

# Promoting Broadband Through Network Diversity

Christopher S. Yoo

Introduction.....	1
I. Network Neutrality’s Misplaced Focus on the Wrong Policy Problem .....	8
A. Network Neutrality and Vertical Integration .....	8
B. The Insights of Vertical Integration Theory .....	11
II. The Relationship Between Broadband Networks and Content/Applications Providers.....	14
A. The Inherent Nonneutrality of Network Neutrality .....	16
B. Network Diversity and the Sources of Market Failure .....	22
1. Supply-Side Sources of Market Failure: Large, Up-Front Capital Investments.....	23
2. Demand-Side Sources of Market Failure: Network Economic Effects .....	27
C. Network Diversity and Investment Incentives.....	29
D. Implementation Difficulties Caused by the Decommodification of Network Usage .....	34
III. The Relationship Between Broadband Networks and End Users.....	38
IV. Debunking the Arguments in Support of Network Neutrality.....	44
Conclusion .....	53

# Promoting Broadband Through Network Diversity

Christopher S. Yoo\*

## INTRODUCTION

During proceedings before Congress and the Federal Communications Commission (FCC) about whether and how broadband networks should be regulated, a group of commentators led by Lawrence Lessig has put forward a series of proposals that can comfortably be grouped within the broad rubric of *network neutrality*.<sup>1</sup> These commentators are concerned that deviating from the universal interoperability that currently characterizes the Internet would inflict irreparable harm to the market for Internet content and applications. They thus endorse regulations requiring network owners to adhere to the nonproprietary protocol currently used on the Internet (known as the *transmission control protocol/Internet protocol* or TCP/IP). They would also prohibit network owners from entering into exclusivity arrangements with content and applications providers or from imposing use restrictions on end users.

There can be no question that network neutrality has an intuitive appeal. Universal interoperability provides substantial economic benefits to end users, network owners, and providers of Internet applications and content. Interoperability is also familiar to anyone accustomed to the atmosphere that pervades the narrowband Internet, in which end users dial in to the Internet using conventional dial-up modems. Furthermore, network neutrality hearkens back to the regime used to foster competition in telephone equipment (known as customer premises equipment or CPE), long distance, and enhanced services (i.e., services that use

---

\* Professor of Law, Vanderbilt University. This research paper draws on *Beyond Network Neutrality*, 19 HARV. J.L. & TECH. 1 (2005); *Network Neutrality and the Economics of Congestion*, 94 GEO. L.J. (forthcoming 2006); and *Would Mandating Network Neutrality Help or Hurt Broadband Competition?: A Comment on the End-to-End Debate*, 3 J. ON TELECOMM. & HIGH TECH. L. 23 (2004).

<sup>1</sup> See, e.g., LAWRENCE LESSIG, *THE FUTURE OF IDEAS* 46-48, 155-76, 246-49 (2001).

modems to enable telephone networks to convey computer-related traffic in addition to voice communications).<sup>2</sup> Concepts like openness and neutrality would also seem to promote such widely held values as equality of treatment and freedom of choice.

That said, when deciding whether to impose network neutrality as a regulatory mandate, the key question is not whether network neutrality provides substantial benefits. (Indeed, to the extent that particular practices are sufficiently beneficial, private actors generally do not need to be compelled to adhere to them.) The key theoretical inquiry is whether deviating from government-mandated and government-supervised network neutrality might yield economic benefits, because it is these benefits that would be foreclosed if network neutrality were imposed. As the Supreme Court recognized in assessing the parallel question of whether to declare a business practice illegal *per se* under the antitrust laws, the key question is whether the challenged practice evinces such a “pernicious effect on competition” and such a “lack of any redeeming virtue” that nothing would be lost if it were “presumed to be . . . illegal without elaborate inquiry as to the precise harm [it] ha[s] caused or the business excuse for [its] use.”<sup>3</sup> In the absence of a clear competitive harm, the standard response under competition policy is to forbear from categorically prohibiting the challenged practice and instead to evaluate its effect on competition on a case-by-case basis.<sup>4</sup> Any other rule would short circuit the process of experimentation with new products and alternate organizational forms essential to a properly functioning market.

The key regulatory question thus turns on whether imposing network neutrality would forestall the realization of important economic benefits. Closer inspection reveals that the costs

---

<sup>2</sup> Enhanced services largely coincide with the regulatory category known as *information services*.

<sup>3</sup> *N. Pac. Ry. Co. v. United States*, 356 U.S. 1, 5 (1957).

<sup>4</sup> *See White Motor Co. v. United States*, 372 U.S. 253, 262-63 (1963).

and benefits associated with network neutrality is more complex than network neutrality proponents suggest.

My analysis reveals that network neutrality proponents are focusing on the wrong policy problem. One of the key insights of vertical integration theory is that markets yield efficient outcomes only if every link of the chain of production is sufficiently competitive. As a result, competition policy should focus on identifying the link that is the most concentrated and the most protected by entry barriers and design regulations to increase its competitiveness.

In the broadband industry, the level of production that is the most concentrated and protected by barriers to entry is the “last mile.” This implies that decisions about Internet regulation should be guided by their impact on competition in that portion of the industry. Rather than adopt this orientation, network neutrality advocates direct their attention to preserving and promoting competition among providers of content and applications, which is the level of production that is already the most competitive and the most likely to remain that way.<sup>5</sup> In directing their efforts towards promoting competition in applications and content, network neutrality focuses on the wrong policy problem.

Once improving the competitiveness of the last mile becomes the central goal of broadband policy, it becomes clear that network neutrality is potentially problematic and counterproductive. Indeed, the term *network neutrality* is something of a misnomer: Adoption of any standardized interface has the inevitable effect of favoring certain applications and disfavoring others. For example, TCP/IP routes packets anonymously on a “first come, first served” and “best efforts” basis. As a result, it inherently disfavors applications that are less

---

<sup>5</sup> There may be some types of local content that may be less subject to competition. As I will argue later, the proper solution to problems, if any, related to access to such content is a targeted, case-by-case approach rather than a sweeping regulatory mandate that affects all content and applications.

tolerant of variations in throughput rates, such as streaming media and Internet telephony (also known as *voice over Internet protocol* or VoIP), and is biased against network-based security features to protect e-commerce and ward off viruses and spam. It also favors innovation at the network's edge over innovations in the network's core even though, as the FCC has recognized, there is no reason to believe *a priori* that such a preference will always prove beneficial.<sup>6</sup> Thus, contrary to what the nomenclature might suggest, network neutrality is anything but neutral. Indeed, using regulation to standardize interfaces has the unfortunate effect of putting the government in the position of picking technological winners and losers.

Furthermore, network neutrality can reinforce the sources of market failure in telecommunications markets by exacerbating the impact of up-front, fixed costs and by network economic effects. Conversely, economic theory shows how allowing network owners to differentiate the service they offer can allow smaller producers to survive despite having lower sales volumes and higher per-unit costs by differentiating their offerings to appeal to a subsegment of the larger market. Such solutions are quite common in other industries. For example, it is the same mechanism that allows specialty stores to survive despite competition from low-cost, mass market discounters. Differentiation allows them to retain those customers who place a higher value on a particular type of product despite the fact that prices may be somewhat higher.

A similar solution is possible in the broadband industry. Allowing network owners to differentiate their networks can better satisfy the increasing heterogeneity of end user demand. In addition, increasing the number of dimensions along which networks compete can mitigate supply-side and demand-side economies of scale that cause market concentration. In short,

---

<sup>6</sup> Appropriate Framework for Broadband Access to the Internet over Wireline Facilities, Report and Order and Notice of Proposed Rulemaking, 20 F.C.C.R. 14853, ¶¶ 70-71 (2005) [hereinafter Wireline Broadband Order].

network diversity might make it possible for three different types of last-mile networks to coexist: one optimized for traditional Internet applications such as e-mail and website access; another incorporating security features to facilitate e-commerce and to guard against viruses, spam, and other undesirable aspects of life on the Internet; and a third that prioritizes packets in the manner needed to facilitate time-sensitive applications such as streaming media and VoIP. Each would survive by catering to the market subsegment that places the highest value on a particular type of service.

At the same time, network neutrality threatens to dampen incentives to increase competition through the construction of new networks. Requiring network owners to share the benefits of any improvements to their networks with their competitors curtails the motivation of incumbents to upgrade existing networks. Moreover, by providing all applications and content providers with access to the existing network, network neutrality deprives would-be builders of alternative network capacity of their natural strategic partners. Concerns about dampening investment incentives carry little weight when last-mile competition is infeasible, as was arguably the case when interconnection and standardization was mandated with respect to CPE, long distance, and enhanced services. They are paramount when entry by new last-mile providers is ongoing and other last-mile technologies are waiting in the wings, as is the case with broadband. Under these circumstances, regulation imposed to curb market concentration can turn into the source of, rather than the solution to, market failure.

What emerges is a vision of competition that is quite different from that envisioned by the current debate. Extended to its logical conclusion, this analysis would suggest that public policy would be better served if Congress and the FCC were to embrace a *network diversity* principle that permits network owners to deploy proprietary protocols and to enter into

exclusivity agreements with content providers. Although the idea of competition between noninteroperable protocols may seem at first blush to be somewhat problematic, there are precedents for this sort of competition even in the communications industry. For example, wireless telephone providers operating in the U.S. have deployed networks using three competing standards -- Time Division Multiple Access (TDMA), which is being replaced by Global System for Mobile Communications (GSM), and Code Division Multiple Access (CDMA) -- without inconveniencing consumers to a significant degree. Indeed, the experience with wireless telephony highlights the economic benefits that can flow from competition among standards. Had the U.S. followed Europe's example and adopted a uniform standard for second-generation wireless telephony, it would have precluded the realization of the benefits associated with CDMA, which supports a broader range of data services, makes more efficient use of spectrum, and provides the most straightforward migration path to the next generation of wireless technologies.<sup>7</sup>

Conversely, preventing network owners from differentiating their offerings would forestall one of the primary mechanisms through which markets solve economic problems. In other words, network neutrality would have the effect of narrowing the dimensions of competition, forcing networks to compete solely on the basis of price and network size. This commodification of bandwidth would reinforce the advantages enjoyed by the largest players.

This is not to say that network diversity would be a panacea. Whether it would promote competition depends on a host of contextual factors that will vary from case to case. When faced with such a situation, competition policy recognizes that the best response in the face of uncertainty is forbearance. Until we can tell whether adhering to or deviating from complete

---

<sup>7</sup> See *id.* at 329-30; Philip J. Weiser, *The Internet, Innovation, and Intellectual Property Policy*, 103 COLUM. L. REV. 534, 586-87 (2003).

interoperability would be the better course of action, competition policy would counsel in favor of permitting both architectures to go forward. Intervening by mandating network neutrality would have the effect of locking the existing interfaces into place and have the inevitable effect of foreclosing experimentation into new products and alternative organizational forms that transcend traditional firm boundaries. Indeed, as I will subsequently discuss in greater detail, the transition from narrowband to broadband technologies is fundamentally altering the role of middle-market providers of Internet access.<sup>8</sup> Policymakers considering whether to impose access requirements on an industry undergoing dynamic technological change must confront the real possibility that regulation could entrench an architecture that has become obsolete.

The decision to permit network diversity to emerge does not ultimately depend on the conviction that it would yield a substantively better outcome, but rather from a technological humility that permits exploration to proceed until policymakers can make a clearer assessment of the cost-benefit tradeoff. Even if network diversity raises competitive problems in certain circumstances, competition policy would forego a blanket regulatory solution in favor of one that can be applied in only those circumstances where it is warranted. In this sense, network diversity is not the mirror image of network neutrality, in that it does not call for the imposition of any mandatory obligations. Rather, network diversity adopts the more modest position that regards regulatory forbearance as the appropriate course of action when confronted with ambiguity. Network diversity also accords better with the institutional capabilities of the FCC. One of the principal drawbacks about network neutrality is that it depends on regulatory tools that have become increasingly suspect and implicitly presupposes that regulation will continue

---

<sup>8</sup> See *infra* notes 58-59 and accompanying text.

indefinitely. Network diversity, in contrast, has the advantage of having embedded within it a built-in exit strategy

## I. NETWORK NEUTRALITY'S MISPLACED FOCUS ON THE WRONG POLICY PROBLEM

Network neutrality's central concern is that owners of cable modem and DSL systems will use their control over the last mile to harm applications and content providers. This Part demonstrates how network neutrality is fundamentally a concern about vertical integration. Section A maps network neutrality onto the two leading approaches for modeling the structure of the broadband industry. Section B draws on the insights vertical integration theory to show that network neutrality proponents are focusing on the wrong policy problem. Broadband policy would be better served if regulation were targeted not at preserving and promoting competition in applications and content, but rather at increasing competition in the last mile.

### A. Network Neutrality and Vertical Integration

Regulations that compel access to bottleneck facilities are inherently about vertical integration.<sup>9</sup> That this is the case can be easily seen if one analyzes the types of providers that comprise the Internet.<sup>10</sup> *Backbone providers* provide high-speed, long-distance connections between a small number of interconnection points.<sup>11</sup> *Middle-mile providers* provide regional

---

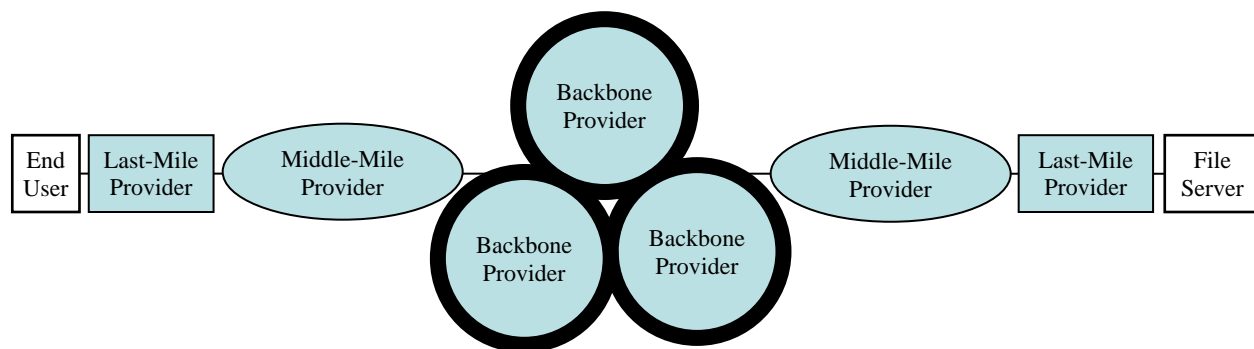
<sup>9</sup> See 3A PHILIP E. AREEDA & HERBERT HOVENKAMP, ANTITRUST LAW ¶ 771, at 169-71 (2d ed. 2002).

<sup>10</sup> See Inquiry Considering the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, Second Report, 15 F.C.C.R. 20913, 20922-28 ¶¶ 18-28 (2000) [hereinafter Second Section 706 Report].

<sup>11</sup> Originally, backbones only interconnected at the four public Network Access Points (NAPs) created by the National Science Foundation (located in San Francisco, Chicago, New York, and Washington, D.C.), as well as the Commercial Internet Exchange maintained in Santa Clara, California. The NAPs have since been privatized, and backbone providers have also created a number of other public interconnection points, where any carrier can exchange traffic. In addition, high-volume backbone providers have begun to exchange traffic directly through private interconnection points. See Christopher S. Yoo, *Would Mandating Network Neutrality Help or Hurt*

distribution functions, carrying the traffic from the interconnection points served by backbone providers to the distribution facilities maintained by last-mile providers in individual cities. *Last-mile providers* convey the traffic from these locally located distribution facilities to the premises of end users.<sup>12</sup> Computers performing the switching functions on the interior of the network are called *routers*. A computer operating on the edge of the network that stores files and fulfills requests for those files from other computer programs is called a *server*.

FIGURE 1  
BASIC ARCHITECTURE OF THE INTERNET



The fundamental concern raised by network neutrality proponents is that last-mile providers will use proprietary protocols or exclusivity arrangements to exert control over the markets for content and applications. Because last-mile transmission services and applications/content represent separate inputs into a larger, integrated product (as opposed to products that

---

*Broadband Competition?: A Comment on the End-to-End Debate*, 3 J. ON TELECOMM. & HIGH TECH. L. 23, 31 (2004).

<sup>12</sup> The FCC has analogized this to a road system. Backbones represent interstate highways, which convey traffic at high speeds and allow for only limited access points. Middle-mile networks are the divided highways that connect interstate exits to local roads. Last-mile networks are the local roads, responsible for delivering traffic to the driveways leading into individual residences. See Second Section 706 Report, *supra* note 10, at 20922-23 ¶ 18. This classification system also includes the “last 100 feet,” which represents the wiring found in individual residences, apartments, and office buildings. *Id.* at 20923 ¶ 18, 20938-39 ¶ 60.

compete directly with one another), placing both functions under the control of a single firm represents a form of vertical integration.

The emphasis on vertical integration remains clear even if network neutrality viewed through the *layered model* that has become an increasingly popular way to conceive of the structure of the Internet. The leading approach disaggregates networks into four horizontal layers that cut across different network providers. The bottommost layer is the *physical layer*, which consists of the hardware infrastructure used to route and transmit the data packets that make up a particular form of communications. The second layer is the *logical layer*, which is composed of the protocols used to route a particular packets to its proper destination and to ensure that it arrives intact. The third layer is the *applications layer*, which is comprised of the particular programs and functions used by consumers. The fourth layer is the *content layer*, which consists of the particular data being conveyed.

FIGURE 2  
THE LAYERED MODEL OF BROADBAND ARCHITECTURE

<p>CONTENT LAYER (e.g., individual e-mail, webpages, voice calls, video programs)</p>
<p>APPLICATIONS LAYER (e.g., web browsing, e-mail, Internet telephony, streaming media, database services)</p>
<p>LOGICAL LAYER (e.g., TCP/IP, domain name system, telephone number system)</p>
<p>PHYSICAL LAYER (e.g., telephone lines, coaxial cable, backbones, routers, servers)</p>

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.

The layered model underscores the extent to which network neutrality is focused on vertical integration. The concern is that owners of the physical layer will use their control over the logical layer to give preferential treatment to selected applications and content. Network neutrality proposes regulating the physical layer to preserve competition in the applications and content layers.

## **B. The Insights of Vertical Integration Theory**

One of the key insights of vertical integration theory is that any vertical chain of production will only be efficient if every link is competitive. The intuitions underlying that literature can be easily illustrated through a hypothetical example based on the Supreme Court's landmark *Terminal Railroad* decision, the seminal case for mandating interconnection to a bottleneck.<sup>13</sup> Suppose that a railway company controlled the only bridge across the Mississippi River at St. Louis and that it was using its control of the bridge either to give preferential treatment to its proprietary rolling stock or to forbid competing carriers from using the bridge altogether. One might be tempted to require the bridge owner to interconnect its bridge with other railway networks and to require it to provide access to the bridge to all comers on reasonable and nondiscriminatory terms. Indeed, that is precisely the type of solution sanctioned by the Supreme Court.

---

<sup>13</sup> United States v. Terminal R.R. Ass'n of St. Louis, 224 U.S. 383 (1912).

Vertical integration theorists have pointed out that this type of compulsory sharing of a bottleneck facility represents something of a competition policy anomaly. When confronted with a concentrated market, the traditional response is to deconcentrate the problematic market, either by breaking up the existing bottleneck or by facilitating entry by a competitor. Compelling interconnection to the bottleneck resource leaves the bottleneck in place and simply requires that it be shared.

The problem is that compulsory sharing of a bottleneck resource fails to reduce prices below or increase output above monopoly levels. For example, suppose that the monopoly price for shipping goods between two points across the bridge is \$100 and that the cost of providing the rolling stock for that shipment represents \$35 of that \$100. A bridge monopolist who had vertically integrated into rolling stock would be expected to charge \$100 for the combined services. Now consider what would occur if regulators forced the bridge owner to provide all railroad companies nondiscriminatory access to its bridge. Absent price controls, the bridge owner would simply charge \$65 to use its bridge. Since the market for rolling stock is competitive, the railroad companies would set their prices equal to their costs and charge \$35. In the end, customers still pay \$100.

Thus, forcing a bridge monopolist to provide nondiscriminatory access to its bridge would provide no consumer benefits, since vertical disintegration would do nothing to displace the bridge monopoly that is the real source of market failure. In essence, the Supreme Court focused on the wrong policy problem. It makes little sense to protect the market for rolling stock. That market was already quite competitive, and the barriers to entering that portion of the industry were quite low. Instead, the Court should have focused its efforts on increasing the

competitiveness of the market for bridges.<sup>14</sup> In other words, competition policy would be better promoted if attention were focused on the level of production that is the most concentrated and the most protected by entry barriers.

The same economic reasoning holds true for broadband. Suppose that vertical integration in broadband were banned altogether and that every last-mile provider were prevented from entering into exclusivity arrangements with any content or applications provider. Would doing so reduce the market power of the last-mile providers? The answer is clearly “no.” To the extent that DSL and cable modem providers exercise market power, it is because of the limited number of options that end users have for obtaining last-mile services. The number of options will remain the same regardless whether unaffiliated content and application providers are granted nondiscriminatory access. Vertical disintegration thus has no effect on whatever market power last-mile providers may exercise.

Indeed, the last fifty years of economic scholarship has been characterized by a sea change in vertical integration theory. Although competition policy was quite hostile toward vertical integration until the 1970s, the prevailing view has shifted and now acknowledges that, so long as the barriers to entry in a particular market segment are low, vertical integration does not pose as much of a threat as previously thought. In fact, it can yield substantial economic benefits.<sup>15</sup> This insight is demonstrated most dramatically by cable television. It is now

---

<sup>14</sup> If demand at any particular point is sufficient to support more than one bridge, it is quite possible that multiple bridges will coexist at the same point. For reasons that I will subsequently explain at some length, it is also possible, if not likely, that any subsequent bridge will establish operations at a different location in order to differentiate itself from the incumbent and in order to enhance its attractiveness to a particular segment of the market. In either case, regulating access to existing bridges is inappropriate so long as entry by a competitor remains feasible.

<sup>15</sup> See, e.g., OLIVER E. WILLIAMSON, *MARKETS AND HIERARCHIES* 20-40, 82-131 (1975) (showing how vertical integration can eliminate the transaction costs incurred to protect against opportunistic behavior); Benjamin Klein, Robert G. Crawford, & Armen A. Alchian, *Vertical Integration, Appropriable Rents, and the Competitive Contracting Process*, 21 J.L. & ECON. 297 (1978) (showing how vertical integration can alleviate the threat of hold-

generally recognized that vertical integration between content and transmission providers played a critical role in the industry's survival.<sup>16</sup>

This analysis underscores the extent to which network neutrality proponents are focusing on the wrong policy problem. By directing their efforts towards encouraging and preserving competition in the market for application and content, they are concentrating on the segments of the industry that are already the most competitive and the most likely to remain that way.

Broadband policy would be better served if such efforts were directed towards identifying and increasing the competitiveness of the last mile, which remains the industry segment that is the most concentrated and protected by entry barriers. Restated in terms of the layered model, decisions about whether to regulate the physical layer should not be driven by a desire to preserve and promote competition in the application and content layers. Such decisions should instead be guided by its impact on competition in the physical layer.

## II. THE RELATIONSHIP BETWEEN BROADBAND NETWORKS AND CONTENT/APPLICATIONS PROVIDERS

Having determined that network neutrality advocates are focusing on the wrong policy problem and that the primary focus of broadband policy should be on fostering greater competition in the last mile rather than promoting competition in content and applications, the next logical step is to assess whether network neutrality would further or hinder that goal. This

---

up created by relationship-specific investments); Joseph J. Spengler, *Vertical Integration and Antitrust Policy*, 58 J. POL. ECON. 347 (1950) (showing how vertical integration can eliminate of double marginalization by successive monopolists); Lester G. Telser, *Why Should Manufacturers Want Fair Trade?*, 3 J.L. & ECON. 86 (1960) (showing how vertical integration can eliminate the transaction costs needed to address free riding on promotional services); John M. Vernon & Daniel A. Graham, *Profitability of Monopolization by Vertical Integration*, 79 J. POL. ECON. 924 (1971) (showing how vertical integration can rationalize input substitution). See generally Christopher S. Yoo, *Vertical Integration and Media Regulation in the New Economy*, 19 YALE J. ON REG. 171, 187-205, 252-68 (2002) (surveying the literature).

<sup>16</sup> See Bruce M. Owen & Gregory L. Rosston, *Local Broadband Access: Primum Non Nocere or Primum Processi? A Property Rights Approach 3* (AEI-Brookings Joint Center for Regulatory Studies, Related Publication No. 03-19, Aug. 2003), available at <http://www.aei.brookings.org/admin/authorpdfs/page.php?id=285>.

Section will analyze the impact of regulating network owners' business relationships with the providers of Internet content and applications. The next Section will analyze the impact of regulating the terms under which network owners' provide service with end users.

Beginning first with the relationship between network owners and providers of Internet content and applications, network neutrality proponents favor prohibiting network owners from deviating from TCP/IP and from entering into exclusivity arrangements. My analysis reveals that these aspects of network neutrality would impair competition in three ways.

First, standardization necessarily reduces economic welfare by reducing product variety. These welfare losses have become increasingly acute as the ways that end users are employing the Internet have become increasingly varied.

Second, network neutrality can reinforce the economies of scale that represent the traditional sources of market failure in markets for telecommunications networks. In short, network neutrality threatens to commodify bandwidth and force providers to compete solely on the basis of price and network size, factors that necessarily favor the largest players. Indeed, network neutrality can have the perverse effect of entrenching industry concentration by short-circuiting one of the most natural ways to mitigate market failure.

Third, network neutrality can perpetuate concentration in the last mile by discouraging investment in new last-mile technologies. The mounting empirical evidence from the local telephone and broadband industries confirms that the imposition of interconnection and standardization regimes of the type envisaged by network neutrality proponents can have the effect of perpetuating concentration in the last mile. Network diversity, in contrast, would avoid these problems and facilitate entry by new last-mile providers.

Network neutrality is also hamstrung by the practical consideration that the regulatory tools traditionally used to promote static efficiency are unlikely to work well in industries like broadband, which are undergoing rapid technological change. Those tools are also unlikely to be effective when the demands that end users are placing on the network are becoming increasingly varied in terms of quality of service and content.

Together these conclusions would suggest that society might be better off if policymakers were to reject network neutrality and instead embrace a *network diversity* principle.

#### **A. The Inherent Nonneutrality of Network Neutrality**

The regime of mandatory interconnection and protocol standardization envisioned by network neutrality proponents would have a potentially dramatic impact on static efficiency that is often overlooked under the standard approach to evaluating the economic impact of regulation. Standard microeconomic models assume that competing goods serve as perfect substitutes for one another. This in turn allows economic welfare to be determined solely by price. Consumer surplus is created when consumers pay prices that are less than the maximum they would be willing to pay, and producer surplus is created when producers receive prices that exceed the minimum price they would be willing to accept. In a world of perfect substitutes, economic welfare consists solely of the sum of consumer and producer surplus.

A different situation obtains when products are differentiated.<sup>17</sup> The economics of product differentiation acknowledges that consumers can also benefit by obtaining goods that fit better with what they want as well as by paying cheaper prices. Although these welfare effects from product differentiation are not observable in the classic price-quantity space that dominates

---

<sup>17</sup> For an overview of the economics of product differentiation, see Christopher S. Yoo, *Copyright and Product Differentiation*, 79 N.Y.U. L. REV. 212, 236-46, 251-67 (2004).

economic analysis, they nonetheless remain an important potential source of economic welfare. Conversely, leading network theorists have recognized that limiting product variety can “prevent the development of promising but unique and incompatible new systems.”<sup>18</sup> Standardization can thus represent an important, but often unnoticed, source of welfare loss.

These problems become more acute when the focus is shifted from standardization in the abstract to the particular form of standardization favored by network neutrality proponents. Adoption of any standardized protocol would have the inevitable effect of favoring certain types of applications and disfavoring others. Even worse, standardization also has the inevitable effect of putting the government in the position of picking technological winners and losers at an early stage when the underlying technology is still in a state of flux.<sup>19</sup>

Consider TCP/IP, which remains the de facto standard governing the Internet. As noted earlier, one of its distinguishing features is that it routes packets anonymously, routing them on a “first come, first served” basis without regard to the application with which they are associated. It also transmits packets on a “best efforts” basis without any guarantee of eventual success.

This approach to routing packets was uncontroversial when usage restrictions prohibited commercial use of the Internet and the network was used primarily by technology-oriented academics to send e-mail, transfer files, and run other applications text-based communications that were not particularly sensitive to delays of up a second.

---

<sup>18</sup> Michael L. Katz & Carl Shapiro, *Systems Competition and Network Effects*, 8 J. ECON. PERSP. 93, 110 (1994); accord Joseph Farrell & Garth Saloner, *Standardization, Compatibility, and Innovation*, 16 RAND J. ECON. 70, 71 (1985).

<sup>19</sup> See Timothy F. Bresnahan, *New Modes of Competition: Implications for the Future Structure of the Computer Industry*, in COMPETITION, INNOVATION AND THE MICROSOFT MONOPOLY: ANTITRUST IN THE DIGITAL MARKETPLACE 155, 200-03 (Jeffrey A. Eisenach & Thomas M. Lenard eds., 1999).

In recent years, however, the environment in which the Internet operates has changed radically.<sup>20</sup> The transformation of the Internet from a medium for academic communication into a mass market phenomenon has greatly complicated the decisions faced by network owners. The number of possible connections has expanded exponentially with network size.<sup>21</sup> The commercialization made possible by the privatization of the Internet has greatly increased the heterogeneity and variability of Internet usage. The shift from text-based applications, such as e-mail and file transfers, webpage downloading and file transfers, to more bandwidth-intensive applications, such as graphics-intensive multimedia, has drastically increased the volume of network demand. The emergence of applications that are even more time-sensitive, such as VoIP and streaming video, has created demand for even greater reliability in throughput rates and is creating pressure for the deployment of policy-based routers, which break from TCP/IP by assigning higher priority to packets associated with time-sensitive applications. Furthermore, the unexpected interactions among network components that are the hallmark of complex systems can be quite sensitive to variability of demand.<sup>22</sup> Increases in the variability of network traffic can thus greatly impede network performance even if on average utilization of network capacity remains quite low.<sup>23</sup>

Similarly, the packet anonymity inherent in TCP/IP may be interfering with network owners' attempts to add security features designed to foster e-commerce or to protect against viruses and other hostile elements that are proliferating on the Internet. In addition, the

---

<sup>20</sup> See generally Marjory S. Blumenthal & David D. Clark, *Rethinking the Design of the Internet: The End-to-End Arguments vs. the Brave New World*, 1 ACM TRANSACTIONS ON INTERNET TECH. 70 (2001) (surveying these changes).

<sup>21</sup> See Daniel F. Spulber & Christopher S. Yoo, *On the Regulation of Networks as Complex Systems: A Graph Theory Approach*, 99 NW. U. L. REV. 1689, 1698 (2005).

<sup>22</sup> See *id.*

<sup>23</sup> See Jeffery K. MacKie-Mason & Hal R. Varian, *Some FAQs About Usage-Based Pricing*, 28 COMPUTER NETWORKS & ISDN SYS. 257, 259 (1995).

Internet's shift away from academically oriented users who enjoyed a similar degree of institutional support and shared certain common institutional norms has increased the justification for moving responsibility for system maintenance and management away from end users and towards the network's core.

These considerations make network management quite challenging. Although it is theoretically possible for network owners to respond to some of these demands by expanding bandwidth, decisions about capacity expansion can be difficult when facing uncertainty about the magnitude, heterogeneity, and variability of the demand that will be placed on the network. Decisionmaking is complicated still further by the "lumpiness" of network capacity created by the indivisibility of fixed costs and the fact that increasing network capacity typically takes a considerable amount of time.<sup>24</sup>

The FCC has recognized the inherent problems associated with limiting the number of ways that network owners can manage network demand in such a technologically dynamic environment.<sup>25</sup> An example from the early days of the Internet illustrates the point nicely. In 1987, end users began increasingly to rely on personal computers instead of dumb terminals to connect to what was then the NSFNET. The increased functionality provided by a shift to personal computers increased the intensity of the demands that end users were placing on the network. The resulting congestion caused terminal sessions to run unacceptably slow, and the fact that fixed cost investments cannot be made instantaneously created an inevitable lag in adding network capacity. This is precisely the type of technology- and demand-driven exogenous shock that makes network management so difficult. NSFNET's interim solution was to reprogram its routers to give terminal sessions higher priority than file transfer sessions until

---

<sup>24</sup> See Spulber & Yoo, *supra* note 21, at 1715, 1722.

<sup>25</sup> See Wireline Broadband Order, *supra* note 6, ¶¶ 70-71.

additional bandwidth could be added.<sup>26</sup> Indeed, such solutions need not be temporary: in a technologically dynamic world, one would expect the relative costs of different types of solutions to change over time. Sometimes increases in bandwidth would be cheaper than reliance on network management techniques, and vice versa. It would thus be short sighted to tie network managers' hands by limiting their flexibility in their choice of network management solutions.

Network neutrality not only limits the ways that network owners can manage network capacity and reliability; it can also restrict the network's functionality. In essence, interoperability around relatively simple protocols like TCP/IP gives preference to innovations operating at the network's edge over innovations in the network's core. As the FCC has recognized, there is no reason to believe *a priori* that that preference will always prove to be beneficial.<sup>27</sup> Two examples from the early days of the Internet illustrate the problem. The introduction of digital transmission technologies required the deployment of protocols that were not interoperable with the existing analog network. That, in turn, required the introduction of computer processing into the core of the network to engage in *protocol conversion*.<sup>28</sup> Similar problems were posed by the emergence of *voice messaging services*, such as voice mail and advance calling. Voice messaging services appeared to function best when its capabilities were

---

<sup>26</sup> See MacKie-Mason & Varian, *supra* note 23, at 259.

<sup>27</sup> See Wireline Broadband Order, *supra* note 6, ¶ 70.

<sup>28</sup> See Amendment of Sections 64.702 of Commission's Rules and Regulations (Third Computer Inquiry), Report and Order, 104 F.C.C.2d 958, 979-80 ¶¶ 33-34 (1986) ("*Computer III Phase I Order*"), *vacated and remanded on other grounds sub nom. California v. FCC*, 905 F.2d 1217 (9th Cir. 1990); Petition for Wavier of Section 64.702 of the Commission's Rules, Memorandum Opinion and Order, 100 F.C.C.2d 1057 (1985); Petition of AT&T Co. for Limited and Temporary Waiver of 47 CFR Section 64.702 Regarding Its Provision of Unregulated Services Externally to the AT&T-C Network, Memorandum Opinion and Order, 59 Rad. Reg. (P&F) 505 (Common Carrier Bur. rel. Nov. 27, 1985) (FCC 84-561); Communications Protocols under Section 64.702 of the Commission's Rules and Regulations, Memorandum Opinion, Order, and Statement of Principles., 95 F.C.C.2d 584, 594 ¶ 22, 595 ¶ 24 (1983).

designed directly into the telephone switch.<sup>29</sup> Both developments were inconsistent with the regime of transparency and interoperability envisioned by the second *Computer Inquiry* as well as the simplistic reading of the end-to-end argument. After considerable regulatory wrangling, the FCC permitted both innovations to be deployed notwithstanding their inconsistency with the commitment to interoperability.<sup>30</sup> Had the FCC adhered to its policy of preserving the ability of unaffiliated providers to obtain transparent access to the network, these innovations would not have been allowed to emerge.

Simply put, any choice of standardized protocol has the inevitable effect of favoring certain applications and disfavoring others, just as TCP/IP discriminates against applications that are time sensitive and end-to-end favors innovation at the edge over innovation in the core. Whether mandating network neutrality would be socially beneficial is a complicated question that depends upon myriad considerations, including the heterogeneity of network uses, the variability in network traffic flows, end users' need for network reliability, and the extent to which technological change is reorganizing the natural boundaries between levels that were previously separated by a natural interface.<sup>31</sup> In short, the desirability of complete standardization and interoperability is an empirical question that cannot be answered *a priori*.

It would thus be a mistake to regard network neutrality as inherently neutral, the engineering analog to a competitive market, or the best way to reflect technological humility, as

---

<sup>29</sup> *Computer III Phase I Order*, 104 F.C.C.2d at 971-73 ¶¶ 17-19, 1109-14 ¶¶ 307-317.

<sup>30</sup> *See* Implementation of the Non-Accounting Safeguards of Sections 271 and 272 of the Communications Act of 1934, 11 F.C.C.R. 21905, 21955-58 ¶¶ 100-105 (1996), *aff'd sub nom.* Bell Atl. Tel. Cos. v. FCC, 131 F.3d 1044 (D.C. Cir. 1997); *Computer III Phase I Order*, 104 F.C.C.2d at 1100-09 ¶ 289-306, 1112-14 ¶¶ 313-317; Petitions for Waiver of Section 64.702 of the Commission's Rules and Regulations to Provide Certain Types of Protocol Conversion with their Basic Network, Memorandum Opinion and Order, FCC 84-561 (F.C.C. rel. Nov. 28, 1984); Petition for Waiver of Section 64.702 of the Commission's Rules, Memorandum Opinion and Order, 100 F.C.C.2d 1057 (1985)

<sup>31</sup> *See* Christopher S. Yoo, *Beyond Network Neutrality*, 19 HARV. J.L. & TECH. (forthcoming 2005).

some network neutrality proponents have suggested.<sup>32</sup> At best, it represents a casual empirical conjecture about how competition and innovation can best be promoted under current circumstances. At worst, it represents an attempt to use engineering principles to impart legitimacy to a naked normative commitment.<sup>33</sup> In short, it appears that the term *network neutrality* is something of a misnomer. Like any baseline principle, it must be supported by substantial normative and empirical justification before being imposed as an absolute mandate. Until that occurs, the more technologically humble position would appear to be to permit network diversity through nonregulation, rather than mandating the use of any particular set of protocols.

## **B. Network Diversity and the Sources of Market Failure**

There is also considerable danger that network neutrality would reinforce the very sources of market failure that it is designed to redress. Despite assurances from the cable industry that it will not block consumers' access to any Internet content or applications, network neutrality proponents have remained concerned that network owners will use their control over the last mile to disfavor particular applications and content providers. Two factors are typically cited as the reasons for the high degree of concentration in markets for last-mile services. The classic source of market concentration is the supply-side economies of scale that arise when entry requires the incurrence of significant, up-front investments. More recently, attention has

---

<sup>32</sup> See, e.g., LESSIG, *supra* note 1, at 37.

<sup>33</sup> In the words of the then-Executive Director of the Computer Science and Telecommunications Board of the National Research Council:

Although the embrace of engineering principles such as [end-to-end] appears to impart a legitimacy to certain kinds of advocacy, that advocacy reaches beyond the engineering to the ideology long associated with the Internet. It is an ideology that associates the Internet with freedoms of various kinds, autonomy for the users, and innovation.

Marjory S. Blumenthal, *End-to-End and Subsequent Paradigms*, 2002 L. REV. MICH. ST. U. DET. C.L. 709, 710.

also focused on the demand-side economies of scale created by *network economic effects*, which arise when the value of the network is largely determined by the number of people connected to it. Both forces tend to give the large players a decisive advantage. In the most extreme case, they create natural monopolies.

Interestingly, my analysis reveals that network neutrality can have the perverse effect of reinforcing both of these sources of market failure. In other words, network neutrality can actually make matters worse by short circuiting one of the most promising ways that smaller players use to survive when confronted with unexhausted returns to scale. If true, this raises the specter that network neutrality could be the source of, rather than the solution to, market failure. It also suggests that policymakers should reject network neutrality in favor of network diversity.

**1. Supply-Side Sources of Market Failure: Large, Up-Front Capital Investments**

How network neutrality can reinforce the supply-side forces that tend to concentrate markets for network services is best understood in terms of the classic source of scale economies: large, up-front, capital investments. The presence of large, up-front capital investments gives the largest firms a decisive economic advantage. The ability to spread those investments over a larger customer base allows them to underprice their smaller competitors.<sup>34</sup>

---

<sup>34</sup> For example, if a producer must incur \$1,000 in up-front costs to enter the market, the up-front costs would contribute the following amounts toward unit (i.e., average) cost:

<u>Quantity</u>	<u>Contribution to Unit Cost</u>	<u>Quantity</u>	<u>Contribution to Unit Cost</u>
100	\$10.00	600	\$1.67
200	\$5.00	700	\$1.43
300	\$3.33	800	\$1.25
400	\$2.50	900	\$1.11
500	\$2.00	1000	\$1.00

This allows them to capture a still larger share of the market, which in turn causes the cost advantage to widen still further. Eventually, the cost advantage enjoyed by the largest player widens to the point where it is able to drive all of its competitors out of the market. In that case, even markets that are initially competitive are doomed to collapse into monopolies. Although the issue is not free from dispute, the high up-front investments needed to establish of the wires and central offices needed to establish telephone service have historically been regarded as turning local telephony into a natural monopoly.

What has been largely overlooked is how allowing networks to differentiate themselves can also alleviate the economies of scale associated with declining average costs. It is the fact that price is the only dimension along which firms can compete that gives the largest players their decisive advantage. A different end-result can occur if competitors are allowed to compete along dimensions other than price. If so, a smaller player may be able to survive notwithstanding lower sales volumes and higher unit costs (and thus higher prices) by tailoring its network towards services that a subsegment of the market values particularly highly. The greater value provided by the differentiation of the network allows a specialized provider to generate sufficient revenue to cover its up-front costs even though its volume is significantly smaller than that of the leading players.

The result is an equilibrium in which multiple players co-exist despite the presence of unexhausted economies of scale. Even though entrants may operate at a cost disadvantage vis-à-vis their larger rivals, they are able to survive by offering products designed to appeal to discrete subsegments of the customer base. Indeed, some wireless telephone networks have attempted to

---

If the impact from the amortization up-front costs dominates the impact of variable costs, average cost will decline. Note that the impact of up-front costs tends to decay exponentially as the quantity over which the up-front costs are spread increases.

compete with entrenched incumbents either by offering better services<sup>35</sup> or by targeting price-sensitive who are more tolerant of dropped calls and a lower quality of service.<sup>36</sup>

Conversely, preventing product differentiation would cause the market to devolve into a natural monopoly. Such network diversity would have little relevance if entry by alternative network providers were infeasible. It has great relevance in a world in which a wide range of broadband technologies, including third-generation mobile wireless (3G), WiFi, WiMax, and broadband over powerline (BPL), have raised the real prospect that consumers may soon enjoy a broader range of last-mile options. The wireless technologies are particularly promising in this regard. The fact that new entrants will not have to incur the sunk costs of deploying a wireline network all but guarantees that end users will be able to choose from a wide array of wireless broadband providers.

How could such differentiation occur in the context of broadband? One way is through protocol nonstandardization, such as through the adoption of a different routing protocol. As discussed above, all protocols necessarily favor certain applications over others. If discrete subgroups of end users place sufficiently different valuations on different types of applications, multiple networks will be able to coexist simply by targeting their networks towards the needs of different subgroups. If demand is sufficiently heterogeneous, the greater utility derived from allowing end users to consume services that they value more highly can more than compensate for any cost disadvantages resulting from the reduction in volume. Indeed, it is conceivable that network diversity might make it possible for three different last-mile networks to coexist: one optimized for traditional Internet applications such as e-mail and website access, another

---

<sup>35</sup> See Neil Gandal et al., *Standards in Wireless Telephone Networks*, 27 TELECOMM. POL'Y 325, 326-27 (2003).

<sup>36</sup> See Christopher S. Yoo, *The Unfulfilled Promise of Korean Telecommunications Reform*, in LEGAL REFORM IN KOREA 169, 185-86 (Tom Ginsburg ed., 2004).

incorporating security features to facilitate e-commerce and to guard against viruses and other hostile aspects of Internet life, and a third that prioritizes packets in the manner needed to facilitate time-sensitive applications such as streaming media and VoIP.

Entering into exclusivity arrangements with respect to content represents another possible means for differentiating one's network. One of the best current examples is the manner in which direct broadcast satellite (DBS) provider DirecTV is using an exclusive programming package known as "NFL Sunday Ticket" to enhance its ability to compete with cable television. Indeed, it appears that exclusive access to NFL Sunday Ticket constitutes one of the major factors helping DBS emerge as a viable competitor to cable. If regulators were to view this exclusivity arrangement solely in static terms, they might be tempted to appease cable customers who have expressed frustration at their inability to purchase NFL Sunday Ticket by requiring that the package also be made available on both platforms. Doing so would reduce DBS's ability to compete by eliminating one of the primary inducements to shift from cable to DBS. In other words, banning program exclusivity would only serve to limit the ways that DBS can compete in the market for multichannel video distribution. There are some indications that Sprint may be pursuing a similar strategy by entering into strategic partnerships with ESPN and Disney in the hopes that the unique content that each can provide will help differentiate Sprint from other wireless broadband providers.<sup>37</sup>

These examples illustrate how using nonstandardized protocols and exclusive access to content—the precise practices that network neutrality would condemn—can in fact facilitate competition in the last mile. The implication is that public policy may well be better served if Congress and the FCC were to reject network neutrality in favor of a network diversity principle

---

<sup>37</sup> See Jesse Drucker & Merissa Marr, *Disney to Enter Cellphone Market, with Kids in Mind*, WALL ST. J., July 6, 2005, at D5.

that would allow networks to differentiate their services in precisely this manner. It is quite possible that such network diversity may take some time to emerge. Indeed, the seminal analyses of production differentiation recognize that the initial industry entrants may well prefer to offer products that are quite similar.<sup>38</sup> As entry increases the level of competition, providers should begin to find it profitable to pursue more targeted strategies.<sup>39</sup> Thus, policymakers should avoid imposing regulations that would foreclose the emergence of network diversity even in the absence of the imminent arrival of a new entrant offering differentiated services. Humility about policymakers' ability to predict which business models will prove successful further underscores the importance of leaving open this possibility.

## **2. Demand-Side Sources of Market Failure: Network Economic Effects**

The other force typically regarded as driving markets for telecommunications services towards concentration is *network economic effects*. Network economic effects exist when the value of a network is determined by the number of people connected to it. The more people that are part of the network, the more valuable the network becomes.<sup>40</sup> Because the value of telecommunications networks increase with the number of people attached to them, they have long been regarded as a paradigmatic case in which network economic effects arise. Network economic effects are often described as creating demand-side economies of scale that tend to favor the largest networks. If significant enough, these demand-side scale economies can give

---

<sup>38</sup> See Harold Hotelling, *Stability in Competition*, 39 ECON. J. 41, 53-55, 56-57 (1929) (providing the classic analysis of the tendency towards excessive sameness in markets for differentiated products).

<sup>39</sup> See Peter O. Steiner, *Program Patterns and Preferences, and the Workability of Competition in Radio Broadcasting*, 66 Q.J. ECON. 194, 200 (1952) (providing a classic application of Hotelling's approach in the context of electronic communications).

<sup>40</sup> One oft-cited example of network economic effects is the battle between Beta and VHS formats for video cassettes. Consumers choosing between the two formats cared less about each format's technical capabilities and more about which format would be adopted by other consumers.

rise to a form of vertical competition that is quite similar to the one that can be created by supply-side economies of scale.

The claim that that network economic effects can be a source of market failure is subject to a number of caveats and criticisms that I will mention briefly later.<sup>41</sup> The most important point for our purposes is the fact that differentiation can ameliorate the demand-side economies of scale created by network economic effects. If the smaller network is optimized for particular functions that a particular group of end users values particularly highly, those end users may be willing to join the smaller network notwithstanding the presence of network economic effects. The increase in value provided by network diversity can more than compensate from any reductions in value resulting from market size.<sup>42</sup>

Conversely, network neutrality threatens to preempt this potential solution by narrowing the dimensions along which firms can compete. Mandating the use of standardized protocols and prohibiting content exclusivity threatens to commodify bandwidth and force providers to compete solely on the basis of price and network size, which would in turn reinforce the advantages enjoyed by the largest players. There is thus a real danger that network neutrality could short circuit one of the most sensible market-based solutions to the problems of market concentration.

---

<sup>41</sup> See *infra* notes 92-94 and accompanying text.

<sup>42</sup> See Katz & Shapiro, *supra* note 18, at 106; S.J. Liebowitz & Stephen E. Margolis, *Should Technology Choice Be a Concern of Antitrust Policy?*, 9 HARV. J.L. & TECH. 283, 292 (1996). For formal models demonstrating this effect, see Joseph Farrell & Garth Saloner, *Standardization and Variety*, 20 ECON. LETTERS 71 (1986); Michael L. Katz & Carl Shapiro, *Technology Adoption in the Presence of Network Externalities*, 94 J. POL. ECON. 822 (1986).

### C. Network Diversity and Investment Incentives

Not only would network neutrality threaten to reduce product variety and reinforce the traditional sources of market failure. It also threatens to worsen competition in the last mile by dampening incentives to invest in alternative last-mile capacity. Conversely, embracing a network diversity principle promises to promote competition in the last mile and thereby alleviate the central issue confronting broadband policy.

The reasons why network neutrality can harm incentives can be easily explained in terms of the hypothetical example based on *Terminal Railroad* discussed above. Suppose that access to the bridge was not compelled and that rates were not regulated. The supracompetitive returns earned by the owner of the existing bridge would provide the incentive for others interested in building bridges to do so. In addition, the railroads that were unable to obtain access to the existing bridge would be clamoring for an alternative. They would thus represent the natural strategic partners for any would-be builder of another bridge.

Similarly, leading content, applications, and device manufacturers have been among the leading investors in new networks. For example, Google, IBM, and Intel have each undertaken major investments in BPL.<sup>43</sup> Other content providers, such as Disney, EarthLink and ESPN, have entered into strategic partnerships with existing wireless broadband technologies.<sup>44</sup>

The situation changes dramatically if access to the bridge is compelled. Granting access lets the customers who would otherwise stand ready to invest in a new bridge off the hook, rescuing them from having to undertake the risks associated with investing in alternative network

---

<sup>43</sup> See Ed Gubbins, *Intel Gets Behind BPL*, TELEPHONY, Sept. 5, 2005 at 16; Ken Kerschbaumer, *Plug-and-Play Internet: Wall-Outlet Broadband Attracts Heavy Hitters*, BROAD. & CABLE, July 18, 2005, at 20..

<sup>44</sup> See Bob Keefe, *Battered Earthlink Shifts Gears: Phone Services Play Role in Makeover*, ATLANTA J. & CONST., July 24, 2005, at C1; *supra* note 37 and accompanying text.

capacity. At the same time, the would-be bridge entrant also finds entry less attractive. Knowing that it would be forced to share the new bridge with all comers at regulated prices weakens the incentives for it to construct another bridge. Indeed, rate regulation can deprive the new entrant of the returns it needs to survive. Granting access thus threatens to frustrate the appearance of alternative bridge capacity that remains the central goal of competition policy in this situation. In so doing, it threatens to entrench the existing bridge monopolist into place. As the Supreme Court has noted in a more recent case, “Firms may acquire monopoly power by establishing an infrastructure that renders them uniquely suited to serve their customers. Compelling such firms to share the source of their advantage is in some tension with the underlying purpose of antitrust law, since it may lessen the incentive for the monopolist, the rival, or both to invest in those economically beneficial facilities.”<sup>45</sup>

The same dynamics can be illustrated by considering a hypothetical town in which there is a single department store. Much like a broadband network, a department store is simply a conduit for goods and services produced by others. Upon reflection, it becomes clear that imposing a rule requiring all department stores to make space available to all manufacturers on a reasonable and nondiscriminatory basis would discourage entry by a second department store. Although entrants often find it profitable to enter into competition with a monopolist earning monopoly rents, this incentive is dampened if rate regulation precludes any such rents from being earned. In addition, the frustrated manufacturers who would otherwise be eager to support construction of a second department store would also lose their enthusiasm for the project. Furthermore, compelling access to the department store shelves would also limit the ability of

---

<sup>45</sup> Verizon Communications Inc. v. Law Offices of Curtis V. Trinko, LLP, 540 U.S. 398, 407-08 (2004).

stores to control whether an appropriate mix of goods was represented or to assure that the goods satisfied certain quality standards.

Limiting the degree to which retailers coordinate and integrate their operations with manufacturers can also preclude the real efficiencies and cost savings that would otherwise be possible through the integration of inventory management and electronic data interchange. Department stores often try to promote their popularity by entering into exclusivity arrangements with key manufacturers, sometimes even establishing boutiques in portions of their stores. Requiring department stores to provide nondiscriminatory access to all manufacturers would thus prevent them from pursuing one of the best entry strategies available to new entrants. Indeed, this type of strategic partnership between manufacturers and retailers appears to have played a critical role in promoting the growth of the cable industry.<sup>46</sup> This mechanism for promoting entry would be frustrated by regulations mandating open access to the retail platform.

This underscores the extent to which mandating access to a bottleneck facility represents surrender to the bottleneck. The normal response of competition policy when it encounters bottlenecks is to dislodge them, either by stimulating new entry or, in rare cases, by breaking them up. Mandating interconnection deviates from this tradition by addressing the symptoms of monopoly power without treating its causes. Instead of breaking up the bottleneck, access leaves it in place and only requires that it be shared. Furthermore, approaches that dislodge bottlenecks by creating competition necessarily have built-in exit strategies embedded within them. Mandated sharing of a bottleneck facility, in contrast, implicitly envisions that the regime of regulatory oversight will persist indefinitely.

---

<sup>46</sup> See *infra* note 16 and accompanying text.

Such an approach might be appropriate if entry by a competitor to the bottleneck were impossible, as was arguably the case when the FCC and the courts relied on interconnection and standardization to promote competition in CPE, long distance, and enhanced services. In that event, any dampening of incentives to invest in alternative network capacity would be beside the point, because such entry would be impossible. The situation is quite different when entry by alternative network capacity is feasible. In that case, the reduction in investment incentives may short-circuit the natural process by which markets diffuse bottlenecks. In the worst case scenario, mandating interconnection can itself have the perverse effect of entrenching the existing bottlenecks into place.

The historical studies of the telecommunications industry largely confirm these insights. Commentators analyzing of telephone competition from 1890 to 1912 have discovered that the refusal of carriers to interconnect with one another actually fueled the rapid geographic buildout of the network.<sup>47</sup> Conversely, empirical studies of modern telecommunications policy indicate that mandating access to local telephone facilities has dampened investment incentives in precisely this manner.<sup>48</sup> Additional empirical studies indicate that unbundling of broadband facilities has had a similar adverse effect.<sup>49</sup>

---

<sup>47</sup> See MILTON MUELLER, *UNIVERSAL SERVICE* 3 (1997).

<sup>48</sup> See Jerry A. Hausman & J. Gregory Sidak, *Did Mandatory Unbundling Achieve Its Purpose? Empirical Evidence from Five Countries*, 1 J. COMPETITION L. & ECON. 173 (2005); Augustin J. Ros & Karl McDermott, *Are Residential Local Exchange Prices Too Low?*, in *EXPANDING COMPETITION IN REGULATED INDUSTRIES* 149 (Michael A. Crew ed., 2000); James Zolnierok et al., *An Empirical Examination of Entry Patterns in Local Telephone Markets*, 19 J. REG. ECON. 143 (2001); Robert W. Crandall et al., *Do Unbundling Policies Discourage CLEC Facilities-Based Investment?* (unpublished manuscript), available at [http://papers.ssrn.com/abstract\\_id=387421](http://papers.ssrn.com/abstract_id=387421).

<sup>49</sup> See Debra J. Aron & David E. Burnstein, *Broadband Adoption in the United States: An Empirical Analysis*, in *DOWN TO THE WIRE: STUDIES IN THE DIFFUSION AND REGULATION OF TELECOMMUNICATIONS TECHNOLOGIES* (Allan Shampien ed., 2003); Martha Garcia-Murillo & David Gabel, *International Broadband Deployment: The Impact of Unbundling*, 50 COMM. & STRATEGIES (forthcoming 2005); Bronwyn Howell, *Infrastructure Regulation and the Demand for Broadband Services: Evidence for OECD Countries*, 47 COMM. & STRATEGIES 33 (2002); Jung Hyun Kim et al., *Broadband Uptake in OECD Countries: Policy Lessons from*

By now, the implications for broadband policy should be manifest. The central focus in deciding whether to mandate network neutrality should be on its effect on stimulating additional competition in the last mile. If network neutrality were imposed, any would-be last-mile entrant would realize that even if it were successful, it would be forced to make its platform available to all content and application providers under rates that would limit it to ordinary returns. In addition, the would-be builder would not find a group of content and applications providers clamoring for additional access, since mandating interconnection to the existing platform would rescue them from having to invest in alternative distribution arrangements.

In the process, network neutrality risks dampening incentives to invest in new last-mile technologies to the extent that it cements the existing last-mile oligopoly into place. Although such a policy might be justifiable if entry by alternative network capacity were impossible, it is indefensible when 3G, WiFi, WiMax, broadband over powerline (BPL), and other technologies are actively searching for capital to support their deployment and when what represents the state of the art in transmission is undergoing rapid technological change. At best, the inevitable lag in enacting new regulations will cause economic losses. At worst, by destroying incentives to build new technologies, regulation might cement the market concentration that represents the central focus of broadband policy into place. Under these circumstances, mandating network neutrality would appear to pose a serious threat to dynamic efficiency. Embracing network diversity as a policy, in contrast, would provide substantial incentives to support the build out of new last-mile facilities.

#### **D. Implementation Difficulties Caused by the Decommodification of Network Usage**

As the FCC discovered when using a form of network neutrality to promote competition in CPE, long distance, and enhanced services, any regime of mandated interconnection and standardized interfaces is not sufficient by itself to induce competition. A recalcitrant last-mile provider could effectively turn interconnection and standardization into a dead letter simply by providing affiliated providers of complementary services with interconnections that were cheaper or substantially better in quality than those provided to unaffiliated providers. Even the addition of a nondiscrimination mandate proved insufficient to prevent local telephone companies from using their bottleneck position to harm competition. The local telephone companies could simply charge everyone interconnection fees that were prohibitively expensive. As noted earlier in the discussion on vertical integration, so long as the local telephone company remained free to charge monopoly prices, compelling access to the bottleneck facility would not yield any consumer benefits. Furthermore, overcharging its affiliate would not affect the local telephone company's bottom line, since any losses incurred by the affiliate would be offset dollar-for-dollar by higher profits earned by the local telephone operations. As a result, when mandating interconnection the FCC has invariably found it necessary to prohibit local telephone companies from discriminating against unaffiliated providers and to regulate the rates they can charge.

The fact that the regime of interconnection and standardization favored by network neutrality proponents inevitably also requires mandating nondiscrimination and rate regulation dramatically lowers the likelihood that it will be successful. The problems associated with the existing approaches to rate regulation are well documented.<sup>50</sup>

---

<sup>50</sup> See, e.g., JAMES C. BONBRIGHT, *PRINCIPLES OF PUBLIC UTILITY RATES* 547-622 (2d ed. 1988); 1 ALFRED E. KAHN, *THE ECONOMICS OF REGULATION* 27-54 (1971); 2 *id.* at 47-94, 345-47; W. KIP VISCUSI ET AL., *ECONOMICS*

Ensuring that charges for interconnection are reasonable and nondiscriminatory is all the more difficult when the product being regulated is not a commodity and instead varies in terms of quality. When product attributes are well defined and do not vary and the interface is relatively simple, interconnection and nondiscrimination can focus on availability and price. As the Supreme Court has noted, policing interconnection and nondiscrimination becomes considerably more complicated when products vary in terms of their quality and reliability and the interface is complex, because network owners have a myriad of effectively undetectable ways to provide discriminatory or substandard interconnection.<sup>51</sup>

The implication is that regulators who wish to mandate interconnection must also impose an elaborate number of secondary regulations to police quality of service and other nonprice terms in ways that amount to fairly comprehensive regulation of the business relationship.<sup>52</sup> While quality regulation is intrusive and hard to administer under the best of circumstances, it becomes almost insuperable when quality varies widely.<sup>53</sup> Indeed, as the diversity of uses to which users are putting the Internet has increased, quality and reliability has become a product feature rather than a minimum standard that all providers must meet. This in turn makes it much more difficult to regulate quality of service without harming consumers. The difficulties the

---

OF REGULATION AND ANTITRUST 364-74 (3d ed. 2000); George J. Stigler & Claire Friedland, *What Can Regulators Regulate?: The Case of Electricity*, 5 J.L. & ECON. 1 (1962); Gregory J. Vogt, *Cap-Sized: How the Promise of the Price Cap Voyage to Competition Was Lost in a Sea of Good Intentions*, 51 FED. COMM. L.J. 349 (1999).

<sup>51</sup> See *Verizon Communications, Inc. v. Law Offices of Curtis V. Trinko, L.L.P.*, 540 U.S. 398, 414 (2004) (recognizing that interconnections disputes are “highly technical” and multifaceted “given the incessant, complex, and costly changing interaction of competitive and incumbent LECs implementing the sharing and interconnection obligations”); *AT&T Corp. v. Iowa Utils. Bd.*, 525 U.S. 366, 429 (1999) (Breyer, J., concurring in part and dissenting in part) (“The more complex the facilities, the more central their relation to the firm’s managerial responsibilities, the more extensive the sharing demanded, the more likely that [the administrative and social costs of compulsory sharing] will become serious.”).

<sup>52</sup> See JEAN-JACQUES LAFFONT & JEAN TIROLE, *COMPETITION IN TELECOMMUNICATIONS* 54-55 (2000); Gerald R. Faulhaber, *Policy-Induced Competition: The Telecommunications Experiments*, 15 INFO. ECON. & POL’Y 73, 81-82 (2003).

<sup>53</sup> See Christopher S. Yoo, *Architectural Censorship and the FCC*, 78 S. CAL. L. REV. 669, 685-87 (2005).

FCC confronted when attempting to implement long-distance interconnection,<sup>54</sup> access to cable television systems,<sup>55</sup> and the unbundled access requirements of the Telecommunications Act of 1996<sup>56</sup> provide an eloquent demonstration of these problems. Finally, the tools needed to implement network neutrality do not function well in industries, such as broadband, that are technologically dynamic.

Consider further what might happen after regulatory authorities require last-mile providers to make their networks available to all applications, content, and devices. The forces of competition naturally cause firms operating on either side of the interconnection interface to try expand into territory occupied by other firms. To the extent that network neutrality forecloses this from occurring, it can stifle an important source of competition.<sup>57</sup> Furthermore, more sweeping technological change can cause the interface between two levels to shift or collapse. Requiring network owners to maintain standardized interfaces would have the inevitable effect of locking the existing interfaces into place despite these changes, which would in turn have the unfortunate effect of inhibiting the emergence of new technologies that transcend the boundaries that previously separated different segments of the industry.

The voice messaging services example discussed above provide one example of a technological change that reorganized the network's natural interfaces.<sup>58</sup> Another example is provided by the debate over *multiple ISP access* or *open access to cable modem systems* that

---

<sup>54</sup> See *MCI v. AT&T Co.*, 708 F.2d 1081, 1131-32 (7th Cir. 1983); *United States v. AT&T*, 552 F. Supp. 131, 188, 189-90 & n.238 (D.D.C. 1982), *aff'd mem. sub nom. Maryland v. United States*, 460 U.S. 1001 (1983); PETER W. HUBER ET AL., *FEDERAL TELECOMMUNICATIONS LAW* 136-40 (2d ed. 1999); Faulhaber, *supra* note 52, at 81-83.

<sup>55</sup> See S. REP. NO. 102-92, at 30-32 (1991), *reprinted in* 1992 U.S.C.C.A.N. 1133, 1163-65; H.R. REP. NO. 102-628, at 39-40 (1992); *Time Warner Entm't Co. v. FCC*, 93 F.3d 957, 968-70 (D.C. Cir. 1996); Donna M. Lampert, *Cable Television: Does Leased Access Mean Least Access?*, 44 FED. COMM. L.J. 245, 266-67 & n.122 (1992).

<sup>56</sup> See *U.S. Telecom Ass'n v. FCC*, 359 F.3d 554, 595 (D.C. Cir. 2004) (criticizing the FCC for its failure to develop lawful unbundling rules eight years after passage of the Telecommunications Act of 1996).

<sup>57</sup> See Bresnahan, *supra* note 19, at 166-68.

<sup>58</sup> See *supra* note 29 and accompanying text.

represented the first round in the network neutrality debate. What has been largely overlooked is that the move towards proprietary ISPs is largely the result of an exogenous change in the underlying technology. In the original narrowband world, in which end users connected to the Internet through analog transmissions sent over conventional telephone lines. As a result, the telephone company providing the end user connection did not need to maintain its own packet-switched network. It could simply connect the end users' calls to the offices maintained by the ISP in the same manner as a conventional voice call.

This is no longer true, however, after the transition to broadband. Both DSL and cable modem providers must maintain equipment, either a DSL access multiplexer (DSLAM) or a cable modem termination system (CMTS), to separate the stream of data packets from other types of communications. In this environment, last-mile providers no longer serve as mere pass-throughs. Instead, they must necessarily maintain a data network to hold the packet-switched traffic once it has been segregated from the other traffic. They must also negotiate some type of interconnection agreement with another carrier so that this traffic can be routed to its final destination.

Given that they are already performing many of the functions traditionally performed by ISPs, the logical next step was for last-mile broadband providers to negotiate their own agreements with backbone providers. The efficiency of this arrangement is eloquently demonstrated by the experience under the AOL-Time Warner merger, which remains the only instance in which multiple ISP access has been mandated. Contrary to the original expectations of the FTC, the unaffiliated ISPs that have obtained access to Time Warner's cable modem systems have not created their own packet networks within Time Warner's cable headends. Instead, traffic bound for these unaffiliated ISPs exits the headend via Time Warner's backbone

and is handed off to the unaffiliated ISP at an external location. The fact that these unaffiliated ISPs have found it more economical to share Time Warner's existing ISP facilities rather than build their own strongly suggests that integrating ISP and last-mile operations does in fact yield real efficiencies.<sup>59</sup> More importantly for our purposes, it demonstrates how technological change can collapse a natural interface between what were once two different levels of production.

In short, the complexity of the interface, the increasing heterogeneity of end users' demands, and the pace of technological change are reducing the utility of the regulatory tools upon which policymakers have traditionally relied to manage interconnection, nondiscrimination, rate regulation, and standardization. It is particularly telling that two distinguished scholars of network industries not particularly noted for deregulatory views have suggested that access regimes have proven so unworkable that they should be abandoned.<sup>60</sup>

### III. THE RELATIONSHIP BETWEEN BROADBAND NETWORKS AND END USERS

In addition to focusing on the terms governing the relationship between network owners and providers of Internet content and applications, some network neutrality proposals have also focused on regulating the terms of service in the contracts between network owners and end users. There is no evidence that last-mile broadband providers are blocking end-user access to any content.<sup>61</sup> Some network owners are experimenting with tiered pricing schemes that force

---

<sup>59</sup> See Yoo, *supra* note 11, at 30-34.

<sup>60</sup> See Paul L. Joskow & Roger G. Noll, *The Bell Doctrine: Applications in Telecommunications, Electricity, and Other Network Industries*, 51 STAN. L. REV. 1249 (1999).

<sup>61</sup> See Amy Schatz & Anne Marie Squeo, *As Web Providers' Clout Grows, Fears Over Access Take Focus: FCC's Ruling Fuels Debate Between Broadband Firms and Producers of Content*, WALL ST. J. Aug. 8, 2005, at A1 (reporting phone and cable companies' insistence that they will not block access to competitors' websites, quoting Chairman Martin as saying "We haven't seen any evidence of this being a problem," and noting that "Congressional proponents of net-neutrality legislation acknowledge that it isn't a problem now"); Peter J. Howe, *News from the Chicago Cable and Telecom Show*, BOSTON GLOBE, June 16, 2003, at C2 (quoting FCC Commissioner Jonathan Adelstein as acknowledging the lack of evidence that last-mile providers were limiting end users' ability to access content and calling network neutrality "a solution awaiting a problem"); National Cable and

heavy bandwidth users to pay more for their connections.<sup>62</sup> Still others have responded to reports that file-sharing programs consume an overwhelming share of the Internet's capacity<sup>63</sup> by deploying technologies that slow down the connections of users running bandwidth-intensive applications, such as file-sharing programs,<sup>64</sup> or by barring the use of file-sharing programs altogether.<sup>65</sup> Other end user restrictions designed to curb high bandwidth uses include higher charges on customers who attach Internet phones, videogame systems, and other devices associated with intensive bandwidth usage<sup>66</sup> and prohibitions on end users reselling bandwidth, operating file servers, or acting as an Internet service provider (ISP).<sup>67</sup>

These developments have prompted calls for regulations prohibiting last-mile providers from restricting end users' ability to run any applications, attach any devices, and access any content that they choose.<sup>68</sup> Industry consortia known as the High Tech Broadband Coalition (HTBC) and the Coalition of Broadband Users and Innovators (CBUI), which are backed by

---

Telecommunications Association, *Cable Provides Open Connectivity for the Internet 1* (June 2004) (asserting that cable operators do not limit customers' ability to access content), available at [http://www.ncta.com/pdf\\_files/IssueBriefs/OpenInternet.pdf](http://www.ncta.com/pdf_files/IssueBriefs/OpenInternet.pdf).

<sup>62</sup> See Tim Wu, *Network Neutrality, Broadband Discrimination*, 2 J. ON TELECOMM. & HIGH TECH. L. 141, 163-64 (2003); Roger Cheng, *ISPs Posed to Slow Bandwidth Hogs*, WALL ST. J., Nov. 11, 2003, at B2.

<sup>63</sup> See *Copyright Infringement and File Sharing – Part 1: Hearings Before the Sen. Judiciary Comm.*, 109th Cong., 1st Sess. (Sept. 29, 2005) (statement of Sam Yagan, President of the company that developed and distributes the market leading file-sharing program known as eDonkey) (reporting a study indicating that in North America and the United Kingdom file sharing represents 76% of total upstream and 48% of total downstream traffic, while in Europe it represents 85% of total upstream and 60% of all downstream traffic); *Adams Picks Sandvine*, XDSL NEWS, Aug. 1, 2005, at 13 (reporting that file sharing consumes 60% of Internet traffic); *Executive Q&A: Can BitTorrent (Yes, BitTorrent) Supercharge Mobile?*, WIRELESS BUS. FORECAST, Aug. 25, 2005 (reporting that as much as 50% of Internet traffic is file sharing); Steven Lawson, *London Is Global Internet Bandwidth Capital*, INFO WORLD DAILY, Sept. 8, 2005, (estimating that file sharing makes up 60% of Internet traffic); Kathy Tracy, *New Technologies Rock the L.A. Screenings*, VIDEO AGE INT'L, May 1, 2005, at 1 (reporting that 50% of all Internet traffic is file sharing).

<sup>64</sup> See Cheng, *supra* note 62.

<sup>65</sup> See Ryan Underwood, *VU Moves to Unload Download Burden: 3 Barred Programs Hog Internet Capacity*, NASHVILLE TENNESSEAN, Oct. 1, 2005, at 1A.

<sup>66</sup> See Schatz & Squeo, *supra* note 61.

<sup>67</sup> See Wu, *supra* note 62, at 156-62.

<sup>68</sup> LESSIG, *supra* note 1, at 156-58; *Ex parte* Letter of Timothy Wu and Lawrence Lessig at 12-15, *Appropriate Regulatory Treatment for Broadband Access to the Internet Over Cable Facilities* (F.C.C. filed Aug. 22, 2003) (CS Dkt. No. 02-52), available at [http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native\\_or\\_pdf=pdf&id\\_document=6514683884](http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6514683884).

leading industry players such as Microsoft and Amazon.com, have proposed “connectivity principles” that would require that all last-mile broadband providers to allow end users to access any content, run any applications, and attach any devices they desire, so long as these efforts do not harm the networks, enable theft of services, or exceed the bandwidth limitations of the particular service plan.<sup>69</sup> In a recent speech, then-FCC Chairman Michael Powell called upon the broadband industry to voluntarily embrace a series of similar “Internet Freedoms.”<sup>70</sup> The FCC eventually adopted a nonbinding policy statement recognizing the agency’s intent to preserve consumers’ rights to access the content, run the applications, and attach the devices of their choice, subject to exceptions for “reasonable network management.”<sup>71</sup> At the same time, Chairman Martin released a statement expressing his confidence that competition will remain sufficiently robust to make adoption of formal regulations implementing the policy statement unnecessary.<sup>72</sup>

Viewing these proposals from the perspective of vertical integration theory reveals they suffer from some fundamental conceptual flaws. These proposals are attempting to protect and promote competition in the segments of the industry that are already the most competitive and the least protected by entry barriers, which underscores the extent to which these proposals have misframed the central policy problem confronting the broadband industry.

---

<sup>69</sup> See Comments of the High Tech Broadband Coalition at 6-9, *Appropriate Regulatory Treatment for Broadband Access to the Internet Over Cable Facilities* (F.C.C. filed June 17, 2002) (CC Dkt. No. 02-52), available at [http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native\\_or\\_pdf=pdf&id\\_document=6513198026](http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6513198026); *Ex parte* Communication from the Coalition of Broadband Users and Innovators at 3-4, *Appropriate Regulatory Treatment for Broadband Access to the Internet Over Cable Facilities* (F.C.C. filed Jan. 8, 2003) (CS Dkt. No. 02-52), available at [http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native\\_or\\_pdf=pdf&id\\_document=6513401671](http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6513401671).

<sup>70</sup> Michael K. Powell, *Preserving Internet Freedom: Guiding Principles for the Industry*, 3 J. ON TELECOMM. & HIGH TECH. L. 5 (2004).

<sup>71</sup> *Appropriate Framework for Broadband Access to the Internet over Wireline Facilities*, Policy Statement, 20 F.C.C.R. 14986 (2005).

<sup>72</sup> FCC Chairman Kevin J. Martin, *Comments on Commission Policy Statement 1* (Aug. 5, 2005), available at [http://hraunfoss.fcc.gov/edocs\\_public/attachmatch/DOC-260435A2.pdf](http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-260435A2.pdf).

In addition, the connectivity principles fail to take into account the extent to which restrictions on applications and equipment represent an alternative approach to addressing congestion in the fiber nodes, backbones, and servers needed to run the Internet. Shared facilities that are subject to congestion confront a fundamental pricing problem. Under the standard measures of economic performance, welfare is maximized when customers use the shared facility only up to the point where the benefits from consuming an additional unit of the shared facility no longer exceeds the costs of allowing them to consume an additional unit.

Firms that charge prices that are not sensitive to the amount of bandwidth used will soon confront a quandary. Since the cost to customers of incremental use is zero, they will increase their use of the facility until the marginal utility of an additional use is zero. The congestion costs of the additional uses are not zero, however. The result is an equilibrium in which the number of visits is economically excessive. The standard solution to this problem is employing a volume-sensitive pricing scheme in which the customer pays both a fixed amount for its connection as well as a per-use amount that is set equal to the congestion costs associated with an incremental use of the system.<sup>73</sup>

Unfortunately, experience in other communications-related industries suggests that the costs of monitoring and billing on a volume-sensitive basis may be prohibitively expensive. When transaction costs render usage-sensitive pricing infeasible, network owners may find it preferable to employ restrictions on end users' ability to access applications and content and attach devices. This alternative approach is based on the insight, derived from Ronald Coase's classic critique of the economic parable of the lighthouse,<sup>74</sup> that the high transaction costs

---

<sup>73</sup> See Jeffrey K. MacKie-Mason & Hal R. Varian, *Pricing Congestible Network Resources*, 13 IEEE J. ON SELECTED AREAS IN COMMUNICATIONS 1141 (1995).

<sup>74</sup> See R.H. Coase, *The Lighthouse in Economics*, 17 J.L. & ECON. 357 (1974).

associated with metered pricing can also be avoided by finding an alternative that can serve as a proxy for usage. If that alternative activity is easier to meter, it can provide a useful approximation of actual usage of the primary services. Given the costs of creating precisely calibrated per-use pricing systems, it should come as no surprise that many last-mile providers have turned to proxies by prohibiting applications and equipment associated with intensive bandwidth use. For example, some last-mile providers have prohibited customers from streaming media, from attaching content servers, or serving as an ISP. Other last-mile providers have begun offering two-tier plans that charge more to users who want to use bandwidth-intensive applications, such as home networking, virtual private networking, and music downloading.

The foregoing discussion reveals that, under certain circumstances, restrictions on the use of particular applications and the attachment of particular equipment can represent an economically rational response to the congestion problems associated with broadband service. Indeed, this analysis suggests that allowing unfettered access to content, applications, and devices may have long-term negative consequences for broadband development and actually harm consumers. Simply put, the current regime of flat-rate pricing and unrestricted access allows high-volume users who contribute more to congestion to impose costs on low-volume users, in effect requiring the latter to subsidize the former. Taking a broader vision of consumer welfare reveals that placing restrictions on high-bandwidth uses can benefit consumers by constraining the behavior of those end users who create the most congestion on the Internet. Conversely, low-volume users will likely benefit from restrictions on applications and devices associated with high-bandwidth use, through increases in the quality of the service they receive

and decreases in the prices they pay.<sup>75</sup> The proposals advanced by the proponents of connectivity principles would have the unfortunate effect of unduly limiting last-mile providers' ability to use such restrictions to address this fundamental problem.

This is not to say that some restrictions on end-users' ability to run certain applications might not be a cause for regulatory concern. Of particular note is Madison River Communication's recent attempt to protect its telephone business by blocking the ports used by its customers for VoIP service.<sup>76</sup> Other potential problems arise from content such as local sports, which is of particular interest only in certain areas and for which the demand is too thin to support real alternatives.

The foregoing analysis demonstrates why policymakers should exercise great caution before compelling a network to provide access to any specific content or application. To the extent that competition exists among transmission technologies, subscribers' ability to change last-mile providers should prove sufficient to forestall any anticompetitive consequences. In addition, as discussed earlier, limiting network owners' ability to use exclusivity arrangements to differentiate their offerings can actually make matters worse by limiting the dimensions along which they can compete and by constraining their ability to manage network traffic. In addition, by dampening the incentives for investing in new transmission technologies, compelling access can actually have the perverse effect of entrenching the current level of concentration into place. This is why courts and leading commentators have consistently condemned compelling access to communications networks whenever competition from alternative network platforms is feasible, even if the emergence of such competition requires the incurrence of significant costs and over

---

<sup>75</sup> See Jeffrey K. MacKie-Mason & Hal R. Varian, *Some FAQs About Usage-Based Pricing*, 28 COMPUTER NETWORKS & ISDN SYS. 257, 258 (1995).

<sup>76</sup> See Madison River Communications, LLC, Order, 20 F.C.C.R. 4295 (2005).

the relatively long run.<sup>77</sup> The level of competition that already exists in broadband and the feasibility of new transmission technologies undercut the justification for depriving last-mile providers of any control over the content and applications that can be accessed over their networks.

In any event, even assuming that these preconditions were met, such considerations would not justify depriving last-mile providers of any control over the content and applications carried on their networks. At most, such considerations would justify the type of targeted response specific to certain applications and content and certain carriers undertaken by the FCC in *Madison River*.<sup>78</sup> Under no circumstances would they provide support for the kind of blanket condemnation of restrictions on the applications end users can run through their broadband connections envisioned under network neutrality.

#### IV. DEBUNKING THE ARGUMENTS IN SUPPORT OF NETWORK NEUTRALITY

Lessig's primary justification for limiting the ways that network owners can manage network capacity and reliability is known as the *end-to-end argument*.<sup>79</sup> The end-to-end argument asserts that the functions performed in the core of the network should be as simple and

---

<sup>77</sup> See *United States Telecom Ass'n v. FCC*, 290 F.3d 415, 428-29 (D.C. Cir. 2002) (UNE access); 3A AREEDA & HOVENKAMP, *supra* note 9, ¶¶ 771, 773 (essential facilities doctrine); *cf.* *AT&T Corp. v. Iowa Utils. Bd.*, 525 U.S. 366, 387-92 (1999) (emphasizing the importance of limiting UNE access to those elements that are truly necessary).

<sup>78</sup> Although the FCC's decision that DSL and cable modem systems represent information services places them outside the regulatory requirements imposed by Title II of the Communications Act of 1934, the FCC has long asserted the authority to regulate information services under its Title I ancillary jurisdiction. See Amendment of Section 64.702 of the Commission's Rules and Regulations (Second Computer Inquiry) Final Decision, 77 F.C.C.2d 384, 435 ¶ 132 (1979). Recent judicial pronouncements suggest that such an exercise of jurisdiction by the FCC would be proper. See *Nat'l Cable & Telecomm. Ass'n v. Brand X Internet Servs.*, 125 S. Ct. 2688, 2696, 2708 (2005) (noting that the FCC "remains free to impose special regulatory duties on facilities-based ISPs under its Title I ancillary jurisdiction"). The FCC has sought comment as to its authority to regulate DSL and cable modem systems on the basis of Title I. See *Wireline Broadband Order*, *supra* note 6, ¶¶ 146-157; *Inquiry Concerning High-Speed Access to the Internet Over Cable and Other Facilities*, Declaratory Ruling and Notice of Proposed Rulemaking, 17 F.C.C.R. 4798, 4839 ¶ 72 (2002).

<sup>79</sup> See J.H. Saltzer et al., *End-to-End Arguments in System Design*, 2 ACM TRANSACTIONS ON COMPUTER SYS. 277 (1984) (providing the seminal statement of end-to-end).

general as possible and that application-specific functionality should be confined to the computers operating at the edge of the network. The rationale underlying this argument is based in cost-benefit analysis. The point is best illustrated by the example of transmitting a file from one computer to another computer via a telecommunications network. Such a function requires the originating computer to prepare the file for transfer and hand off the packets to the last-mile provider that serves that end user. The last-mile provider in turn passes the packets either to a backbone provider, which may in turn pass the traffic on to one or more additional backbone providers. Eventually, the final backbone provider transmits the packets to the last-mile provider serving the final destination, which delivers the packets to the terminating computer for reassembly into a single file.

The question is how best to ensure that the file is transmitted accurately. One way to accomplish this is to introduce error checking at each step of the transmission process. Because confirming the accuracy of a transmission inevitably requires additional traffic between every two computers in the system, this solution would introduce a degree of redundancy into the network that would have the inevitable effect of slowing it down. In short, increasing the functions performed in the core of the network can increase the reliability of the network, but only at the expense of reduced network performance. The problem is that all applications would have to bear the costs associated with the reduction performance even though some applications gain no compensating benefits from the increase in reliability. This tradeoff can be avoided by adopting an alternative approach known as *end-to-end check and retry*, in which the only error checking occurs when the receiving computer verifies the accuracy of the file transfer with the initiating computer after the entire transaction has been completed. This basic insight suggests that networks should be designed so that the core of the network performs only those functions

that benefit all applications and if higher-level, application-specific functions are confined to the servers operating at the network's edge. In other words, the pipes comprising the core of the network should be kept as "dumb" as possible, and the intelligence should be confined to the servers operating at the edge of the network.

Although the end-to-end argument is frequently invoked in support of network neutrality, such claims appear to be misplaced. The architects of the end-to-end argument themselves recognized that it is "too simplistic to conclude that the lower levels should play no part in obtaining reliability" and stress that that "the end-to-end argument is not an absolute rule, but rather a guideline that helps in application and protocol design analysis." They explain that correct application of the cost-benefit tradeoff that lies at the heart of the end-to-end argument requires "subtlety of analysis" and can be "quite complex."<sup>80</sup> Indeed, the architects of end-to-end acknowledge that "[t]here are some situations where applying an end-to-end argument is counterproductive" and concludes that the proper approach is to "take it case-by-case."<sup>81</sup> The end-to-end argument is thus more properly regarded as merely "one of several important organizing principles for systems design" rather than as an absolute. Properly construed, the end-to-end argument calls for case-by-case analysis rather than a blanket regulatory prohibition. As the original architects of the end-to-end argument candidly acknowledge, "there will be situations where other principles or goals have greater weight."<sup>82</sup> The FCC's recent *Wireline Broadband Order* confirmed the import of this criticism when it acknowledged that

---

<sup>80</sup> *Id.* at 280, 284, 285. To take but one example, the desirability of end-to-end depends in part on the length of the file. If a system drops one message per one hundred messages sent, the probability that all packets will arrive correctly decreases exponentially as the length of the file increases (and thus the number of packets composing the file) increases. *Id.* at 280-81.

<sup>81</sup> See David P. Reed et al., *Commentaries on "Active Networking and End-to-End Arguments,"* 12 IEEE NETWORK 69, 70 (1998).

<sup>82</sup> *Id.* at 69 n.1, 70 see also Samrat Bhattacharjee et al., *Active Networking and the End-to-End argument*, 1997 PROC. INT'L CONF. ON NETWORK PROTOCOLS 220, 221; Blumenthal & Clark, *supra* note 20, at 71, 80, 102 n.19; Dale N. Hatfield, *Preface* 8 COMMLAW CONSPECTUS 1, 3 (2000).

“[i]nnovation can occur at all network points and at all network layers as well as in non-network applications and equipment” and that continued application the regime of mandatory interconnection and standardization created by the *Computer Inquiries* “would prevent much of this innovation from occurring.”<sup>83</sup>

Lessig also suggests that congestion problems can be solved by increasing capacity rather than by giving network owners more control over network flows.<sup>84</sup> As noted earlier, there is no compelling reason to believe that bandwidth will necessarily increase faster than demand, especially in light of the fact that the number of potential connections goes up exponentially with the number of computers added to the system. Relying on capacity expansion to solve the problems related to congestion is made all the more problematic by the fact that capacity cannot be expanded instantaneously. Even when capacity expansion is feasible in the long run, any underestimation of projected demand will necessarily create short-run scarcity that cannot be addressed through increased bandwidth. Adding bandwidth and using network management techniques that deviate from TCP/IP are simply alternative ways to solve the problems of congestion. Given that the relative attractiveness of each alternative should vary depending on the situation, it would seem to be a mistake to precommit to one approach over the other. Indeed, in some cases, where the nonstandardization inherent in network diversity are used to improve security or increase functionality wholly apart from the desire to reduce congestion, the possibility of adding bandwidth is not responsive to the problem.

---

<sup>83</sup> See Wireline Broadband Order, *supra* note 6, ¶¶ 70.

<sup>84</sup> Although Lessig recognizes that this vision contradicts the basic economic notion that all commodities are inherently scarce, he nonetheless states, “I’m willing to believe in the potential of essentially infinite bandwidth. And I am happy to imagine the scarcity-centric economist proven wrong. LESSIG, *supra* note 1, at 47.

Lessig also suggests that network neutrality might be justified by the growing level of concentration in network ownership.<sup>85</sup> As an initial matter, the last three decades of economic theory have revealed the implausibility of the leading claims that monopolists can use vertical integration to harm competition.<sup>86</sup> On the contrary, last-mile providers have powerful incentives to maximize usage and the degree of innovation on their networks.<sup>87</sup>

Even more importantly, it is far from clear that concentration represents the threat that Lessig suggests once the precise markets that network neutrality is designed to protect have been identified. The concentration is most acute in the market in which last-mile broadband providers bargain with end users. As noted earlier, preventing owners of last-mile technologies from entering into exclusivity arrangements and forcing them to employ nonproprietary protocols that permit complete interoperability would not affect this market one iota. The economic relationship between last-mile providers and end users is a function of the number of last-mile providers. Net neutrality will not change that number. In fact, as suggested above, it could actually deter the growth of competition in the last mile.

Imposing network neutrality would, however, have a significant impact on the upstream market in which last-mile providers bargain with providers of applications and content. The

---

<sup>85</sup> *Id.* at 173-74. Lessig is quite candid about his bias against incumbent network owners:

Dinosaurs should die. . . . And innovators should resist efforts by dinosaurs to keep control. Not because dinosaurs are evil; not because they can't change but because the greatest innovation will come from those outside these old institutions. Whatever the scientists at Bell Labs understood, AT&T didn't get it. Some may offer a theory to explain why AT&T wouldn't get it. But this is a point most understand without needing to invoke a fancy theory.

*Id.* at 176. The irony is that this argument relies on incumbents' supposed reluctance to innovate to stifle innovation.

<sup>86</sup> See Yoo, *supra* note 15, at 187-205, 252-68.

<sup>87</sup> See Joseph Farrell & Philip J. Weiser, *Modularity, Vertical Integration, and Open Access Policies: Towards a Convergence of Antitrust and Regulation in the Internet Age*, 17 HARV. J.L. & TECH. 85, 104 (2003); 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, 76 (2000).

proper question is thus not whether the broadband transport provider wields market power vis-à-vis broadband users in any particular city, but rather whether that provider has market power in the upstream market for obtaining broadband content. As a general matter, this market is a national one, not a local one.<sup>88</sup> This point is well illustrated by a series of recent decisions regarding the market for cable television programming. As the FCC and the D.C. Circuit have recognized, a television programmer's viability does not depend on its ability to reach any particular viewers, but rather on the total number of viewers they are able to reach. So long as a cable network can reach a sufficient number of viewers nationwide, the fact that a particular network owner may refuse carriage in any particular locality is of no consequence.<sup>89</sup> Simply put, it is national reach, not local reach, that matters.

When the relevant market is properly defined, it becomes clear that this market is too unconcentrated for vertical integration to pose a threat to competition. The concentration levels in the broadband industry fall far below the thresholds identified by the FCC,<sup>90</sup> the Federal Trade Commission, and the Justice Department for determining when vertical integration is the cause

---

<sup>88</sup> This is subject to the aforementioned caveat about local content, such as local sports. *See* text following *supra* note 76. As noted earlier, even when this is the case, compelling access is inappropriate when competition from new networks is feasible. In any event, such concerns would never justify requiring all network owners to provide access to all available content and applications. Such a requirement would sweep too broadly, applying without heed to the number of available alternatives, compelling network owners to provide access even when end users could access a wide array of options. In any event, at most such concerns would justify a more targeted regulatory solution tailored to the precise nature of the problem rather than the type of categorical mandate inherent in network neutrality.

<sup>89</sup> *See* *Time Warner Entm't Co. v. FCC*, 240 F.3d 1126, 1131-32 (D.C. Cir. 2001) (relying on the FCC's conclusion that a cable television programmer need only reach 18.56% of the country to be economically viable) (citing Implementation of Section 11(c) of the Cable Television Consumer Protection and Competition Act of 1992, Third Report and Order, 14 F.C.C.R. 19098, 19114-18 ¶¶ 40-50 (1999)).

<sup>90</sup> *See* Applications of Nextel Communications, Inc. and Sprint Corp. for Consent to Transfer Control of Licenses and Authorizations, Memorandum Opinion and Order, 20 F.C.C.R. 13967, ¶ 63 (2005); Applications of Western Wireless Corp. and Alltel Corp. for Consent to Transfer Control of Licenses and Authorizations, Memorandum Opinion and Order, 20 F.C.C.R. 13053, ¶¶ 46-47 (2005); Applications of AT&T Wireless Services, Inc. and Cingular Wireless Corp. for Consent to Transfer Control of Licenses and Authorizations, Memorandum Opinion and Order, 19 F.C.C.R. 21522, 21568 ¶¶ 106-107 (2004).

for anticompetitive concern.<sup>91</sup> Indeed, Lessig's concerns about concentration seem better suited to the network of the past than the network of today. His arguments seem to stem from the manner in which AT&T was able to stem innovation during the time in which it was the dominant network player. They are considerably less compelling in a universe in which the largest player controls roughly twenty percent of all broadband customers and the levels of concentration fall below levels traditionally thought necessary to threaten competition.

Indeed, the ambiguity inherent in the issues surrounding concentration is underscored by comparing Lessig's concern, which is that portions of the network will be too eager to deviate from the established standard,<sup>92</sup> with the concern associated more frequently with network economic effects, which is that users will be too reluctant to deviate from the established standard, thereby allowing an obsolete technology to become locked in.<sup>93</sup> When the latter is the primary concern, the presence of large players is a potential boon, rather than a bane. Because larger players are able to internalize a greater share of the benefits created by their own technology choices, they are logical candidates to mitigate the lock-in effects caused by network externalities by becoming the sponsor of a new technology.<sup>94</sup> In other words, to the extent that network economic effects create excess inertia rather than excess momentum, attempts to deviate from the existing standard should be embraced, rather than rebuffed.

In the end, Lessig's primary concern is that network diversity would hurt the environment for innovation, which he believes stems from the existence of an "innovation commons" in which applications and content providers can have access to the entire universe of potential

---

<sup>91</sup> See Yoo, *supra* note 11, at 52-53.

<sup>92</sup> See LESSIG, *supra* note 1, at 48, 168, 171, 176.

<sup>93</sup> See Joseph Farrell & Garth Saloner, *Installed Base and Compatibility: Innovation, Product Preannouncements, and Predation*, 76 AM. ECON. REV. 940, 941-43 (1986); Katz & Shapiro, *supra* note 18, at 108.

<sup>94</sup> See Katz & Shapiro, *supra* note 42, at 825, 838-39.

customers without having to obtain permission from any gatekeeper. Network owners, Lessig argues, are too eager to fracture the interoperability of the Internet because they fail to internalize the benefits from innovation associated with network neutrality.<sup>95</sup> A close reading of the economic literature, however, reveals that the impact of network economic effects on innovation is ambiguous<sup>96</sup> and that such concerns appear to be misplaced in the context of a physical network that can be owned<sup>97</sup> and in an industry undergoing exponential growth.<sup>98</sup> Indeed, the use of the term “commons” creates some degree of irony, since the accepted solution to the tragedy of the commons is the creation of well-defined property rights,<sup>99</sup> which would be more consistent with network diversity than network neutrality. Indeed, more recent scholarship on the anticommons has underscored the fact that property rights can be too small as well as too large.<sup>100</sup> The presence of innovation externalities thus more properly implies some notion of a property right’s optimal size rather than a blanket presumption in favor of an innovation commons.

---

<sup>95</sup> See LESSIG, *supra* note 1, at 8, 168, 171, 173, 175. This is a point that is more important to him than even the end-to-end argument. Indeed, Lessig acknowledges that even if discrimination is imposed by end users in a manner consistent with end-to-end, he would still be concerned. See *id.* at 171, 173.

<sup>96</sup> Network neutrality advocates overlook the fact that any decision to switch networks necessarily involves two offsetting externalities. On the one hand, a person adopting a new technology increases the value of the new network. The inability to capture this benefit may make network users too reluctant to switch networks. At the same time, any decision to switch network necessarily reduces the value of the old network. The fact that the end user switching networks does not bear these costs may make it too eager to switch. Whether end users switch networks too frequently or not frequently enough depends upon which of these two effects dominates. See Farrell & Saloner, *supra* note 93, at 941-42.

<sup>97</sup> Network externalities are not a problem when the network in question is a physical network. Even if individual users may not be in a position to internalize all of the costs and benefits created by their network adoption decisions, the network owner will almost certainly be in a position to do so. See S. J. Liebowitz & Stephen E. Margolis, *Are Network Externalities a New Source of Market Failure?*, 17 RES. LAW & ECON. 1, 11-13 (1995); S. J. Liebowitz & Stephen E. Margolis, *Network Externality: An Uncommon Tragedy*, 8 J. ECON. PERSP. 133, 137, 141-44 (1994).

<sup>98</sup> Existing market positions mean little in rapidly growing industries. People concerned about network economic effects will focus on the size of the network that will exist in the future, not the size of the one that exists today. See Michael L. Katz & Carl Shapiro, *Product Introduction with Network Externalities*, 40 J. INDUS. ECON. 55, 67, 73 (1992); Liebowitz & Margolis, *supra* note 42, at 292.

<sup>99</sup> See Garrett Hardin, *The Tragedy of the Commons*, 162 SCIENCE 1243 (1968).

<sup>100</sup> See, e.g., Michael Heller, *The Tragedy of the Anticommons: Property in the Transition from Marx to Markets*, 111 HARV. L. REV. 621 (1998).

Network diversity thus has the potential to provide substantial benefits that would be foreclosed were policymakers to mandate network neutrality. Is there a simple policy inference that can be drawn? The problem is that acknowledging that products compete on more dimensions than simply price greatly complicates the welfare analysis. The multidimensionality of competition under network diversity inevitably requires a complex tradeoff among myriad considerations, including the heterogeneity of network uses, the variability in network traffic flows, end users' need for network reliability, the speed of entry, and the extent to which technological change is reorganizing the natural boundaries between levels that were previously separated by a natural interface. In short, the desirability of complete standardization and interoperability is an empirical question that cannot be answered *a priori*.

Fortunately, competition policy offers a potential way out of this analytical limbo. It suggests that when policymakers cannot determine whether a new institutional form would help or hinder competition, the proper response is to forbear prohibiting the practice *per se* and to instead undertake a case-by-case analysis of its impact on competition. Forbearing from either forbidding or mandating any particular solution leaves the room for the experimentation upon which markets depend.<sup>101</sup>

Nonintervention is particularly appropriate where, as here, regulators will struggle to distinguish anticompetitive from procompetitive behavior. Regulatory forbearance represents the proper way for regulators to show technological humility. Placing the burden of proof on those favoring regulatory intervention accords with our notions of liberty and the classic vision of the proper relationship between the individual and the state. It also allows decisionmaking about technology adoption to be decentralized. It also avoids the risks of locking the existing

---

<sup>101</sup> See *supra* notes 3-4 and accompanying text.

technological boundaries between firms into place in industries undergoing dynamic technological change. In the most extreme case, regulation can itself become the source of market failure, in which case intervention would have the perverse effect of reinforcing the market failure that regulation was designed to redress.

## CONCLUSION

There can be no question that network neutrality holds considerable allure. The vision of a world in which every end user can obtain access to every available application and piece of information is quite compelling. It is thus quite understandable that so many commentators have endorsed network neutrality as a concept. The economic advantages of interoperability are considerable, and I would expect interoperability to play a central role in the business plans of the vast majority of Internet-based businesses.

The question that must be asked is not whether network neutrality yields benefits, but rather whether forbidding deviations from network neutrality might impose harms. My exploration of the arguments underlying network neutrality provides substantial reason for caution. Standardization can reduce welfare both by reducing diversity and by biasing the market against certain types of applications. It can have the perverse effect of reinforcing the sources of market failure used to justify regulatory intervention in the first place. It can further entrench monopoly power by dampening incentives to invest in alternative network neutrality.

Instead, my analysis suggests that public policy might be better served if policymakers were instead to embrace network diversity. Doing so would permit end users to enjoy the benefits of product variety. Network diversity also has the potential to mitigate the supply-side and demand-side scale economies that concentrate telecommunications markets and to make it easier for multiple networks to coexist. The more restrained approach inherent in network

diversity is also more consistent with the current understanding of the institutional capabilities of courts and agencies. It also accommodates technological dynamism and humility by providing maximum room for experimentation and development. This is not to say that policymakers should reject network neutrality once and for all. What is called for is a sense of balance and optimality that can adjust with the circumstances. But in the face of technological uncertainty, the more appropriate and humble approach would appear to favor forbearing from mandating any particular architecture.