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Bringing Neutrality to Network Neutrality

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BRINGING NEUTRALITY TO NETWORK NEUTRALITY

By Kai Zhu

Can internet service providers (ISPs) such as AT&T and Verizon prioritize internet traffic by its type, source, destination, or volume? If yes, can they do it for profit? Internet content providers (ICPs) such as Google, Yahoo, and Microsoft want to ban such prioritization via legislation. They have argued that all internet traffic, be it from a heavy-traffic and delay-sensitive videoconference or from an e-mail, should be treated equally.[1] This debate over what has been coined "network neutrality" ("NN")[2] has gained momentum quickly. SavetheInternet.com, a grassroots coalition formed in April 2006, collected more than one million signatures in just two months to support NN.[3] Congressmen introduced five bills, either for or against NN, between March and May 2006.[4] The issue has divided legal scholars, but both sides agree that internet innovation is at risk.

At its core, the network neutrality debate focuses on a technical question that has great economic significance, although the exact meaning of the term has received different and confusing interpretations. Interestingly, the legal community originated and popularized the debate, which has since fallen victim to political and ideological polarization. If the industry giants and Congress were actually neutral to this "neutrality" debate, they should have found a middle ground by now. If legal scholars understood the technicalities of the internet, they could have reached that middle ground as well.

This Note argues that (1) the internet has never been neutral and has never been designed to be neutral; (2) internet traffic prioritization can both coexist with and encourage internet innovation; and (3) some minimal regulation is needed to prevent market power abuses and usage discrimination in the internet service market. Part I explains some technical de-

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1. *See* Anne Broache & Declan McCullagh, *Playing favorites on the net?*, CNET NEWS.COM, Dec. 21, 2005, http://news.com.com/2100-1028_3-6003281.html.

2. This Note will use the term "network neutrality" and its abbreviation "NN" interchangeably.

3. *See* Press Release, Free Press, One Million Americans Urge Senate to Save the Internet (June 24, 2006), http://www.freepress.net/press/release.php?id=155.

4. *See* Declan McCullagh, *House plans vote on net neutrality*, CNET NEWS.COM, June 7, 2006, http://news.com.com/2100-1028_3-6080983.html.

tails and the evolution of the internet that are critical to understanding the NN debate. Part II describes the development of the debate. Part III analyzes the debate and points out the engineering and economic realities that have been overlooked in the debate. Part IV proposes a middle-ground solution that can unite both sides of the debate.

I.   THE TECHNOLOGIES AND EVOLUTION OF THE · INTERNET

To understand the network neutrality debate, it is critical to grasp the technical details of the internet and to understand that the modern internet is very different from what it was thirty years ago. The internet began its life in 1969 as a research network funded by the U.S. government, but was commercialized in the early 1990s.[5] Since then it has grown rapidly and steadily—in its size, territorial scope, the number of users, the number and types of applications running over it, and, most importantly, in the sophistication of the many technologies underlying it. The architects of the original internet did not and could not envision the many new technologies and applications that are now common for the internet. In addition, some engineering solutions designed for the original internet later generated some technical problems, although initially these problems were not detrimental or obvious. As the evolution of the internet shows, the original internet architecture cannot serve current or future internet applications efficiently.

This Part explains the underlying technologies and the evolution of the internet. Section I.A gives a technical overview of the internet. Section I.B discusses some inherent technical problems of the internet. Sections I.C and I.D discuss real-time applications and their requirements for Quality of Service (QoS). Section I.E shows how the internet has continuously evolved to adapt to new technologies and applications.

A.   A Technical Overview

The internet is a computer network.[6] For internet communication to occur, the source computer splits digitized data into small pieces called packets and submits those packets into the network. The network then de-

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5. *See* JAMES F. KUROSE & KEITH W. ROSS, COMPUTER NETWORKING 52-59 (3d ed. 2005).

6. This Section gives a very high-level overview of some technical aspects of the internet that are most relevant to the network neutrality debate. *See generally* KUROSE & ROSS, *supra* note 5; DIMITRI BERTSEKAS & ROBERT GALLAGHER, DATA NETWORKS (2d ed. 1992).

livers the packets to the destination computer.[7] Multiple intermediate hops, called routers, exist between the source and the destination.[8] Along this path, each router receives a packet from an upstream router and then forwards it to a downstream router.[9] Thus the packet is "routed" hop-by-hop to its destination. Each packet contains some basic information such as Internet Protocol (IP) addresses of its source and destination.[10]

Routers run sophisticated software called routing protocols among themselves to learn the topology of the internet and establish routing tables.[11] A router knows how to forward a packet by looking at both its routing table(s) and the destination IP address of the packet.[12] When packets arrive, a router may need to queue them before forwarding them on.[13] The queuing is necessary because packets may arrive from different upstream routers around the same time and need to go to the same downstream router, but the instant router has fixed bandwidth—limited by installed communication links—toward that downstream router, and can't accommodate all of the packets at once.[14] Thus a competition for limited resources may exist in a router, and a packet may experience unpredictable queuing delay at each router. The technical essence of the NN debate is whether routers can reduce the queuing delays of some packets by increasing the delays of other packets.

B.   Inherent Technical Problems of the Internet

Most internet applications send data in random bursts of variable sizes.[15] Such traffic makes queuing delays even more unpredictable.[16] When queuing occurs, a router needs to store queued packets in memory buffers. When the buffers are full, the router has to drop either new arriving packets or existing queued packets.[17] When such packet-dropping continues, a

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7. KUROSE & ROSS, *supra* note 5, at 4.

8. The intermediate hops may also be switches, which differ slightly from routers. For the purpose of discussing network neutrality, this technical difference is immaterial, and this Note does not make distinction between routers and switches. *See id.* at 4, 18, 301-04.

9. *Id.* at 4.

10. *Id.* at 81, 327, 331-35.

11. *Id.* at 301-04.

12. *Id.*

13. *Id.* at 18-19.

14. *Id.*

15. *See* BERTSEKAS & GALLAGHER, *supra* note 6, at 14; *see also* K. R. RAO ET AL., INTRODUCTION TO MULTIMEDIA COMMUNICATIONS 605-06 (2006).

16. *See* K. R. RAO ET AL., *supra* note 15, at 605-06.

17. KUROSE & ROSS, *supra* note 5, at 19, 42.

phenomenon called "network congestion" occurs,[18] for which the key Transport Control Protocol (TCP) of the internet has a fairly sophisticated congestion control mechanism.[19] Under this mechanism, the TCP of each application[20] independently detects network congestion and slows down the traffic of that application. When all applications cooperate, the network may recover from serious congestion.[21] Network congestion was not a problem in the early days because the original internet had light traffic loads and no real-time applications. It was also because TCP can recover dropped packets by retransmission.[22] Thus, users simply did not notice transient packet losses of their applications.

C.   The Challenges of Real-time Applications

The arrival of real-time applications distinguishes the modern internet from the original internet.[23] A real-time application such as streaming video or online gaming is time-sensitive; its data can only tolerate a very limited end-to-end delay.[24] Because the communication is in real time, a packet not meeting the end-to-end delay requirement is useless and is equivalent to a lost packet.[25] Loss or significant end-to-end delay of a small fraction of packets may lower the quality of the communication to the point of rendering the application useless.[26]

Real-time applications can be classified as interactive or non-interactive.[27] For a non-interactive real-time application such as streaming video, only one direction of the communication is real-time. Data caching,

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18. *See* BERTSEKAS & GALLAGHER, *supra* note 6, at 493.

19. *See* KUROSE & ROSS, *supra* note 5, at 188, 264-84.

20. TCP is implemented within the operating system of a computer; thus, every computer on the internet has a TCP module. *See* BERTSEKAS & GALLAGHER, *supra* note 6, at 29.

21. *See* KUROSE & ROSS, *supra* note 5, at 264-84 (describing how TCP, working properly, controls congestion).

22. *Id.* at 239-46.

23. *See* Domenico Ferrari, *Client Requirements for Real-Time Communication Services*, 26 IEEE COMMC'NS. MAG. 65 (1990) (envisioning real-time applications on the internet and studying their performance requirements), *available at* http://www.ietf.org/rfc/rfc1193.txt; *see also* KUROSE & ROSS, *supra* note 5, at 565-69, 643 (discussing multimedia internet applications).

24. *See* KUROSE & ROSS, *supra* note 5, at 586. Besides the queuing delay, an end-to-end packet delay includes other components such as processing, transmission and propagation delays. *Id.*; BERTSEKAS & GALLAGHER, *supra* note 6, at 150.

25. *See* KUROSE & ROSS, *supra* note 5, at 585-86.

26. *Id.* at 586.

27. *Id.* at 566-69.

a technique by which a destination computer collects and temporarily buffers data and then replays the buffered data a short while later, can "smooth out" the packet delays and rebuild a "delayed copy" of the original real-time data.[28] Data caching, however, cannot overcome excessively random delays. Interactive real-time applications such as online gaming or tele-surgery, which are real-time in both directions, are the most challenging ones for the internet; data caching does not help them.

Applications such as web browsing have real-time characteristics, but are not real-time *per se*. For such applications, a user will not be as concerned with the delays of individual data packets as with the throughput, or the average data transfer rate,[29] of her communications. But the individual packet delays cannot be excessive; otherwise the user would think that the communication is "frozen."

D.   Quality of Service

Quality of Service (QoS), a technical term describing the quality of communication that an internet application receives, is at the center of the technical dimension of the network neutrality debate. As discussed earlier, queuing within routers can cause queuing delay and packet loss. Because it is useless to recover excessively delayed or lost packets for real-time applications, the major QoS metrics for such applications are end-to-end delay bounds and packet loss rates, where an end-to-end delay bound refers to the maximum end-to-end delay that an application demands from the network, and a packet loss rate refers to the fraction of the packets that either get lost due to full buffers or fail to meet the end-to-end delay bound. Real-time applications cannot work well without reasonable QoS. In contrast, non-real-time applications can recover lost packets without disrupting user experiences. Thus, QoS is generally not a concern for non-real-time applications. NN proponents tend to downplay or misinterpret the importance of QoS because they are not familiar with the technical challenges faced by QoS provision.[30]

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28. *Id.* at 586-87.

29. Roughly, throughput is defined as the average data transfer rate over a relatively long period; it is not the instantaneous data transfer rate. *See* KUROSE & ROSS, *supra* note 5, at 255-56; BERTSEKAS & GALLAGHER, *supra* note 6, at 282 (discussing throughput in the context of a multiaccess local area network).

30. *See, e.g.*, LAWRENCE LESSIG, THE FUTURE OF IDEAS 46-47 (2001) (asserting "technologists have begun" to change the internet architecture to provide QoS and expressing willingness to "believe in the potential of essentially infinite bandwidth" as a QoS solution). Lessig did not seem to be aware that the networking community started QoS research in the 1980s. *See, e.g.*, KUROSE & ROSS, *supra* note 5, at 636.

A router can take certain measures to provide QoS. A router controls queuing delays primarily via link schedulers.[31] A link scheduler is a functional module within the router that controls the sending order of queued packets at the outgoing link toward a downstream router. Because the link has a fixed bandwidth, the scheduler cannot limit the delay of every waiting packet if the queue is long; it can only limit the delays of some packets by giving those packets higher priorities for transmission. The router controls packet losses primarily via buffer managers.[32] A buffer manager is another functional module within the router that controls the access to memory buffers by assigning priorities to packets. To save space for high-priority packets when a buffer is full or is close to being full, the manager drops low-priority packets, which are either just arriving or already being buffered.[33] Thus, a router prioritizes packets to offer QoS.

The simplest link scheduler is First-In-First-Out (FIFO), which sends packets out in their arrival order.[34] This order-preservation nature of FIFO is tightly coupled with the "neutrality" concept in the NN debate. FIFO is a trivial link scheduler because it does not practically prioritize packets. However, it is very easy to implement FIFO, and thus FIFO became ubiquitous in older routers and is still dominant in modern routers. However, a link scheduler can be very sophisticated. It can take many parameters as its inputs, such as the end-to-end delay bound and/or local delay bound of each application, the traffic characteristics of that application such as its average data rate and peak data rate, and so on.[35] Based on those parameters, a scheduler can implement very complex algorithms. Like a link scheduler, a buffer manager can also implement complex algorithms.[36]

Besides link-scheduling and buffer management, the internet may also need ancillary mechanisms such as "resource reservation," "call admission control" and "traffic conditioning" to provide QoS.[37] Resource reservation enables a newly launched application to negotiate with the network on the traffic characteristics and QoS requirements of that application, and accordingly, to reserve some network resources such as link bandwidth or buf-

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31. *See* KUROSE & ROSS, *supra* note 5, at 321, 621.

32. *Id.* at 322.

33. *Id.*

34. FIFO is also called First-Come-First-Served (FCFS). *See id.* at 321, 621.

35. *See, e.g.*, KUROSE & ROSS, *supra* note 5, at 621-25; BERTSEKAS & GALLAGHER, *supra* note 6, at 495.

36. *See* KUROSE & ROSS, *supra* note 5, at 322.

37. *See id.* at 625-43.

fer space.[38] With resource reservation, the application can expect that its packets will traverse the network without excessive delays or losses. Call admission control complements resource reservation by allowing the network to determine whether sufficient network resources can be reserved for an application, and whether the network should accordingly admit or reject that application; call admission control prevents over-reservation of network resources.[39] The network also needs traffic conditioning to monitor an application and ensure that the application will not generate a traffic load higher than what was agreed upon at the resource reservation phase.[40] Under each of these ancillary mechanisms, the network essentially prioritizes individual applications or their packets.

Some have argued that over-provision, which means building a network with significantly more bandwidth than what the normal level of network traffic load demands, will solve the QoS problem.[41] However, the idea has not become mainstream.[42] Two related problems challenge this idea. First, the "normal level" of network traffic load is a moving target, because whenever the network has "extra resources" due to over-provision, those "extra resources" will induce newer applications with heavier traffic to appear. Such heavier traffic tends to exhaust those "extra resources." Second, this idea can at best "almost" solve the QoS problem: it cannot guarantee QoS for mission-critical applications such as tele-surgery because the network does not take *ex ante* measures such as link-scheduling and buffer management but relies on chance to provide QoS. When the network indeed has moderate traffic load during a particular period, the over-provision approach toward QoS may appear to work, but it tends to create an illusion that it will continue to work.[43]

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38. *See id.* at 625, 629, 636-37.

39. *See id.* at 628-29, 642-43.

40. *See id.* at 625-28.

41. *Id.* at 571-72 (discussing the debate within the networking research community on how to provide QoS); *see, e.g.,* LESSIG, *supra* note 30. Although some networking researchers disfavor a QoS approach that may fundamentally change the internet architecture, they are primarily concerned with the technical complexities of such a change, which differs from the concerns of network neutrality proponents. *See* KUROSE & ROSS, *supra* note 5, at 571-72. This issue is discussed further in Section II.B.

42. *See* KUROSE & ROSS, *supra* note 5, at 628-43 (discussing the current internet QoS standard, which includes two QoS architectures, Intserv and Diffserv, and an accompanying signaling protocol, RSVP).

43. *See id.* at 636, 631 (discussing the phenomenon that internet users not paying for QoS may perceive QoS-comparable quality for their applications when the network is not loaded, but such quality rapidly degrades when the network becomes more loaded).

E.   Internet Architecture Is Alive and Growing

The internet is a gigantic network of smaller heterogeneous networks with an evolving architecture. The Internet Engineering Task Force (IETF) is an international organization in charge of the technical development of the internet.[44] IETF sets up the de facto technical standards for the internet by publishing a series of documents called "Request for Comments" ("RFCs").[45] The actual technical work of IETF is split among many Working Groups ("WGs") for specific technical areas of the internet.[46] As of this writing, 121 active WGs exist under IETF.[47] Those WGs keep producing new RFCs in their individual technical areas and thus keep shaping the overall internet architecture.[48]

Although the internet has enjoyed rapid growth for many years, the standard-setting process for the internet is still accelerating.[49] Beyond the sheer number of new RFCs produced each year, the internet continues to

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44. *See* Harald Tveit Alvestrand, A Mission Statement for the IETF (2004), http://www.ietf.org/rfc/rfc3935.txt; Paul Hoffman, The Tao of IETF: A Novice's Guide to the Internet Engineering Task Force (2006), http://www.ietf.org/rfc/rfc4677.txt. IETF is not the only organization that contributes to technical standards related to the internet; many other organizations, such as the Institute of Electrical and Electronics Engineers (IEEE), also set up technology-specific standards that directly impact the internet.

45. *See* RFC Editor, http://www.rfc-editor.org (last visited Feb. 27, 2007).

46. *See* Hoffman, *supra* note 44, at 23-27 (describing IETF working groups).

47. *See* Active IETF Working Groups, http://www.ietf.org/html.charters/wg-dir.html (last visited Mar. 18, 2007). There are 12 WGs in the Application Area, 1 WG (Intellectual Property Rights) in the General Area, 29 WGs in the Internet Area, 17 WGs in the Operations and Management Area, 14 WGs in the Real-time Applications and Infrastructure Area, 16 WGs in the Routing Area, 17 WGs in the Security Area, and 15 WGs in the Transport Area. *Id.*

48. In February 2007, the cumulative index number of all RFCs reached a whopping 4,816, with the first RFC produced in 1968 (RFC 31; for some reason all other RFCs, including RFC 1, were produced after 1968). An RFC may go through several versions; typically the latest version of a RFC makes older versions of the same RFC obsolete, but the index number will simply accrue. *See* RFC Index, http://www.ietf.org/iesg/1rfc_index.txt (last visited Feb. 27, 2007).

49. There were about 234 new RFCs in 2003, about 281 new RFCs in 2004, about 327 new RFCs in 2005, and about 459 new RFCs in 2006. In contrast, there were only 1,068 RFCs produced before 1990. *See* RFC Index, *supra* note 48. For a new internet standard document to gain RFC status, it must go through an Internet-Draft stage for wide discussion in the networking community. Any organization or individual can propose an Internet-Draft, but many drafts do not end up with RFC status. Because there are so many Internet-Drafts proposed every year, they are not even archived. *See* Internet-Drafts, http://www.ietf.org/ID.html (last visited on Feb. 27, 2007). Thus, the actual internet standard-setting activities are even more rigorous than the growing number of RFCs suggests.

evolve even in its most basic areas. For its key TCP and IP protocols, many changes and updates were made in the last twenty-five years.[50] Routing is an extremely critical function for any data network, and internet routing keeps evolving.[51]

Many of the IETF WGs and the RFCs produced by them represent technical progresses that are completely new to the original internet. The first RFC dedicated to real-time applications appeared in 1990,[52] while today fourteen WGs work in the Real-time Applications and Infrastructure Area.[53] No major RFCs on internet security appeared before 1990, but to-day seventeen WGs work in the Security Area alone.[54] As another example, the modern internet adopts a two-level hierarchical routing architecture to accommodate the exponentially growing numbers of computers and routers on the internet.[55] This architecture contrasts sharply with the

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50. The first RFC for the TCP protocol was published in 1981 as RFC 793. *See* RFC Index, *supra* note 48. TCP has received numerous improvements since that time, and the latest RFC, which directly updates RFC 793, was RFC 3168, published in 2001. *Id.* The latest TCP-specific RFC was RFC 4614, published in September 2006. *Id.* Similarly, the first RFC for the IP protocol was published in 1981 as RFC 791, which has been known as IPv4 because the version number of the protocol as specified in this RFC was 4. *See* Information Sciences Institute, Internet Protocol 11 (1981), http://www.ietf.org/rfc/rfc 0791.txt. IPv4 was last directly updated by RFC 1349 in 1992. *See* RFC Index, *supra* note 48. The next version of the IP protocol, known as IPv6, was first published in 1995 as RFC 1883, and last directly updated in 1998 by RFC 2460. *Id.* The IETF IPv6 WG is a very active group and has produced numerous IPv6 related RFCs, with the latest as of this writing published in August 2006 as RFC 4620. *See* IP Version 6 Working Group (ipv6) Charter, http://www.ietf.org/html.charters/ipv6-charter.html (last visited Feb. 27, 2007).

51. For example, the most important routing protocol on the internet, Border Gate-way Protocol (BGP) was first specified in 1989 as RFC 1105. *See* RFC Index, *supra* note 48; RADIA PERLMAN, INTERCONNECTIONS: BRIDGES, ROUTERS, SWITCHES, AND INTER-NETWORKING PROTOCOLS 435 (2d ed. 2000) (arguing that the internet is probably stuck with BGP forever). The subsequent direct updates of BGP included RFC 1163 in 1990, RFC 1267 in 1991 (BGP-3), RFC 1654 in 1994 (BGP-4), RFC 1771 in 1995 and RFC 4271 in 2006. *Id.* During this period, the IETF Inter-Domain Routing WG produced many other BGP related RFCs. *See* Inter-Domain Routing (IDR) Charter, http://www. ietf.org/html.charters/idr-charter.html (last visited Feb. 27, 2007).

52. *See* Ferrari, *supra* note 23.

53. *See* Active IETF Working Groups, Real-time Applications and Infrastructure Area, http://www.ietf.org/html.charters/wg-dir.html#Real-time (last visited Feb. 27, 2007).

54. *See* Active IETF Working Groups, Security Area, http://www.ietf.org/ html.charters/wg-dir.html#Security (last visited Feb. 27, 2007).

55. *See generally* PERLMAN, *supra* note 51, at 367-445 (discussing routing protocols of the internet); KUROSE & ROSS, *supra* note 5, at 370-84 (discussing same).

simple routing architecture of the original internet, in which a clear hierarchy did not exist.[56] All the examples and data above show that the internet architecture is alive and growing.

II.   DEVELOPMENT OF THE NETWORK NEUTRALITY DEBATE

This Part describes the development of the network neutrality debate from several angles. Section II.A discusses how recent commercial disputes about internet usage have brought NN to the attention of the general public. Section II.B discusses how the NN concept and debate was developed among academics. Section II.C discusses the regulatory and legislative developments surrounding NN.

A.   Controversies in the Internet Service Market and in the Public

As the internet grew, disputes emerged between ISPs and their customers over who should have what rights regarding internet usage. This is hardly surprising because the internet was not designed to be a commercial network; its commercialization and exponential growth came too fast and too unexpectedly.

1.   Controversies Over Internet Access Rights of Consumers

Although cable companies have used contracts to prevent their residential customers from specific internet usage for quite some time,[57] controversies related to internet usage did not receive much publicity until recently. Most of those controversies involved blocking some internet content, sites, or services.

In 2004, Madison River Communications LLC ("Madison River"), a small ISP in North Carolina, blocked its customers from using the market-leading Vonage Voice over IP (VoIP) service.[58] After the Federal Communications Commission (FCC) intervened, Madison River restored the

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56. *See* 1 DOUGLAS E. COMER, INTERNETWORKING WITH TCP/IP 234-40, 249-55 (3d ed. 1995) (discussing the simple early internet routing architecture and the first inter-domain routing protocol, EGP); PERLMAN, *supra* note 51, at 367-68 (discussing the history of intra-domain routing protocols). One of the earliest intra-domain routing protocols, Routing Information Protocol (RIP), did not exist until the late 1980s. *See id.* at 367;C. Hedrick, Routing Information Protocol (1988), http://www.ietf.org/rfc/rfc1058.txt.

57. *See* Tim Wu, *Network Neutrality, Broadband Discrimination*, 2 J. TELECOMM. & HIGH TECH. L. 141, 156-62, 173-75 (2003) (surveying broadband usage restrictions) [hereinafter Wu, *Network Neutrality, Broadband Discrimination*].

58. *See* Declan McCullagh, *Telco agrees to stop blocking VoIP calls,* CNET NEWS.COM, Mar. 3, 2005, http://news.com.com/2100-7352_3-5598633.html.

service, entered into a consent decree, and paid a $15,000 fine.[59] In 2005, Canadian telephone giant Telus blocked the access to a website supporting the company's labor union during a labor dispute; the blocking lasted for approximately sixteen hours.[60] In April 2006, Time Warner's AOL blocked all e-mails mentioning an advocacy campaign opposing AOL's pay-to-send e-mail scheme, but the company said the incident was a "software glitch."[61] Importantly, *In re* Madison River Communications LLC remains the only administratively adjudicated internet-blocking case as of this writing, and no internet-blocking case has ever been brought to a court.

2. Industry Giants in Dispute

ISPs now complain that major internet content providers (ICPs) such as Google, Yahoo, and Microsoft generate too much traffic and that such traffic burdens the network and worsens the experience for general internet users. ISPs have proposed ways to charge ICPs higher fees. For example, AT&T and the former BellSouth proposed to provide better QoS to either their own traffic or to ICPs willing to paying higher fees.[62] Such a scheme has been generally termed a "two-tier" internet.[63] Debates over such proposals turned bitter. Some ISP executives have used hyperbolic language to threaten ICPs with higher fees.[64] Those threats resulted in equally hyperbolic responses from ICPs such as Google, counter-threatening to pursue network neutrality legislation and antitrust law-

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59. *Id.*; *see also In re* Madison River Commc'ns LLC, 20 F.C.C.R. 4295 (2005), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-05-543A2.pdf.

60. *See* CBC News, Telus Cuts Subscriber Access to Pro-Union Website (July 24, 2005), http://www.cbc.ca/canada/story/2005/07/24/telus-sites050724.html.

61. *See* Stefanie Olsen, *AOL charged with blocking opponents' e-mail*, CNET NEWS.COM, Apr. 13, 2006, http://news.com.com/2100-1030_3-6061089.html.

62. *See, e.g.*, Hiawatha Bray, *Telecoms Want Their Products to Travel on a Faster Internet*, BOSTON GLOBE, Dec. 13, 2005, http://www.boston.com/business/globe/articles/2005/12/13/telecoms_want_their_products_to_travel_on_a_faster_internet/?page=full.

63. *Id.*

64. *See, e.g.*, Jonathan Krim, *Executive Wants to Charge for Web Speed*, WASH. POST, Dec. 1, 2005, at D5, *available at* http://www.washingtonpost.com/wp-dyn/content/article/2005/11/30/AR2005113002109.html (analogizing NN to regulating what results Google's search engine can return); Arshad Mohammed, *Verizon Executive Calls for End to Google's "free lunch"*, WASH. POST, Feb. 7, 2006, at D1, *available at* http://www.washingtonpost.com/wp-dyn/content/article/2006/02/06/AR2006020601624.html (accusing Google of enjoying a free lunch by doing business via nothing but cheap servers).

suits.[65] Not surprisingly, telecommunications equipment vendors such as Cisco, Motorola, Qualcomm, and Corning joined their customers to oppose NN because they expected to sell ISPs equipment that enable QoS.[66]

3. Advocacy Groups Adding Heat to the Debate

Numerous advocacy groups are taking strong positions on the network neutrality debate. Among many others, SavetheInternet.com is a NN-supporting coalition,[67] which includes the largest consumer advocacy groups in the nation.[68] Hands Off The Internet is an anti-regulation coalition funded by major telecommunications companies.[69] As of this writing, the SavetheInternet.com coalition has set up an ambitious agenda to push Congress to pass NN laws.[70] Collectively, such advocacy groups have generated much publicity for the NN debate.

B.   Conceptual Development of Network Neutrality Within Academia

Some legal scholars initiated and advocated the network neutrality concept, but they tend to disagree on the scope of NN. Other legal scholars and economists do not believe in NN as a solid public policy. This Section gives a detailed account of these developments.

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65. *See* Mohammed, *supra* note 64 (claiming that NN legislation protects the internet's freedom, consumer choices, economic growth, technological innovation and U.S. global competitiveness); Anne Broache, *Net neutrality debate still simmers*, CNET NEWS.COM, July 11, 2006, http://news.com.com/2100-1028_3-6092927.html (threatening antitrust lawsuits if NN legislation fails).

66. *See* Anne Broache, *Tech manufacturers rally against net neutrality*, CNET NEWS.COM, Sept. 19, 2006, http://news.com.com/2100-1028_3-6117241.html.

67. *See* SavetheInternet.com, http://www.saveteinternet.com (last visited Feb. 27, 2007).

68. *See* SavetheInternet.com Charter Members, http://www.saveteinternet.com/=coalition (last visited Feb. 27, 2007).

69. *See* Hands Off The Internet, http://www.handsoff.org (last visited Feb. 27, 2007); Jeffrey H. Birnbaum, *No Neutral Ground in This Internet Battle*, WASH. POST, June 26, 2006, at D1, *available at* http://www.washingtonpost.com/wp-dyn/content/article/2006/06/25/AR2006062500735_pf.html (reporting the funding sources of Hands Off The Internet).

70. *See* SavetheInternet.com, *supra* note 67.

1. Invention of the Term and a Narrow View on Network Neutrality

In 2002, Professors Tim Wu and Lawrence Lessig expressed their concerns about some cable carriers blocking access to certain websites.[71] Wu and Lessig felt that the behavior was "a threat to the 'neutrality' of the internet,"[72] and in 2003, they sent the FCC an *ex parte* letter proposing a set of network neutrality rules on internet broadband access.[73] They proposed to grant internet users a general right to use their broadband connections as long as the usage was not "publicly detrimental."[74] They also proposed to prohibit carriers from restricting this right,[75] subject to a set of exceptions detailing "publicly detrimental" behaviors.[76]

Separately, Wu studied NN and discriminatory behaviors in the broadband access market in a now widely cited paper published in 2003.[77] He also updated his suggested NN rules in 2004.[78] In 2003, Wu acknowledged that some internet applications required special QoS guarantees.[79] Indeed, Wu and Lessig had explicitly listed QoS provision as an exception to their NN rules.[80] But in 2004 Wu dropped this exception without explanation.[81] Wu also implicitly endorsed price discrimination[82] in internet

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71. *See* Tim Wu, Network Neutrality FAQ, http://www.timwu.org/network_neutrality.html (last visited Jan. 15, 2007).

72. *Id.*

73. *See* Letter from Tim Wu, Associate Professor, University of Virginia School of Law, and Lawrence Lessig, Professor of Law, Stanford Law School, to the Fed. Commc'ns Comm'n (Aug. 22, 2003) (on file with author), *available at* http://www.freepress.net/docs/wu_lessig_fcc.pdf.

74. *Id.* at 13.

75. *Id.*

76. *Id.*

77. *See* Wu, *Network Neutrality, Broadband Discrimination*, *supra* note 57, at 156-62, 173-75.

78. Tim Wu, *The Broadband Debate: A User's Guide*, 3 J. TELECOMM. & HIGH TECH. L. 69, 95 (2004) [hereinafter Wu, *The Broadband Debate*].

79. *See* Wu, *Network Neutrality, Broadband Discrimination*, *supra* note 57, at 149.

80. *See* Wu & Lessig, *supra* note 73, at 13.

81. *See* Wu, *The Broadband Debate*, *supra* note 78, at 95.

82. Price discrimination is a term in economics and "is one of the most prevalent forms of marketing practices." *See generally* Hal Varian, *Price Discrimination*, *in* 1 HANDBOOK OF INDUSTRIAL ORGANIZATION 598 (1987). Standard economics taxonomy uses first-degree, second-degree, and three-degree price discrimination to distinguish different price discrimination scenarios. *Id.* at 601-17; *cf.* CARL SHAPIRO & HAL R. VARIAN, INFORMATION RULES: A STRATEGIC GUIDE TO THE NETWORK ECONOMY 39-81 (1998) (applying the three types of price discrimination to information goods).

services if such discrimination was not based on application types.[83] More generally, he agreed that there existed "both justified and suspect bases of discrimination."[84]

2. Root of the Term and a Broad View on Network Neutrality

To Lessig, however, the NN proposal is just a small example of his general belief that the internet is a platform for innovation and should remain an "innovation commons."[85] Lessig applied a model with three layers—a physical layer, a code (logical) layer, and a content layer—to study a communication system by determining whether each layer of the system is free or controlled.[86] He asserted that the internet has a controlled physical layer, a free code layer, and a somehow controlled but largely free content layer.[87] Lessig centrally asserts that these last two layers together turned the whole internet into an innovation commons.[88]

Lessig based his free-code-layer model[89] partially on an end-to-end principle promoted by some early internet architects, where the principle says that most of the internet intelligence should exist at the edge of the network and within applications, rather than inside the network.[90] Although this principle was articulated in a purely technical context that reflected the state-of-the-art of the internet at the time, Lessig asserted that it was good public policy because it made the internet neutral to applications

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83. *See* Wu, *Network Neutrality, Broadband Discrimination, supra* note 57, at 154 (proposing to use different tiers of service with low, medium, or high bandwidth to eliminate discrimination exclusively based on application types). Wu's language in the 2003 study was vague as to whether he regarded this proposal to be a form of "price discrimination." In economics, Wu's proposal is arguably *product differentiation*, but the boundary between these two marketing practices can sometimes be fuzzy. Jean Tirole, a well-respected economist and competition policy authority, acknowledged the difficulty to "offer an all-encompassing definition" for price discrimination, and pointed out that product differentiation is "also partly an attempt to capture consumer surplus by separating consumers into different groups." JEAN TIROLE, THE THEORY OF INDUSTRIAL ORGANIZATION 133-34 (1988).

84. *See* Wu, *Network Neutrality, Broadband Discrimination, supra* note 57, at 150.

85. *See* LESSIG, *supra* note 30, at 19-23.

86. *Id.* at 23 (using the word "free" in the "freedom" sense).

87. *Id.* at 25.

88. *Id.* at 23, 48, 57-58, 72, 85-86.

89. Lessig attributed the largely free content layer primarily to the open source software movement. *Id.* at 49-61, 72.

90. *See* J. H. Saltzer et al., *End-to-End Arguments in System Design*, 2 ACM TRANSACTIONS ON COMPUTER SYSTEMS 277 (1984), *available at* http://web.mit.edu/Saltzer/www/publications/endtoend/endtoend.pdf.

and thus encouraged innovation.[91] In particular, Lessig argued: (1) innovators with new applications need only to connect their computers to the internet without modifying the network; (2) because the network is not optimized to any particular applications, it is open to innovations not originally imagined; and (3) the principle effects a neutral platform "because the network owner can't discriminate against some packets while favoring others."[92] This last argument is the most general statement of network neutrality and it bans ISPs from prioritizing packets in any way; in particular, ISPs cannot use product differentiation or price discrimination to serve different markets, especially an emerging QoS market.

Lessig's innovation-commons belief was embodied in his proposal of an open access policy for the broadband internet access market.[93] This open access proposal, discussed in the following Section, predated the Wu-Lessig NN proposal and can be regarded as an early version of NN.

3. Open Access: an Early Version of Network Neutrality

For the greater part of the 1990s, phone line dial-up was almost the only residential internet access option in the nation. In the late 1990s, two broadband access options became available: Digital Subscriber Line (DSL) and cable modem service. Under the Telecommunications Act of 1996 ("1996 Act"), the FCC classified DSL service as a "telecommunication service"[94] and subjected to regulation as a "common carrier," meaning that local phone companies must open their wires to competing DSL providers on a nondiscriminatory basis. Under the 1996 Act, however, cable modem service was classified as an "information service,"[95] and thus cable companies could monopolize the cable broadband access market.

Professors Lessig and Mark Lemley worried that this monopoly would further reduce the competition and drive up prices in the broadband market.[96] In a paper published in 2001, they advocated that the FCC adopt an "open access" policy toward cable companies, meaning that cable companies need to open their wires to other ISPs, but do not need to be subject to a full-scale "common carrier" rule.[97] Their focal point, however, was that

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91. See LESSIG, *supra* note 30, at 34-37.

92. *Id.* at 36-37.

93. See Mark A. Lemley & Lawrence Lessig, *The End of End-to-End: Preserving the Architecture of the Internet in the Broadband Era*, 48 UCLA L. REV. 925 (2001).

94. 47 U.S.C. § 153(43), (46) (2000).

95. *Id.* § 153(20) (2000).

96. See Lemley & Lessig, *supra* note 93, at 929, 934-36.

97. See id. at 927-29, 963-64.

the monopoly allowed the cable companies to bundle the access service with other services such as backbone internet services or content services.[98] They argued that this potential vertical integration might damage the end-to-end principle, destroy internet neutrality, and impede internet innovation because it would give cable companies excessive power to improperly influence or even control the internet architecture.[99]

In contrast, Wu has argued that open access is neither a correct nor an effective approach toward network neutrality.[100] Among other things, he argued that open access may prevent broadband operators from "architectural cooperation with ISPs for the purpose of providing QoS dependent applications."[101]

4. Different Views on Network Neutrality

Numerous scholars have taken opposing or cautious views on network neutrality, either from a policy perspective or from an economic perspective. Among them, Professor Christopher Yoo is the leading academic opposing NN. In a series of papers, Yoo has opposed NN on several grounds.[102] He has argued that NN will reduce ISPs' incentives to invest and innovate,[103] that NN will defeat the QoS requirements from newer internet applications,[104] and that the end-to-end principle has been misread into the NN debate.[105]

Professor James Speta has argued that regulations such as NN are unnecessary because ISPs have no incentives to discriminate against independent applications.[106] Adam Thierer has argued that the "dumb pipe" approach toward the internet architecture, as mandated by the end-to-end

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98. *Id.* at 940-43.

99. *Id.* at 943-46.

100. *See* Wu, *Network Neutrality, Broadband Discrimination, supra* note 57, at 147-49.

101. *Id.* at 149.

102. *See* Christopher Yoo, *Would Mandating Broadband Network Neutrality Help Or Hurt Competition? A Comment on the End-to-End Debate,* 3 J. TELECOMM. & HIGH TECH. L. 23 (2004) (criticizing network neutrality) [hereinafter Yoo, *A Comment on the End-to-End Debate*]; Christopher Yoo, *Beyond Network Neutrality,* 19 HARV. J.L. & TECH. 1 (2005) (calling for network diversity rather than network neutrality); Christopher Yoo, *Network Neutrality and the Economics of Congestion,* 94 GEO. L.J. 1847 (2006) (opposing network neutrality by applying an economic theory of network congestion).

103. *See* Yoo, *A Comment on the End-to-End Debate, supra* note 102, at 63.

104. *See id.* at 35-36.

105. *See id.* at 43-46.

106. *See* James B. Speta, *Handicapping the Race for the Last Mile? A Critique of Open Access Rules for Broadband Platforms,* 17 YALE J. ON REG. 39, 84-85 (2000).

principle, is not good public policy, because it oversimplifies the need of emerging internet applications and also discourages the development of competing infrastructures.[107] Thierer also has agreed with Yoo in that NN will reduce ISPs' incentives to invest and innovate.[108]

Professors Joseph Farrell and Philip Weiser gave a informative account of the relationship between vertical integration and antitrust laws in the context of telecommunications.[109] Farrell and Weiser showed that integrative efficiency, subject to certain exceptions,[110] may exist for vertical integrations and can be a rationale against an open access regulation.[111] This view is an answer to Lemley and Lessig's concern on ISPs' service-bundling behaviors.[112] Separately, Weiser has proposed to let the FCC take an antitrust-like, *ex post* approach to ensure competition and prevent discrimination in the internet service market.[113]

C. Regulatory and Legislative Developments

In light of the Wu-Lessig proposal, in February 2004 then FCC Chairman Michael Powell set forth four "Internet freedom" principles: (1) freedom to access content; (2) freedom to run applications; (3) freedom to attach devices; and (4) freedom to obtain service plan information.[114] Noticeably, *Madison River* was adjudicated after those principles were announced.[115] In June 2005, the Supreme Court upheld, in *National Cable & Telecommunications Association v. Brand X Internet Services*, the FCC's classification of cable modem service as an information service.[116] In that case, the FCC filed a declaratory ruling on this classification and the Supreme Court held that the ruling was lawful.[117] Soon after *Brand X*, the

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107. *See* Adam D. Thierer, *Are "Dumb Pipe" Mandates Smart Public Policy? Vertical Integration, Network Neutrality, and the Network Layer Model*, 3 J. TELECOMM. & HIGH TECH. L. 275, 276, 287-91 (2005).

108. *Id.* at 287-88.

109. *See* Joseph Farrell & Philip J. Weiser, *Modularity, Vertical Integration, and Open Access Policies: Toward a Convergence of Antitrust and Regulation in the Internet Age*, 17 HARV. J.L. & TECH. 85 (2003).

110. *Id.* at 105-19.

111. *Id.* at 100-05.

112. *See* Lemley & Lessig, *supra* note 93.

113. *See* Philip J. Weiser, *Toward A Next Generation Regulatory Regime*, 35 LOY. U. CHI. L.J. 41, 74-84 (2003).

114. *See* Michael Powell, *Preserving Internet Freedom: Guiding Principles for the Industry*, 3 J. TELCOMM. & HIGH TECH. L. 5, 11-12 (2004).

115. *See* McCullagh, *supra* note 58.

116. 545 U.S. 967, 985-1000 (2005).

117. *Id.*

FCC reclassified DSL from a telecommunication service to an information service.[118] At the same time, the FCC issued a policy statement that followed the framework of Powell's four "Internet freedom" principles but limited the scope of "freedom."[119] Although this statement sounds like a weak endorsement of NN, proponents of NN have regarded the FCC's reclassification of the DSL market as a threat to NN.[120] In response, they brought their concerns to Congress.

Since the FCC's reclassification of DSL service, Congress has been exceptionally active on network neutrality legislation with Republicans generally opposing it, and Democrats supporting it.[121] Five bills on NN were introduced between March and May 2006, among which the Communications Opportunity, Promotion, and Enhancement Act ("the COPE Act"), a comprehensive bill that aimed to reform the 1996 Act, was the most important one.[122] The COPE Act incorporated the "Internet freedom" principles announced by Powell[123] and gave the FCC limited authority to oversee internet usage discriminations, but such authority has been regarded by some commentators as being even less than what exists under the current law.[124] Representative Ed Markey offered an amendment to the COPE Act with much stronger NN language.[125] On June 8, 2006, the House passed the COPE Act by a vote of 321-101 but failed to pass the

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118. *See* Marguerite Reardon, *FCC changes DSL classification*, CNET NEWS.COM, August 5, 2005, http://news.com.com/2100-1034_3-5820713.html.

119. *See* Federal Communications Commission, Policy Statement FCC 05-151, 20 F.C.C.R. 14986 (adopted Aug. 5, 2005), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-05-151A1.pdf.

120. See Faith in Neutrality, Posting of Susan Crawford to Susan Crawford Blog, http://scrawford.blogware.com/blog/_archives/2005/8/5/1111877.html (Aug. 5, 2005, 07:21 p.m. EST); Lawrence Lessig & Robert W. McChesney, *No Tolls on The Internet*, WASH. POST, June 8, 2006, at A23, *available at* http://www.washingtonpost.com/wp-dyn/content/article/2006/06/07/AR2006060702108.html.

121. *See, e.g.*, Robert D. Atkinson & Philip J. Weiser, *A Third Way on Network Neutrality*, 13 NEW ATLANTIS 47, 48 (2006), *available at* http://www.thenewatlantis.com/archive/13/atkinsonweiser.htm; Declan McCullagh, *House rejects net neutrality rules*, CNET NEWS.COM, June 8, 2006, http://news.com.com/2100-1028_3-6081882.html.

122. *See* McCullagh, *supra* note 4; Communications Opportunity, Promotion, and Enhancement Act of 2006, H.R. 5252, 109th Cong. § 2 (2006), *available at* http://thomas.loc.gov/cgi-bin/query/z?c109:H.R.5252: (version 4, referred to Senate committee after being received from House, June 12, 2006).

123. *See* Powell, *supra* note 114.

124. *See* Atkinson & Weiser, *supra* note 121, at 54.

125. *See* McCullagh, *supra* note 4.

Markey Amendment by a vote of 152-269.[126] None of these bills have been enacted into law.

III. THE MISSING TECHNICAL AND ECONOMIC UNDERSTANDING IN THE NETWORK NEUTRALITY DEBATE

The network neutrality debate immediately puts the interests of many industry giants at stake. Any solution for the debate will likely have profound and enduring social and economic impact. In searching for a solution, it is crucial to differentiate the real problems that NN seeks to solve from the interests of the debating parties. The many dimensions of the debate make this a challenging exercise, because it is hard for anyone to grasp all the technical, economic, legal, and social complexities as well as subtleties of something as big as the internet.

Legal scholars often resort to nonprofessional resources such as trade magazines, journalists, or even other social scientists to understand the technical aspects of the NN debate because it is often quicker and easier to do so.[127] While this might help them in crafting their arguments, they often get incomplete explanations, and this incomplete knowledge then distorts the debate.[128] At the other end, technology professionals often cannot effectively participate in the debate because their technical training and lack of social science background often position them in assisting but not leading roles in a legal debate. All these difficulties are exacerbated by the in-

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126. *See* McCullagh, *supra* note 121.

127. *See, e.g.*, LESSIG, *supra* note 30, at 277-78 nn.69-70 (stating that he learned QoS from another social scientist and citing trade magazines to support his arguments on QoS).

128. For example, the Wu-Lessig proposal stated that "[u]nder the neutrality principle here proposed . . . [u]sers interested in a better gaming experience would then need to buy more bandwidth." Wu & Lessig, *supra* note 73, at 15. However, an application "buying" more bandwidth is simply asking link schedulers in routers for a higher queueing priority—that is the only way the application can "receive" more bandwidth in any packet-switching network such as the internet. But this higher priority is exactly the "discrimination" that many strong network neutrality proponents, including Lessig himself, have condemned. Indeed, it is ironic that Wu's endorsement of this type of "non-application-type-based discrimination" clashes with other NN proponents and advocacy groups. *See supra* note 83 and accompanying text. That is hardly surprising; many of those proponents and advocacy groups do not really understand the technical aspects of either the internet or the buzzword "network neutrality" in the first place. *See infra* Section III.B.3.

fluences of powerful companies that have great financial interests in the debate.[129]

This Part analyzes the network neutrality debate with a focus both on a technical explanation and an economic explanation of NN. Section III.A discusses what NN really means, both as a technical term and as a public policy. Section III.B analyzes the positions and interests of major debating parties.

A.   What Does Neutrality Mean to the Internet?

In the network neutrality debate, nothing is more paramount than agreeing on what "neutrality" means. As Wu has acknowledged, the concept is "finicky" and depends on "what set of subjects you choose to be neutral among."[130] Consider two packets at a router: a packet from an e-mail arriving *slightly* earlier than a packet from a tele-surgery application. Should the router send out the e-mail packet first? An e-mail message can wait for a short while, but a patient under surgery cannot. So is this FIFO order neutral? Such a question inevitably asks for value judgment, but the example used here illustrates a point: NN cannot be debated in the abstract without considering the underlying engineering realities.

1.   The Internet Has Never Been Neutral and Has Never Been Designed to Be Neutral

Contrary to what many NN proponents have asserted,[131] the internet has never been neutral and has never been designed to be neutral. Simplifying the technically complex and elegant TCP/IP into a "dumb pipe"[132] or a "code layer"[133] is both technically inaccurate and conceptually misleading for the NN debate. Examples of this non-neutrality abound, but this Note focuses on those that are most fundamental to the internet.

In Request for Comment (RFC) 791, the RFC that was published in 1981 to define an IP packet, a Type of Service (TOS) field was defined for every IP packet. This TOS field was designed to convey QoS information, such as "precedence," "delay," and "throughput."[134] The field is mandato-

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129. *See, e.g., supra* notes 62, 64-66 and accompanying text.

130. *See* Wu, *Network Neutrality, Broadband Discrimination, supra* note 57, at 147-48.

131. *See, e.g.,* Dynamic Platform Standards Project, Introduction and Summary for Congressional Staff, http://www.dpsproject.com/CongressSummary.html (last visited Feb. 27, 2007) ("[T]he Internet is, in fact, neutral.").

132. *See* Thierer, *supra* note 107, at 281.

133. *See* LESSIG, *supra* note 30, at 23.

134. *See* Information Sciences Institute, *supra* note 50.

ry and it takes one full byte, which is significant in protocol design.[135] As explicitly indicated in RFC 791, the early internet architects were seriously considering QoS and packet prioritization.[136] IPv6, the newer version of IP published in 1995, emphasized QoS even more.[137] As FIFO scheduling does not need information in a TOS field, the dominance of FIFO on the internet shows that TOS has not been utilized much. Such a result, however, was due to the facts that (1) FIFO is very simple; (2) it is very difficult to implement complex link schedulers;[138] and (3) real-time applications emerged only recently. The result was not because of a "neutrality" principle.

Border Gateway Protocol (BGP) is the most important routing protocol for the internet.[139] RFC 1105, the first RFC on BGP that was published in 1989, specified policy routing as a fundamental design goal.[140] In non-technical terms, this means AT&T routers can make discriminatory routing decisions such as treating traffic from Sprint more favorably than traffic from Verizon, or even rejecting Verizon traffic altogether. In practice, almost all routers from Cisco and Juniper, the two dominating router vendors that have consistently captured more than eighty percent of the world's internet router market in the past, provide rich functions for ISPs to implement such routing policies on a daily basis.[141]

Nor is TCP, the key Transport Control Protocol of the internet, neutral. In Lessig's view, every internet application has the freedom to send pack-

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135. In network protocol design, a mandatory byte in a packet is significant because the byte can convey a lot of control information. It would be a significant waste of network resources to add a byte of no use to every IP packet.

136. *See* Information Sciences Institute, *supra* note 50, at 1 ("The Type of Service is used to indicate the quality of the service desired.").

137. *See* Stephen E. Deering & Robert M. Hinden, Internet Protocol, Version 6 (IPv6) Specification 25 (1998), http://www.ietf.org/rfc/rfc2460.txt (using a 20-bit field in an IP packet to carry QoS information).

138. *See* Itamar Elhanany et al., *Packet Scheduling in Next-Generation Multiterabit Networks*, 34 IEEE COMPUTER 104 (2001) (commenting that implementing smart schedulers under heavy traffic loads is a difficult task).

139. *See* PERLMAN, *supra* note 51.

140. *See* Kirk Lougheed, A Border Gateway Protocol (BGP) (1981), http://www. ietf.org/rfc/rfc1105.txt (stating that "policy decisions at an AS level may be enforced").

141. *See, e.g.*, Cisco Systems, Connecting to a Service Provider Using External BGP, http://www.cisco.com/en/US/products/ps6350/products_configuration_guide_chapter091 86a0080446c4a.html (last visited Feb. 27, 2007) (BGP configuration manual for Cisco routers); Juniper Networks, BGP Configuration Guidelines, http://www.juniper.net/ techpubs/software/junos/junos82/swconfig82-routing/html/bgp-config.html (last visited Feb. 27, 2007) (BGP configuration manual for Juniper routers).

ets without consulting with the network because the network should not have intelligence under the end-to-end principle.[142] As discussed in Section I.B above, TCP implements congestion control by voluntarily reducing the data rate of its application, even if the application is not an actual contributor to the congestion. From that application's perspective, however, its TCP is part of the network.[143] Thus, the network indirectly discriminates the application via its TCP,[144] and the application certainly cannot send data "at will."

2. Neutrality as a Public Policy for the Internet

The social and economic dimensions of the network neutrality debate center around internet innovation. Proponents argue that application innovations, especially those from individuals or "garage"[145] innovators, need NN protection because traffic prioritization may deny their access to the internet completely.[146] Opponents argue that NN will deter network innovation because it will discourage ISPs from investing in the network infrastructure.[147]

A dilemma about the relationship between a network and its applications can shed some light on the NN debate: do new applications drive the development of a better network or does a good network drive the development of newer applications? To support newer applications, such as tele-surgery, that have heavy traffic and strict real-time requirements, the network needs faster hardware, faster physical links, better algorithms, more sophisticated and more stable software, and possibly even a better architecture. Enhancing such network capacities requires significant investments in scientific research, engineering development, and large-scale network upgrades. Such investments can be justified only if newer applications are emerging either to predictably make the investments profitable,

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142. *See* LESSIG, *supra* note 30, at 36-38.

143. This is because the application software runs on the top of TCP. *See supra* note 20; BERTSEKAS & GALLAGHER, *supra* note 6, at 17-20 (discussing the architectural principle of layering that the internet has followed).

144. Here the instant well-behaving application and other bandwidth-hogging applications are equally "punished." This type of discrimination is similar to a form of price discrimination where identical products with different costs are sold at the same price. *See* Varian, *supra* note 82, at 598.

145. *Cf.* Atkinson & Weiser, *supra* note 121, at 47 (calling small application companies "garage" companies).

146. *See, e.g.*, Lemley & Lessig, *supra* note 93, at 932; Wu, *Network Neutrality, Broadband Discrimination, supra* note 57, at 153.

147. *See supra* notes 103 and 107 and accompanying text.

in the case of private investments, or to significantly utilize the enhanced network capacities to generate social values, in the case of governmental investments.[148] On the other hand, developing new major applications usually takes considerable time and institutional resources; motivation to develop such applications will be seriously dampened if the network stops its evolution and does not technically support those applications.[149] This is a classic chicken-and-egg problem. The past evolution of the internet, however, had a simple answer for this problem: both the network development and the applications development were incremental, and they drove each other in a positive feedback loop. More specifically, a few new applications such as the World Wide Web generated more traffic and greater demand for a faster network, which stimulated ISPs to build a somewhat, but not revolutionarily better network. This marginally improved network gave the birth of a few even newer applications such as online stock trading and internet chat, which in turn stimulated the building of an even better network. This positive feedback loop continued to drive the internet's evolution forward.

The NN debate is partially a chicken-and-egg dilemma in the following sense. The development of major QoS-oriented applications needs QoS support from the network, but uncontrolled QoS provision may, as those NN proponents have worried, stifle garage innovation if the innovators cannot receive meaningful bandwidth under the product differentiation regimes that would be in place. The evolution of the internet has witnessed both institutional and garage-based innovations. From a technical perspective, the incremental nature of the internet's evolution makes those garage innovations, which are typically smaller application innovations such as Wikipedia, particularly significant. From an economic perspective, the many application innovations discussed by Lessig[150] have not only directly driven up the demand side of the networking market, but also naturally generated the *network effect* that is invaluable to an information economy.[151] Although it is important to protect and encourage garage innovation, it is also critical to sustain ISPs' incentives to invest so that ma-

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148. The internet, however, has been privatized since the early 1990's. Its current size makes it nearly impossible for any government to make significant and meaningful investments.

149. It may be argued that garage innovators can develop many "minor" new applications without major network evolution. However, the mileage of those innovators, although better than that of institutional developers of major new applications, is still limited if the network stops evolving.

150. See LESSIG, *supra* note 30, at 120-36.

151. See SHAPIRO & VARIAN, *supra* note 82, at 13-14, 183-84.

jor new applications, which typically require institutional efforts, will have a capable network as their platform.

The NN proposals try to protect garage innovation by banning QoS-based product differentiation or even traffic prioritization altogether. They solve one problem of the dilemma but exacerbate the other more serious problem. They may even defeat themselves in the sense that they will impede institutional application innovation. The key policy challenge in the NN debate is to strike a balance between incentives and monopolies. This challenge, however, is a familiar issue in many intellectual property laws.

B.   The Interests and Stakes of the Debating Parties

1.   The Dilemma and Fallacies of ISPs

The chief problem that ISPs face is a pricing model crisis—they cannot serve all available markets and cannot capture the consumer surplus in an emerging QoS market. QoS, which has received extensive research in the last twenty years,[152] had not been practically available until recently. Due to this limitation and other technical and marketing difficulties, ISPs were forced to adopt a flat-rate pricing model to sell their bandwidth in the early days of the internet. Commercial and individual customers have become used to this model for many years and now take it for granted. Now that ISPs are ready to capture some consumer surplus via QoS-based product differentiation, they just have found that they are locked into this flat-rate model.[153]

Capturing consumer surplus via product differentiation is not illegal. Capturing consumer surplus via price differentiation is not illegal in most

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152. *See* KUROSE & ROSS, *supra* note 5, at 636 (discussing numerous unsuccessful attempts on QoS by the networking community in the last twenty years).

153. QoS-based product differentiation can also be regarded as a form of second-degree price discrimination on bandwidth. Fundamentally, ISPs sell as QoS the "timeliness" of the usage of their communication links. Applications not receiving QoS may still have their traffic—of exactly the same amount—delivered by the network; they just experience larger, more unpredictable packet delays than those QoS-receiving applications do. *See* SHAPIRO & VARIAN, *supra* note 82, at 39, 53-63 (applying a more flexible definition of second-degree price discrimination, termed as "versioning," for information goods). *But cf.* Varian, *supra* note 82, at 600 (applying a traditional definition of second-degree price discrimination based on quantity of goods); *cf.* TIROLE, *supra* note 83 (suggesting that classes in airplanes might be a form of price discrimination). It is noteworthy that, as to price discrimination, bandwidth of a packet network seems to be a good that differs from all traditional goods, including information goods. The reason seems to be that bandwidth has both a rivalrous nature and a "timeliness" nature.

cases.[154] However, some ISP executives have both exaggerated and done an embarrassing publicity job. For example, when a vice president of Verizon alleged that Google "enjoy[ed] a free lunch,"[155] he forgot that Google had paid its internet service fees. Although Google might have taken more bandwidth than Verizon originally expected, such expectation, if any, was not part of the service contracts between Google and Verizon.

The exaggeration by ISPs has technical dimensions as well. First, most of the current internet content does not generate interactive real-time traffic, but only non-real-time or non-interactive real-time traffic that consumes vast bandwidth due to its volume. Second, and also as a business issue, QoS provision today is far from satisfactory. Because QoS provision is end-to-end, every router along the path from a source computer to a destination computer must participate in the provision. But the sheer size of the internet makes it impossible for any single ISP to provide end-to-end internet services; instead, ISPs must interconnect with one another.[156] Consequently, ISPs need to cooperate to provide true end-to-end QoS, but in general this cooperation proves difficult.[157] In summary, although the heavy traffic generated by ICPs today does cause network congestion that hurts other "innocent" applications, ISPs should not charge premiums on such traffic, either under existing service contracts or in the name of QoS.

2.   The Rights and Obligations of ICPs

Because of the ubiquitous flat-rate ISP service contracts and the competitive nature of fixed network resources, the ever-increasing traffic volume generated by ICPs has indeed caused a "tragedy of the commons"[158] problem for bandwidth consumption. Despite this problem, the ISPs do not have the right to *block* the sites or contents of those ICPs for two closely related reasons. First, as discussed above, this tragedy-of-the-commons problem does not result in a breach of the flat-rate contracts. Second, the ISPs have an implied-warranty duty under contract law not to block; blocking is different from downgrading internet services as blocking means no service at all. On the other hand, the flat-rate contracts pro-

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154. *See* Varian, *supra* note 82, at 598 and accompanying text. Illegal price discrimination under the Robinson-Patman Act, 15 U.S.C. § 13, represents a narrow exception to this general statement.

155. *See* Mohammed, *supra* note 64.

156. *See* KUROSE & ROSS, *supra* note 5, at 636.

157. *Id.*

158. *See* Garrett Hardin, *The Tragedy of the Commons*, 162 SCI. 1243 (1968).

vide no guarantee that the ISPs cannot downgrade the services to a certain degree.

Concerns about ISP's blocking behavior, however, have been largely historical. The FCC set a precedent to ban such discriminatory behavior in *Madison River*.[159] The FCC policy statement in August 2005 reaffirmed the agency's position to follow the *Madison River* precedent.[160] Nevertheless, ICPs tend to use those narrow and obsolete examples of blocking in order to launch a wholesale attack on QoS, and cloak their bandwidth tragedy-of-the-commons behavior.

3. The Motivations and Irrationalities of Consumers

Because the ISP market—in particular the broadband access market—has limited competition, consumers in general need some protection to deter market power abuse. This is the traditional realm of antitrust law, not telecommunications policy. Many consumers are both the initiators *and* the victims of the bandwidth tragedy-of-the-commons problem, which is the essence of the term "tragedy:" on one hand, they generate heavy traffic when they retrieve contents from ICPs; on the other hand, they downgrade the services of each other by their own bandwidth-hogging behavior. For consumers, codifying network neutrality is probably overkill because it is much stronger than antitrust law. Moreover, it is a double-edged sword because it may prevent many useful QoS-based applications from taking off. Nevertheless, consumer advocacy groups, exemplified by SavetheInternet.com, decided to fight together with the ICPs to advocate NN.

Two explanations exist for such irrational positions. First, most consumers do not understand NN in either a technical sense or an economic sense, but they can be easily provoked by abstract terms such as "net freedom," "digital democracy," or "consumer rights" that are used by NN proponents.[161] For many of those consumers, QoS provision sounds like a

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159. *See* McCullagh, *supra* note 58.

160. *See supra* notes 58-59 and note 119 and accompanying text.

161. *See, e.g.*, Jon Leibowitz, Comm'r, Fed. Trade Comm'n, Remarks at the Broadband Connectivity Competition Policy Workshop: Navigating Between Dystopian Worlds on Network Neutrality, With Misery and Wretchedness on Each Side, Can We Find A Third Way? (Feb. 13, 2007), http://www.ftc.gov/speeches/leibowitz/070213 Navigating_Between_Dystopian_Worlds.pdf (discussing Powell's four "Internet freedom" principles and consumer rights on the internet); Free Press, The Struggle for Net Freedom, http://www.freepress.net/netfreedom (last visited Feb. 27, 2007); Bryan Zandberg, *Canada Sleeps Through War to 'Save the Internet'*, THE TYEE, Jan. 17, 2007, http://thetyee.ca/Mediacheck/2007/01/17/NetNeutrality ("Digital democracy at risk if telecoms get their way say opponents.").

new conspiracy among monopolistic ISPs,[162] while few of those consumers know that the networking community started QoS research at least twenty years ago.[163] Second, because QoS-based product differentiation may significantly limit or even eliminate bandwidth-hogging, people may perceive an imminent threat to an existing privilege, and simply react by trying to fend off that threat.

IV. A MIDDLE-GROUND PROPOSAL

Based on the analyses above, a working middle-ground solution to the network neutrality debate needs to: (1) allow ISPs to serve an emerging QoS market; (2) sustain and encourage garage innovation; (3) give consumers meaningful protection; and (4) treat all ISP customers, including the ICPs, fairly. This Part proposes such a solution and explains how it meets these four objectives.

A. Protecting Garage Innovation Under QoS Provision

Robert Atkinson, president of the Information Technology and Innovation Foundation, and Professor Philip J. Weiser published a moderate proposal in 2006 that addressed some of the objectives enumerated above.[164] Extending Weiser's earlier idea,[165] they proposed to give the FCC antitrust-like regulatory power to protect consumers. They also proposed that the FCC mandate that ISPs use "some not insignificant portion of the broadband bandwidth" to provide basic internet services. This last idea and some more sophisticated versions of it, however, have been well known in the networking community for many years, a fact suggesting that the current NN debate has not attracted enough attention from the technical community.[166]

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162. *See* Christopher Stern, *The Coming Tug of War Over the Internet*, WASH. POST, Jan. 22, 2006, at B1, *available at* http://www.washingtonpost.com/wp-dyn/content/article/2006/01/21/AR2006012100094_pf.html. ("But the nation's largest telephone companies have a new business plan.").

163. *See* KUROSE & ROSS, *supra* note 5, at 636.

164. *See* Atkinson & Weiser, *supra* note 121, at 55-58.

165. *See* Weiser, *supra* note 113.

166. For example, the once hyped but largely failed Asynchronous Transfer Mode (ATM) network offers an Available Bit Rate (ABR) service for non-real-time applications. *See* ATM Forum Technical Committee, Traffic Management Specification Version 4.0, at 5 (1996), http://www.mfaforum.org/ftp/pub/approved-specs/af-tm-0056.000.pdf. ABR has a Minimum Cell Rate (MCR) parameter that sets a lower bound on the bandwidth that an application can receive. *Id.* Essentially, ATM reserves a portion of its bandwidth to serve applications having no QoS requirements.

This Note argues that QoS provision can co-exist with garage innovation protection. More specifically, a certain fraction of network bandwidth can be reserved to protect garage innovation, and the rest of bandwidth can be used for QoS provision. This is technically feasible, as will be explained below.

B.   How It Works

Understanding and appreciating the idea above requires a detailed discussion of link-scheduling algorithms. As discussed in Section I.D, a router controls packet queuing delays mainly via link schedulers. By controlling the sending-order of packets, a link scheduler effectively distributes the link bandwidth among applications. This can be better understood by studying the traffic-control mechanism at freeway entrances in many metropolitan areas. At such an entrance, two or more ramps lead to a single on-ramp of a freeway. During rush hour, one of the ramps is an express lane for carpools. A traffic light controls the ramps and one car goes per green signal at the car's ramp. By controlling the interval lengths between the green signals at each ramp, the traffic light can assign different fractions of the highway passage to the ramps, and the carpool ramp can receive a faster passage. However, any other ramp can still receive a fraction of the passage and will not be starved. In computer networking, such a scheduling scheme is known as Weighted Fair Queuing (WFQ), which was a breakthrough in QoS research.[167] Very sophisticated link schedulers based on WFQ can deliver very flexible QoS services, although it is in general difficult to implement any complex scheduling algorithms such as WFQ.[168]

In theory, ISPs can dedicate all or most of their bandwidth to QoS provision; other applications not paying premiums may only be served on a "best effort" basis, which means their packets will consume the residual bandwidth, if any, in a FIFO order. The residual bandwidth can go down

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167. *See* KUROSE & ROSS, *supra* note 5, at 625 ("WFQ plays a central role in QoS architectures."). The WFQ algorithm is generally credited to the Ph.D. work of Abhay Parekh of MIT. The idea itself was arguably not a breakthrough, as the highway entrance example shows. However, Parekh proved that, with WFQ at each router, a deterministic end-to-end delay bound can be guaranteed to an application that has reserved a minimum bandwidth at each intermediate router. *See* Abhay Parekh & Robert Gallagher, *A Generalized Processor Sharing Approach to Flow Control—The Single Node Case*, 1 IEEE/ACM TRANSACTIONS ON NETWORKING 344 (1993); Abhay Parekh & Robert Gallagher, *A Generalized Processor Sharing Approach to Flow Control—The Multiple Node Case*, 2 IEEE/ACM TRANSACTIONS ON NETWORKING 137 (1994).

168. *See* Elhanany et al., *supra* note 138.

to zero in the worst case. This situation is similar to a highway on-ramp where no signal exists for the carpool ramp and the signals at other ramps are always red if at least one car exists on the carpool ramp. Thus, in theory, the carpool ramp can take almost all the passage and starve the other ramps. Many NN proponents have challenged such a situation vigorously. Indeed, as in the blocking case, even for applications not paying premiums, ISPs have an implied-warranty duty to avoid such a starvation or near-starvation. With advanced link schedulers, however, ISPs can eliminate such starvation by reserving a nontrivial fraction of their bandwidth to provide the "typical" services of today, although all applications not paying premiums need to share this reserved bandwidth and the bandwidth tragedy-of-the-commons problem may still exist among those applications.

C.   A Counter-argument and a Rebuttal

Network neutrality proponents may argue that this bandwidth reservation scheme effectively downgrades the services of those non-premium-paying applications from their current levels. This argument, while valid, is economically misplaced.

For a simplified illustration, assume that the reserved fraction of bandwidth is set at fifty percent. With the remaining fifty percent of bandwidth set aside to serve the QoS market, ISPs can increase their profits and then invest in a faster internet in response to greater QoS demands. With a QoS market taking off, such a feedback loop is positive and the ISPs could triple the capacity of the internet within a certain period of time. This calculation is realistic because a QoS-enabling network will incubate many newer QoS-based applications demanding for larger network capacities. While this positive feedback occurs, the reserved bandwidth will also increase three-fold, and will then be fifty percent larger than what it is now. In contrast, if the ISPs are discouraged from investing, the capacity of the internet may stay relatively flat for a long time. Clearly, the proposed scheme can sustain garage innovation as well as promote it via steadily driving the internet's evolution. Thus, internet traffic prioritization can both coexist with and encourage internet innovation, including network innovation, institutional application innovation, and garage application innovation.

D.   The Other Objectives to Be Achieved

Protecting consumers and enforcing fair dealing across all ISP customers do not present any problems if the market is competitive and has FCC policies as well as antitrust laws present in the background, where

competition will assure fair treatment of all customers. Perhaps new inter-
net service contracts with non-flat-rate billing will be written, but competi-
tion will prevent ISPs from overcharging specific customers. It is possible,
and indeed likely, that when the market reaches its equilibrium, ICPs will
pay more than what they do now, even without requesting QoS. This will
be, however, because the ICPs currently are enjoying a historical pricing-
model lock-in and treating the flat-rate bandwidth as a commons, not be-
cause they will receive discrimination in the future.

A counter-argument for this last analysis is that since the current com-
petition in the broadband access market is limited, there is no guarantee of
fair dealing. This Note argues otherwise. First, as other commentators
have argued, current FCC policies (as suggested by *Madison River*), newer
antitrust-like FCC policies, or even antitrust law itself can help enforce
fair dealing.[169] Second, the limited competition in the current broadband
access market should not be taken as a given; newer broadband access
technologies such as wireless, power-line, metro-Ethernet or optical-fiber
are technically available now, although with small penetration rates and
high initial costs. The policy-making focus should be on solving the com-
petition problem by stimulating those new technologies to establish a more
competitive market, rather than artificially neutralizing the problem by
stifling the evolution of the internet via regulation.

V.   CONCLUSION

The network neutrality debate is complicated. Navigating it requires a
solid understanding of the technical details of the internet and some eco-
nomic aspects of internet evolution. As a living engineering miracle, the
internet has never been neutral and has never been designed to be neutral.
Rather, it has been designed to be practical and it continues to evolve in a
practical way. Many of the current arguments in the debate are misplaced,
prejudiced or hyperbolic. The fundamental policy goal should be striking a
balance between securing incentives for network innovation as well as in-
stitutional application innovation, and protecting garage application inno-
vation. Driven by their respective financial interests, ISPs and ICPs essen-
tially dispute, under the name of network neutrality, their legacy internet
service contracts, which are increasingly problematic with today's tech-
nical and economic realities on the internet. This Note has proposed a
technically feasible middle-ground solution to the debate. The solution is

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169. *See* Atkinson & Weiser, *supra* note 121, at 55-58.

to use bandwidth reservation to protect garage innovation under QoS pro-
vision.