

59. Vishesh Kumar & Christopher Rhodes, *Google Wants Its Own Fast Track on the Web*, Wall St. J., Dec. 15, 2008, *available at* http://online.wsj.com/article/SB122929270127905065.html).