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The Regulation of Broadband Telecommunications, the Principle of Regulating Narrowly Defined Input Bottlenecks, and Incentives for Investment and Innovation

William P. Rogerson[†]

Recent technological advances in computers, the internet, and telecommunications hold out the promise that people's lives will be revolutionized by the creation of high-speed or broadband connections to the home. The simple telephone line will be replaced by new connections that allow hundreds or even thousands of times as much data and information to flow between a home or business and the rest of the world. This change will allow high-speed access to information on the internet, telecommuting, video conferencing, transmission of streaming video and audio, and high-speed downloads of files. Existing telephone and cable systems can be adapted to provide these broadband connections. Furthermore, such connections can also be provided using fixed wireless technology and, ultimately, will likely be provided by satellites as well.

While some of these technologies—particularly those that provide connections over local telephone and cable networks—have advanced far enough that functioning broadband connections are now being deployed, most industry participants and observers would agree that there is still more potential for enormous and rapid technological advance over the next decade. Thus, broadband networks a decade from now may vastly outperform any networks that we could imagine using currently available technology. The broadband access industry, then, is a classic example of a high-technology industry, such as computers

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or biotechnology, where it is appropriate to measure the performance of the industry at least as much by the innovations it generates as by the price and quality of the products it currently produces.¹

It is well understood by economists and policy makers that traditional cost-based regulation is not well suited to industries where technology and products change rapidly so that there is a need for innovation, a diversity of approaches, and risk-taking. This is true for at least two reasons. First, and probably most importantly, cost-based regulation provides very little incentive for firms to innovate, experiment, and take risks. There is no potential for a firm to earn enormous profits if its innovative efforts are successful, because the firm is always restricted to earn a fair rate of return. Moreover, there is even the risk of losses if a firm's innovative efforts are unsuccessful, because risky innovative projects that do not bear fruit might well be branded ex-post by regulators as imprudent expenditures that ought not to be reimbursed. Second, cost-based regulation often goes hand-in-hand with the existence of a single large bureaucratic firm, while unregulated competition allows for a larger number of more diverse, smaller firms. In some cases, it may well be that a diverse group of smaller firms is better able to produce innovations than a single large bureaucratic firm simply because the smaller firms can bring a more diverse set of approaches and ideas to bear on a problem.

Rapid technological change and the enormous potential for innovation, then, create a strong case for the general presumption that the Federal Communications Commission ("FCC") should not attempt at present to regulate extensively the provision of broadband services. Given that multiple competitors are

¹ This Article draws heavily on a number of papers that discuss broadband technology. See generally Sanford C. Bernstein & Co and McKinsey & Co, *Broadband!* (Jan 2000); Deborah Lathen, *Broadband Today*, available online at <<http://fcc.gov/Bureaus/Cable/Reports/broadbandtoday.pdf>> (visited Feb 18, 2000); James B. Speta, *Handicapping the Race for the Last Mile?: A Critique of Open Access Rules for Broadband Platforms*, 17 Yale J Reg 39 (2000); Jason Oxman, *The FCC and the Unregulation of the Internet* (July 1999), available online at <<http://www.fcc.gov/Bureaus/OPP/working-papers/oppwp31.pdf>> (visited Feb 18, 2000); *In the Matter of Inquiry Concerning the Deployment of Advanced Telecommunications Capability*, 14 FCC Rec 2398 at 20 (1999); Stagg Newman, Doug Sicker, and Lynn Remly, *Open Access for Internet over Cable—the Technical Issues*, OET FCC paper (Aug 1999) [on file with U Chi Legal F]; Barbara Esbin, *Internet Over Cable: Defining the Future In Terms of the Past* (Aug 1998), available online at <<http://www.fcc.gov/Bureaus/OPP/working-papers/oppwp30.pdf>> (visited Feb 18, 2000); *Third Report and Order Deployment of Wireless Services Offering Advanced Telecommunications Capability*, 14 FCC Rec 20912 (1999).

poised to enter most markets, that the vast majority of potential customers have not yet been won by any firm, and that a tremendous need for a diversity of approaches and strong incentives for innovation exist, the advantages to having the FCC simply "get out of the way" are readily apparent.

This Article will argue, however, that in fact a sound economic rationale supports one limited form of regulation that applies to provision of broadband services over copper loops of the local telephone network. More specifically, this Article will argue that regulations requiring local telephone companies (the Incumbent Local Exchange Carriers or ILECs) to make their copper loops available to other potential broadband suppliers at cost-based rates would be desirable.

My policy prescription can be viewed as an application of a concept that telecommunications regulators are already attempting to use, which I will refer to as the principal of regulating narrowly defined bottleneck inputs instead of outputs. The general idea is that regulators can bring the benefits of competition (increased incentives for innovation and increased diversity) to as many parts of the local telephone network as possible, while still protecting consumers from the exercise of monopoly power, by requiring the incumbent local exchange carrier to sell individual parts of its network to competitors at cost-based prices, instead of regulating final output prices. By this means, competition can infiltrate all parts of the network that are not monopoly bottlenecks and regulators can restrict themselves to regulating only the monopoly bottleneck portions of the network. This principle essentially allows regulators to "have their cake and eat it, too," in situations where the main need for innovation lies in parts of the local telephone network that are not subject to monopoly bottlenecks.

The case of broadband access over the local telephone network is in some ways ideally suited for application of the principle of regulating narrowly defined bottleneck inputs. The existing technology used to provide broadband access over the local telephone network is referred to as direct subscriber line ("DSL") technology. In many cases this technology can be used to provide a broadband connection using the existing copper loop of the telephone network between the end user and the ILEC's switch. Electronic equipment is simply added at each end of the loop and, generally speaking, it is possible and economical for multiple DSL providers to install the necessary equipment in the ILEC's

switching offices. Almost no additional investment, innovation, or changes are required in the existing copper loops owned by the ILEC. Furthermore, it is possible for different DSL providers to adopt different technological approaches on the same network. That is, requiring the ILEC to make its copper loops available to multiple DSL providers does not constrain the ability of providers to experiment with different DSL technologies on the lines available to them.² Therefore, the FCC can create a vibrant and diverse industry of DSL providers over the existing ILEC network of copper loops by requiring the ILEC to sell access to its copper loops at regulated prices and then neither regulating the retail prices of DSL providers (including the retail prices for DSL services charged by the ILEC itself) nor requiring the ILEC to provide any sort of unbundled access at all to any of the equipment on each end of the line that it installs to provide DSL.

While it is true that cable, wireless, and satellite alternatives would provide some competition for the ILEC if the ILEC remained the sole user of its copper loops, allowing multiple providers of DSL access to the ILEC's copper loops would provide a tremendous incentive to diversity and competition without damaging the ILEC's incentives in any important way, because the existing copper network is already largely in place and can be used without significant changes.

One complication raised by this policy is that, in some cases, the traditional all-copper loop is being replaced by connections that use both copper and optical fiber. Employing digital loop carrier ("DLC") technology, copper wires run from end users to small remote terminals, at which point the signals are aggregated and carried the remainder of the way to the switching office on high capacity optical fiber. Furthermore, it is possible that the best technological approach to providing broadband connections over the existing ILEC networks may ultimately require that much more copper be replaced by fiber.³ The problem with a regulation requiring the ILEC to make this new transmission capacity available to CLECs at cost-based prices is that the ILEC will have a reduced incentive to invest and innovate if it is required to sell the fruits of its efforts at cost-based prices. That is, to the ex-

² It is possible for signals traveling over adjacent lines to create interference problems with one another, but these sorts of problems, in general, are not so severe as to preclude the use of various DSL technologies.

³ As will be discussed below, this is because existing all-copper loops are sometimes too long for existing DSL technology, and because new DSL technologies that allow faster transmission speeds may require even shorter lengths of copper.

tent that the need for innovation is in the loop itself, it is no longer the case that the monopoly bottleneck can be isolated from the parts of the network requiring innovation. Therefore, the issue of whether and how the FCC should require unbundling of mixed copper/fiber loops is a more complex issue that requires further analysis.

With respect to cable firms, there is no analog to the existing set of copper wires that provide the loop connection and that are separable from the new investments required for creating broadband connections. Therefore, the problem identified above would also beset any scheme requiring cable firms to provide unbundled access to their transmission capacity.

Specifically, provision of broadband connections requires massive new investments, innovations, and upgrades in the physical plant connecting end users to the network (the analog of the loop). Regulating these facilities (either through regulating retail prices or mandating some type of unbundled access to other providers at regulated prices) would blunt the incentives for investment and innovation. Therefore, I believe that the present asymmetric treatment of ILECs and cable providers may be justified with respect to unbundling obligations, at least insofar as ILECs are required to provide unbundled access to their traditional copper loops.

Part I of this Article begins with a brief explanation of the technology at issue. Part II explains the principle and history of regulating narrowly defined bottlenecks instead of outputs. Part III then applies this principle to the regulation of broadband access over the ILEC network, where broadband connections can be created using the ILEC's existing copper loops. Part IV counters the argument that competition from cable firms and others will obviate the need for the additional competition that unbundling would induce. Part V discusses the significant issues that arise when the possibility of new loop technologies involving mixed fiber/copper loops is considered. Part VI explains why the principle of regulating narrowly defined input bottlenecks cannot be applied to the cable industry and argues that asymmetric regulatory treatment of the ILEC and cable firms may therefore be appropriate.

I. BACKGROUND ON TECHNOLOGY AND DEPLOYMENT

The massive expense and investment associated with connecting end users to the internet involves the so-called "last mile"

connection between the end user's place of residence or work and some initial aggregation node that receives connections from thousands of end users over a local area.⁴ Once this first level of aggregation has been accomplished, subsequent investments to provide connections to the internet are less expensive on a per-user basis.

The speed of a connection is measured in kilobits per second (kbps) and megabits per second (mbps) where 1 mbps is equal to 1,000 kbps. The traditional "narrowband" connection provided through a modem connected to a regular telephone line typically operates at speeds between 33 kbps and 56 kbps. The speed that is sufficient to constitute a "broadband" connection has become a constantly moving target as applications requiring higher and higher transmission speeds are invented. In its recent report to Congress, the FCC chose a minimum speed of 200 kbps as reasonably defining a broadband connection, because this speed "is enough to provide the most popular forms of broadband—to change web pages as fast as one can flip through the pages of a book and transmit full-motion video."⁵ However, speeds of closer to 1 mbps are necessary to view television-quality streaming video.⁶ The waiting time to download a 10-megabyte file (approximately the equivalent of a ten- to twenty-minute movie clip) is ninety seconds at a speed of 1 mbps; a speed of 10 mbps is required to reduce waiting time to under ten seconds.⁷ Therefore, at the present time, increments in transmission speeds up through 1 or 2 mbps will clearly be highly valued by consumers. Increases beyond this will be valued to the extent that they shorten download times.

Broadband connections over the local telephone network can be created using DSL technology. The traditional switched local telephone network can be thought of as consisting of three parts. The first part is the connection between the end user and the local switching office. This connection is typically referred to as the loop. Each loop is created by an individual pair of twisted copper

⁴ Obviously, if the initial stage of aggregation is small enough—for example, aggregating users into pairs—then considerable expense will still remain. The initial level of aggregation which captures the "last mile" expense corresponds roughly to the aggregation that occurs when local telephone signals are aggregated at the first switch. In most non-rural areas an average switch will serve approximately twenty thousand to fifty thousand lines.

⁵ See *Development of Advanced Telecommunications Capability*, 14 FCC Rec 2398 at 9 (cited in note 1).

⁶ See Speta, 17 Yale J Reg at 19 n 42 (cited in note 1).

⁷ See Lathen, *Broadband Today* at 19 (cited in note 1).

wires that runs from the end user to the local switch. As will be discussed in more detail below,⁸ in some cases traditional copper loops are beginning to be replaced by mixed copper/fiber connections using DLC technology. The second part of the network is the local switch, which decides where to send the call. The third part, called transport, consists of all connections between the switch, other switches of the ILEC, and other networks.

So long as the loop is all-copper—that is, so long as DLC technology is not being used—and so long as the loop is less than twelve thousand feet in length, it is fairly straightforward to provide a broadband connection over the loop using DSL technology.⁹ An interface is placed at the end user's location, equipment including a digital subscriber line access multiplexer and a splitter (hereinafter collectively referred to as a "DSLAM") is placed in the ILEC's switching office, and the copper loop runs between these two pieces of equipment. The DSLAM separates voice and data traffic, routing voice traffic to a circuit switched network and data traffic to a packet switched network. The DSLAM is relatively small and inexpensive, and there is generally enough room at the ILEC's switch to enable multiple DSL providers to collocate the necessary equipment to provide a DSL connection. In many cases, the ILEC must "condition" the loop before it is suitable for DSL use by removing loading coils and bridge taps, but the expenses associated with this conditioning are generally minor. Therefore, the existing copper loop can be used for DSL without any significant changes to, or new investments in, the loop itself. All of the significant incremental investments are associated with the addition of new electronic equipment at either end of the loop that each DSL provider can supply for itself.

There are different types of DSL and an extra letter is often added to the acronym to denote the particular type.¹⁰ Asymmetric DSL ("ADSL") provides downstream transmission rates of up to approximately 1.5 mbps and upstream transmission rates of up to 640 kbps. ADSL is thought to be particularly well suited to residential use, since the typical residential user places much higher demands on downstream transmission (receiving informa-

⁸ See text accompanying notes 33–35.

⁹ Approximately 44 percent of all residential loops meet the criteria that they are within twelve thousand feet of a central office and are not served by DLC. See Sanford C. Bernstein & Co and McKinsey & Co, *Broadband!* at 9, Exhibit 4 (cited in note 1). See also Part V for a discussion of the additional complications that arise when these criteria are not met.

¹⁰ See Lathen, *Broadband Today* at 21 (cited in note 1).

tion from the internet) than upstream transmission (sending information to other users). ADSL is less expensive than other types of DSL both because the electronic equipment is less expensive and because ADSL can “share” a loop with regular circuit switched voice transmissions. (That is, a single loop can be simultaneously used both for voice telephony connected to the circuit switched network and ADSL connected to a packet switched network.¹¹)

Symmetric DSL (“SDSL”) provides up to 1.5 mbps in both directions but is more expensive both because the electronic equipment is more expensive and because SDSL requires its own entire loop (it cannot “share” a loop with regular voice transmissions).¹² SDSL is generally thought of as a product for businesses, since they more often require high rates of transmission in both directions and the higher cost is less of an issue. Newer and faster versions of DSL are being created. Many of the faster versions, however, require shorter and shorter copper loops. For this reason, in the long run, the ILEC may be forced to replace much of its existing copper plant with optical fiber.

Cable systems can be upgraded to hybrid fiber coaxial (“HFC”) networks capable of carrying broadband signals in addition to regular cable TV by investing in electronic equipment and by replacing much of their existing coaxial cable with optical fiber. Cable systems are also generally able to offer somewhat higher transmission rates than DSL systems. However, the comparison is somewhat clouded by the fact that, while DSL systems offer a “dedicated circuit” to each user that always guarantees the same transmission rates, cable systems’ co-axial cables are a “shared medium,” which means that the transmission speed experienced by an individual user will be affected by the amount of other traffic on the system at that time. Under current technical standards, cable systems have a maximum transmission rate of 27 mbps downstream and 10 mbps upstream. However, given typical levels of traffic, cable users generally experience data speeds fairly similar to those offered by DSL.¹³ The fact that cable systems are a “shared medium” also creates some extra potential

¹¹ See Third Report and Order, Deployment of Wireless Services Offering Advanced Telecommunications Capability, 14 FCC Rec 20912 at Part IV (cited in note 1).

¹² High-speed DSL (“HDSL”) is the technological precursor to SDSL. HDSL exhibits approximately the same transmission speeds as SDSL.

¹³ See Sanford C. Bernstein & Co and McKinsey & Co, *Broadband!* at 37, Exhibit 33 (cited in note 1).

security problems that do not exist on DSL networks that have “dedicated circuits.”

Spectrum has been made available for provision of both fixed wireless and satellite broadband connections. There are various “line of sight” problems for the fixed wireless technology that may limit its use to large business users and large multiple dwelling residential units, at least in the medium run. Satellite connections will not be available for three to four years at the earliest.

In terms of deployment, at the end of 1999 cable systems led with approximately 1.1 million residential customers for cable versus 160,000 residential subscribers for DSL. At this point there are almost no fixed wireless broadband connections and absolutely no satellite broadband connections. By the year 2007 it is estimated that there will be fourteen million broadband cable subscribers and another ten million residential DSL subscribers. Fixed wireless and satellite technologies are not likely to achieve significant deployment over this period.¹⁴

II. THE PRINCIPLE OF REGULATING NARROWLY DEFINED INPUT BOTTLENECKS

A. The Theory of Benefit

I begin by engaging a fairly abstract notion of what I mean by limiting regulation to narrowly defined bottleneck inputs instead of regulating outputs. Thus, the usefulness of this regulatory strategy will become more readily apparent. The model presented in this section is very simple, but it will help to clarify the central concepts of my argument.

Suppose that production of a final product is accomplished through producing n intermediate products indexed by i , which can take values in the set $\{1, \dots, n\}$. I will now define two different types of regulatory regimes. The regulated firm will always be referred to as the incumbent, while unregulated firms will be referred to as competitors.

In traditional retail regulation, the incumbent produces all n intermediate products and combines them into the final product. The price at which the final product is sold is regulated. The firm does not have to make any of the intermediate products available to competitors at any price.

¹⁴ See Lathen, *Broadband Today* at Appendix B (cited in note 1).

Under regulation of selected inputs, the incumbent is required to produce a set of selected inputs and sell these to other firms at regulated prices. Competitors can purchase one or more of the selected inputs at the regulated prices in order to produce the final product. Neither retail prices of the incumbent nor the retail prices of competitors are regulated.

The crux of the argument is simply that regulating the price and availability of selected inputs instead of the price of output can be efficient if production of some inputs is more efficiently carried out in an unregulated environment. To illustrate this idea, assume that there are two possible unit costs of production for each intermediate product. Let u_i denote the cost that would result if production were unregulated and multiple firms were allowed to enter and compete and let r_i denote the cost that would result if production were regulated and restricted to a single firm. Two factors will influence the relative sizes of u_i and r_i . To the extent that there are economies of scale in production, r_i will be smaller than u_i . However, regulation itself potentially induces inefficiencies. The focus of this Article is on inefficiencies that are created when regulation is applied to a product for which innovation is required, so the discussion of efficiencies will be cast in terms of innovation efficiencies. As discussed in the introduction, regulation may interfere with innovation both because it reduces incentives of firms to innovate, and because it reduces the diversity of the pool of innovators. For simplicity, assume that all of these effects are captured in the unit cost variable (in other words, better innovation means a lower unit cost).¹⁵ Therefore, to the extent that an unregulated industry structure creates superior levels of innovation, this will tend to cause u_i to be lower than r_i . It is the combination of these two effects—economies of scale and inefficiencies induced by regulation—that determines which cost is smaller. When economies of scale are most significant, then r_i will be smaller than u_i . When the need for innovation is high and regulation cannot induce this level of innovation, then u_i will be smaller than r_i . I will say that an intermediate good i is a monopoly bottleneck input if r_i is less than u_i . That is, an intermediate good is defined as a bottleneck input if economies of scale are large enough and/or the need for innovation is small enough that regulation is on net more efficient than no regulation.

¹⁵ Even if I add the complication that innovation may affect product quality as well as cost, the analysis remains unchanged. I thus confine my analysis to the simpler case in order to minimize notational complexity.

It is clear enough in this simple model that traditional retail regulation is sufficient to provide the lowest possible prices to consumers when every input is a monopoly bottleneck. The regulator could require the regulated monopolist to make intermediate inputs available at cost to competitors, but this would not result in lower prices for consumers. However, the situation is different when some but not all of the inputs are monopoly bottlenecks. In this case, the regulator can make consumers strictly better off by switching from traditional retail regulation to regulating only monopoly bottleneck inputs. If the regulator requires the regulated monopolist to make the bottleneck inputs available at regulated prices, competitors will be able to purchase these inputs at regulated prices. Unregulated production of the other inputs will occur at the lower costs that can be achieved in an unregulated market and competition in the retail market will result in these savings being passed on to consumers.

Note that the benefit from switching to input regulation is *not* that the need for regulation vanishes. A single firm still ends up supplying the bottleneck inputs and this firm therefore still has monopoly power and must be regulated. The benefit is more subtle, but just as real: fewer segments of the industry will be dominated by a single firm and more and better innovation will occur in the segments of the industry that are opened up to competition.

Finally, it is important to note that this approach will only work when there are not large and inherent cost advantages to integrated production. That is, if competitors had to incur significant extra transport and coordination costs that the incumbent did not, then regulation of bottleneck inputs would not be a useful strategy, since an implicit assumption in the above argument is that no extra costs were incurred because of non-integrated production.

B. Regulatory Evasion and the Separate Subsidiary Requirement

The regime of regulating only bottleneck inputs creates a clear and obvious opportunity for the regulated firm to attempt to evade this regulation. Namely, if the regulated firm could somehow degrade its competitors' access to the bottleneck input in ways that the regulator could not monitor or control, then the regulated firm would be able to charge a high price in the unregulated retail market and earn monopoly profits there. There-

fore, at a minimum, regulators need to be explicitly aware of this incentive and monitor to prevent its occurrence to the extent possible.

The most extreme solution to the problem, of course, would simply be to forbid the regulated firm from participating in the retail market and instead restrict it to selling the bottleneck input. However, this reduces the amount of competition in the final product market to the extent that the incumbent would have been a strong competitor in this market. A less extreme solution to the problem that the FCC has sometimes used in other areas is to require the regulated firm to place its retail operations in a separate subsidiary.¹⁶ The division supplying the bottleneck input is required to deal at arm's length with the retail subsidiary and is not allowed to discriminate in the terms and prices it offers its own subsidiary as compared to competitors.

The theory concerning the benefit for the separate subsidiary requirement is often misunderstood. The benefit is *not* that incentives for discrimination are changed. The input producer and retail subsidiary still have common owners and therefore the incentive for the input supplier to discriminate against rivals of the retail firm is unchanged. The difference is simply that non-discrimination requirements become easier to enforce because the transactions between the input producer and subsidiary occur at arm's length. The benefit of this policy is often therefore described as making the relationship between the input supplier and the retail subsidiary more transparent.

C. Transitional Strategies

As long as the regulator has perfect information about whether each intermediate product is a monopoly bottleneck, there is no need to regulate both the incumbent's retail price and its intermediate product prices. Similarly, there is no need to regulate prices for intermediate products that are not monopoly bottlenecks. However, in the real world, regulators will never have perfect information about such issues. Therefore, an important question is whether the regulator can cope with this lack of

¹⁶ The Telecommunications Act of 1996, Pub L 104-104, 110 Stat 56, codified at 14 USC §§ 151-641 (Supp 1996), adopted this approach for allowing the Regional Bell Operating Companies ("RBOCs") to enter the long-distance market. Specifically, RBOCs, upon receiving approval to provide in-region long distance services, must provide these services through a separate subsidiary and offer the same access terms and conditions to all long distance providers, including their own affiliates.

information by simply implementing both regulatory regimes simultaneously and then letting the market determine which inputs are subject to monopoly bottlenecks and which are not. This double regime will be called regulation of retail price and all inputs.

Under regulation of retail price and all inputs, the incumbent's retail price is regulated, and the incumbent is required to provide competitors with access to all of its intermediate products at regulated prices. However, competitors' retail prices are *not* regulated.

Competitors' incentives to compete will still be maintained if regulation of retail price and all inputs is imposed on the incumbent, because their retail prices are still unregulated. A problem arises with respect to the incumbent's incentives. Suppose for a moment that the regulator knows which inputs were not monopoly bottlenecks and is able simply to require the incumbent to provide access to the bottleneck inputs at regulated prices (but does not force the incumbent to provide access to non-bottleneck inputs or regulate the incumbent's retail price). In this case, the incumbent has an equally powerful incentive as any of its competitors to innovate and reduce costs in the non-bottleneck inputs. This is because the monopolist would not have to share these innovations with its competitors (through access requirements) or with consumers (through retail rate regulation). Therefore we would expect the incumbent to play a large role in innovating and reducing costs. However, if we continue to regulate the incumbent's retail price and to require the incumbent to share innovations it discovers related to non-bottleneck inputs with competitors, the incumbent has little incentive to innovate. Therefore, if the regulator hopes that the incumbent itself will be a major source of competitive innovation, the strategy of continuing to regulate the retail price of the incumbent and requiring the incumbent to provide access to all of its inputs will be a bad one.

Therefore, regulation of both retail prices and bottleneck inputs is not a desirable long-term strategy. However, in a world where regulators do not have perfect information about which inputs are bottlenecks and which are not, it might be very sensible for a regulator to attempt to transition between a regime of regulating retail price to regulating only bottleneck inputs by first moving from a regime of pure retail regulation to a regime where the incumbent's retail price was still regulated and the

incumbent was required to provide access to all intermediate products. During this transition period, the regulator could observe which inputs competitors appeared to be able to produce themselves and for which inputs they appeared to need the incumbent. The regulator could also wait for sufficient competition to develop at the retail level for it to be feasible to deregulate the retail price of the incumbent without this resulting in immediate and large price increases. Even if these increases were only temporary until competitors entered, regulators would, quite understandably, be highly averse to letting these increases occur. At that point, the regulator could deregulate the retail price of the incumbent and also remove access requirements from inputs that did not appear to be monopoly bottlenecks. During the transition period, the incumbent would face poor incentives and possibly begin to fall behind its competitors. If the incumbent knew that this situation was only temporary, that knowledge might ameliorate the undesirable incentive effects even during the transition period.

There is another advantage of requiring the incumbent to provide access to all inputs (and not just the monopoly bottleneck inputs) during a transition period. Such a requirement would provide a temporary foothold for, and facilitate the entry of, firms that ultimately would compete using their own facilities. Because the ILEC is required to make elements of its network available to CLECs at the ILEC's average cost, a CLEC can essentially enter at a small scale and take advantage of the ILEC's economies of scale until the CLEC has built up a sufficiently large customer base to justify investing in its own facilities. The risk of entry is also reduced for CLECs because they can enter a market and see if they can establish a base of customers before they are required to make significant sunk investments.

As I will discuss further below,¹⁷ it is possible to interpret the regulatory changes introduced by the Telecommunications Act of 1996 ("1996 Act")¹⁸ as being consistent with this sort of exploratory transition strategy.

¹⁷ See text accompanying note 22.

¹⁸ Telecommunications Act, 110 Stat 56 (1996).

D. Technological Rigidities Induced by Regulating Bottleneck Inputs

In order to define a particular input that is to be unbundled, the regulator may have to issue technical standards and/or requirements that essentially freeze or radically constrain the ILEC's ability to innovate and make changes to all of its network. Defining an input thus potentially introduces technological rigidities. I will say that an input is separable from the network if it can be defined without introducing large technological rigidities. Generally speaking, a separate piece of equipment is likely to be more separable than one service of many that are produced by the same piece of equipment.¹⁹

The relevance of this issue to my argument is that, generally speaking, the copper loop between an end user and the ILEC's switch tends to be extremely separable from the rest of the ILEC network. Mandating that the ILEC allow some other firm to use a particular pair of copper wires generally does not constrain the type of switching the ILEC chooses or the type of services it chooses to offer over its network or constrain in any way the use the ILEC makes of the remaining copper loops under its control.

E. The Movement Towards Regulating Narrowly Defined Bottleneck Inputs Introduced by the Telecom Act

ILECs have historically been subject to traditional retail price regulation. This type of regulation is now conducted largely through price cap mechanisms or other forms of incentive regulation. The 1996 Act did not remove or reduce any of this retail regulation.²⁰ However, the 1996 Act added a new set of regulations requiring the ILECs to provide competitors with access to certain inputs. The 1996 Act directed the FCC to identify network elements that ILECs must make available to CLECs at cost-based rates. These were called unbundled network elements ("UNEs"). Among the network elements that the FCC required ILECs to make available were loops, switching, and trunking.²¹ The intent was that a CLEC would be able to "mix and match"

¹⁹ The FCC has gravitated towards generally defining inputs that must be made available to competitors as consisting of facilities rather than services.

²⁰ Telecommunications Act, 110 Stat 56 (1996).

²¹ See *FCC Promotes Local Telecommunications Competition*, available online at <http://www.fcc.gov/Bureaus/Common_Carrier/News_Releases/1999/nrcc9066.html> (visited Aug 15, 2000) (containing the Commission's most recent rulings and a history of rulemakings up to this point).

between purchasing some network elements from the ILEC and supplying some itself using its own facilities.

Therefore, in terms of the definitions introduced above, the 1996 Act introduced a regime regulating both retail and input prices. As discussed above, this has obvious weaknesses as a permanent regime. However, it may be a very desirable transitional mechanism for switching from a regime of retail regulation to a regime where only bottleneck inputs are regulated, and it makes sense to view the 1996 Act as attempting to begin such a transition.

While the development of competitive markets for switching and trunking appeared possible, there was greater uncertainty as to whether and how competition would evolve with respect to providing loops, particularly residential loops in less-dense areas. This set of circumstances was thought desirable for implementation of UNE regulation. There appeared to be a reasonably good chance that competition would at least infiltrate switching and trunking, and there was clearly a large need for innovation and risk taking in these segments. If the infiltration of competition stopped there, then the policy would have created desirable innovation incentives in these segments. If the infiltration continued into the loop, innovation incentives would also be increased for this segment and government might ultimately be able completely to deregulate services at least to some groups of customers.

The advantage of the transitional approach of the 1996 Act was, of course, that no final agreement on the precise nature of the ultimate competitive structure was necessary to begin the transition. After implementing the policy, industry structure would then naturally evolve to a state where facilities-based competition infiltrated all of the non-bottleneck inputs. If there were no monopoly bottlenecks, facilities-based competition would infiltrate all segments of the network and the need for regulation would vanish. If (as appeared more likely) some of the segments of the network were subject to monopoly bottlenecks, then competition would not infiltrate these segments. However, competition would infiltrate the other segments and the amount of innovation in these non-bottleneck segments would increase. Of course, Congress or the FCC would have to be ready to deregulate the incumbent's retail prices and deregulate access to non-bottleneck inputs as appropriate levels of competition developed.

Four years after the passage of the 1996 Act, we are clearly still in the transitional stage. The amount of facilities-based competition is growing, particularly for large business customers (particularly in switching and trunking), and the FCC is beginning to deregulate retail prices by introducing more pricing flexibility where it feels that competition has developed sufficiently.²² It is fair to say, however, that we have not yet achieved sufficient levels of competition that regulators could broadly abandon retail price regulation of the ILEC and simply focus on regulating the price of the loop, at least for residential customers. Nor does sufficient competition exist to completely deregulate the entire industry, including the price of the loop. Therefore, while it is still possible that UNE regulation will ultimately allow significant deregulation of the narrowband voice network, this development has not occurred quickly in the four years following passage of the Act.

F. Summary

Regulating narrowly defined inputs instead of outputs is one approach regulators can use to attempt to confine regulation to as small a sphere as possible, and thereby allow the benefits of competition to infuse more segments of an industry. The 1996 Act's unbundling requirements can be interpreted as introducing a transitional step towards such a regulatory regime, motivated by the hope that, while the loop (and possibly other network elements) might remain a monopoly bottleneck, provision of other parts of the network such as switching and transport might prove to be competitive. While these unbundling requirements have not yet had an enormous impact in the traditional voice telephony market, they have the potential to play a much more significant role in the development of competition in the broadband arena.

III. REGULATING BROADBAND ACCESS OVER THE ILEC NETWORK

The principle of regulating narrowly defined bottlenecks can be applied (and in fact is being applied) to have an immediate and significant impact on incentives for innovation and diversity in the industry supplying DSL broadband connections. That is, it appears that the loop is the only bottleneck input for providing

²² See Fifth Report and Order and Further Notice of Proposed Rulemaking in the Matter of Access Charge Reform, 14 FCC Rec 14221 (1999), for the Commission's most recent efforts in this regard.

broadband connections over the ILEC network, and the FCC can create a diverse, competitive, and largely unregulated industry of DSL suppliers simply by mandating that the loop be made available to competing suppliers of DSL. At least where the loop does not use DLC technology and is less than twelve thousand feet in length, it appears that the existing loop infrastructure can be used largely in its existing form and that the need for investment and innovation is confined to facilities that are quite separable from the loop. Therefore, the FCC is able to not only protect consumers from the exercise of monopoly power where it exists, such as in the loop, but also to deregulate to provide incentives for innovation and investment where these are needed, such as in electronics to implement DSL technology and in the switching/trunking facilities for broadband networks.

The main difference between the narrowband case and the broadband case is that, while the enthusiasm firms have shown to invest in their own narrowband switching and trunking facilities to serve the general residential market has been limited at best, firms appear to be more enthusiastic about making these investments in the analogous broadband facilities.

A variety of factors may underlie this differential enthusiasm for competitors to invest in narrowband switching/trunking facilities as opposed to broadband switching/trunking facilities. First, it may be that the potential size and value of the broadband market dwarfs the size of the narrowband market. Second, because it may be that no one has yet won the broadband market, and that winning it will require significant innovation and risk-taking, it may seem much more likely to potential competitors that they can win a significant share of business away from the ILEC. Third, there may be fewer economies of scale in switching/trunking facilities for broadband communication than narrowband communication.

For whatever reasons, the government can almost instantaneously achieve vibrant facilities-based competition in all segments of the DSL industry, except for provision of the copper loop, if it provides cost-based access to the loop. This does not obviate the need for regulation of the price of the loop, but it does guarantee that there will be maximum incentives for innovation in other elements of the broadband communication network.

The actual policy that has been implemented by the FCC has three major elements.²³ First, CLECs are provided access to the ILEC's copper loop at cost-based prices. The ILEC is also required to allow collocation of competitors' DSLAMs and other necessary equipment at the ILEC's switching offices. Second, retail prices for broadband services provided by either the CLEC or ILEC are not regulated.²⁴ Third, the ILEC is generally not required to provide any type of unbundled access to equipment used exclusively for the provision of broadband services, for the copper loop. That is, the ILEC is not required to provide unbundled access to its DSLAM or to its packet switches.

The rationale for the first element is clear. To the extent that providing the "last mile" connection is a monopoly bottleneck, regulation should ensure cost-based access to it. The rationale for not regulating retail prices of CLECs is that they then have the maximum incentive to innovate in the parts of the network they control themselves. The rationale for leaving the ILEC's retail price unregulated and not requiring the ILEC to unbundle any part of its broadband network (except for the copper loop) is to provide the ILEC with incentives to innovate and invest in segments of its own broadband network other than the copper loop.

Therefore, to the extent that existing copper loops can be used as a platform for the "last-mile" connection of DSL providers without requiring significant changes or innovations in the copper loops themselves, the policy of narrowly focusing regulation of DSL on the single input of the copper loop can enable government to control the ILEC's monopoly power over the copper loop, while simultaneously allowing a competitive and diverse industry to develop that provides all remaining elements of the broadband connection.

²³ See First Report and Order in the Matters of Deployment of Wireline Services Offering Advanced Telecommunications Capability, 14 FCC Rec 4761 (1999), and Third Report and Order, Deployment of Wireline Services Offering Advanced Telecommunications Capability, 14 FCC Rec 20912.

²⁴ Formally, DSL services provided by the ILEC are being treated as a new service in the interstate access basket and therefore are regulated under price caps. Superficially, this may sound like the retail prices of the ILEC are in fact being regulated. However, a little familiarity with the arcana of telecommunication regulations (which rarely make anything simple or transparent) reveals that this treatment will be essentially equivalent to not regulating retail DSL prices at all, in terms of its impact on the ILEC's incentives for innovation. The ILEC is allowed to choose freely the price that it initially sets for any new service, and only then does price cap regulation apply. (Technically, certain weak requirements apply but these are almost never binding.) Thus, the ILEC can essentially set its initial prices as high as it wishes, subject to no constraints.

The FCC could improve its current policy, however, by requiring the ILEC to conduct its broadband operations in a separate subsidiary that operates at arm's length from the ILEC. As discussed in the previous section, this would make the relationship between the ILEC and its own broadband operations more transparent and make it much easier to enforce non-discrimination regulations. The FCC has achieved this result for SBC by imposing the separate subsidiary requirement as a condition for approving the SBC-Ameritech merger.²⁵ It is possible that the same sort of condition might be agreed to as a condition approving other mergers, but a single comprehensive requirement would better replace this piecemeal approach.

IV. INSUFFICIENCY OF COMPETITION PROVIDED BY OTHER PLATFORMS

Of course, any regulation is costly to implement and likely to create various distortions that would not occur if it were possible for competition to operate freely and perfectly. A natural first question, then, is whether sufficient competition from facilities-based competitors that do not use the ILEC's network at all will obviate the need for regulating the ILECs. If the ILEC faced sufficiently intense competition from other independent facilities-based providers, then there would be no need to create extra competition by mandating regulated access to the ILEC's copper loops. While the ILEC might be the only provider of DSL, it would face intense competition from other firms using the cable infrastructure, fixed wireless technologies, satellite technologies, or even firms laying their own new fiber to the curb. If this competition were intense, there would be no need to regulate the ILEC's retail prices, and the ILEC would have a large incentive to invest and innovate. Furthermore, according to this argument, where there are competitive advantages to allowing multiple providers to innovate and provide DSL over the ILEC network, competition from other providers would induce the ILEC, itself, to grant access to its network.

Cable firms, in particular, appear likely to prove strong competitors to the ILECs. Cable firms have a significant deployment lead at this time, and, although there is debate on this point, many industry analysts feel that cable systems will continue to

²⁵ FCC Approves SBC-Ameritech Merger Subject to Competition-Enhancing Conditions, 1999 WL 795991 (Oct 6, 1999).

be the dominant supplier into the future because of certain technological advantages.²⁶ Furthermore, there is strong evidence that the ILECs have been compelled to respond to this competitive threat by attempting to innovate and to deploy new products themselves. For example, it has been widely observed that, although DSL technology has been available for five or more years, ILECs as a group showed almost no enthusiasm for using this new technology until recently, when the threat that cable firms could offer a competing alternative has forced them to act.²⁷ Finally, although fixed wireless and satellite technologies will not be significantly deployed within the next year or two, the technology is changing so rapidly that either of these could become significant competitors within the next five years.

Therefore, the option of not requiring the ILECs to provide access to their copper loops for competitive DSL providers deserves serious consideration. However, there are at least three factors that suggest that the benefits of competition from other providers may be limited. First, although it is completely clear that cable systems will be strong competitors, the prospects for additional competitors are much less certain. If it turns out that over the medium run that the local cable system and the existing ILEC are the only two significant competitors, this will create a duopoly. There is a long tradition of skepticism among economists and antitrust enforcers as to whether two firms are sufficient to create effective competition.²⁸ When there are only two competi-

²⁶ See Sanford C. Bernstein & Co and McKinsey & Co, *Broadband!* at 7 (cited in note 1) ("Cable is likely to stay ahead thanks to its early start, technical advantages, and its control of data displays on televisions in non-PC households.").

²⁷ See Lathen, *Broadband Today* at 27 (cited in note 1):

The ILECs' aggressive deployment of DSL can be attributed in large part to the deployment of cable modem service. Although the ILECs have possessed DSL technology since the late 1980s, they did not offer the service, for concern that it would negatively impact their other lines of business. [Citations omitted.] The deployment of cable modem service, however, spurred the ILECs to offer DSL or risk losing potential subscribers to cable. In various communities where cable modem service becomes available, the ILECs would soon deploy DSL service that was comparable in price and performance to the cable modem offering. [Citations omitted.] Thus, prior to cable modem deployment, the ILECs had little incentive to deploy DSL and the consumer had no choice for high-speed Internet access.

²⁸ For example, an industry with two firms would have a Herfindahl-Hirshman Index ("HHI") of 5,000, which is well above the level of 1,800 at which the Department of Justice ("DOJ") defines a highly concentrated market. See Dennis Carlton and Jeffrey Perloff, *Modern Industrial Organization* at 369-70 and 743 (Addison-Wesley 2000) (discussing the HHI and its use by the DOJ in its Merger Guidelines); see generally William Cohen and

tors, the two often achieve some sort of implicit accommodation with one another not to compete vigorously.

The case of wireless telephony is often cited as an example of this phenomenon. There is consensus that the introduction of new PCS licenses increased the number of wireless carriers in most large markets from two to four or five and that wireless prices dropped dramatically after this occurred.²⁹ While it is difficult to prove causality in the absence of a controlled experiment, this example is certainly suggestive. Furthermore, enormous national consolidations among local telephone networks and local cable networks, that will enable a very small number of key players to control these entities across the entire nation, may also make it more likely that, in any given market, the local telephone company and local cable company will be able to reach an accommodation that does not involve intense competition.³⁰

Second, DSL technology may be uniquely well suited to supply services to some customer groups compared to the technology that can be deployed using cable systems or wireless technologies. For some groups, these other platforms will not provide significant amounts of competition, and meaningful competition can only occur if multiple firms are given access to the ILEC's copper loops to provide competing DSL services. For example, it appears that cable does not represent a good substitute product for DSL for some business customers. One reason for this is that cable systems often simply do not cover purely business areas, so cable service is not available to many business users. Another reason, as discussed earlier, is that businesses are often willing to pay for the guaranteed rates of transmission and extra security that come with having a dedicated circuit over DSL instead of using the shared medium of the cable network.³¹ It has been widely observed that ILECs have been loath to provide DSL to businesses

Gary Zanfagna, *Inside the Competitor-Collaboration Guidelines: the Forest among the Trees*, 2000 U Chi Legal F 191.

²⁹ See, for example, Nicole Harris, *National Cellular Plans with Flat Rates Stir Industry*, Wall St J B10 (Nov 10, 1998) (noting that some markets have "as many as six players" resulting in lower prices for consumers).

³⁰ See Douglas Bernheim and Michael Whinston, *Multimarket Contact and Collusive Behavior*, 21 Rand J Econ 1 (1990); Jean Tirole, *The Theory of Industrial Organization*, at 243, 251 (MIT 1988).

³¹ See Sanford C. Bernstein & Co and McKinsey & Co, *Broadband!* at 13 (cited in note 1) ("In the small business market, DSL has the most potential to serve as the major distribution platform for broadband services. . . . The shared nature of the cable data service is particularly unsuited to the kinds of high-duty-cycle applications that small businesses will require in the future.").

because it threatens to cannibalize ILECs' existing T1 business.³² Therefore, the only firms willing to supply DSL to this group of consumers have been CLECs such as Northpoint or COVAD that have no existing business to cannibalize.

The third reason that the benefits of competition from other providers may not be a complete solution is that even if the ILECs themselves turn out to be somewhat lethargic and ineffective competitors against cable, they may still refuse to open up their networks to alternate DSL providers that could provide much more effective competition and innovation against the cable firms. That is, the ILECs may refuse to open up their networks even if they could earn higher profits by doing so. They might do this to avoid risks, to avoid the shakeups that a new competitive focus would cause, or simply because a large bureaucratic organization historically subject to cost-based regulation cannot change its culture overnight. Requiring ILECs to open up their networks to a diverse group of firms, most of which have never been regulated, reduces the risk that innovation will be stifled simply because historically regulated firms are unable to change their cultures.

Therefore, my own assessment is that there is a reasonable likelihood that requiring the ILEC to provide DSL providers with unbundled access to its loops would significantly increase the level and effectiveness of competition compared to what would occur if we were simply to rely on competition from non-DSL providers.

V. MIXED FIBER/COPPER LOOPS

Recall that the loop is defined to be the connection between the end user and the ILEC's central office, where thousands of loops are aggregated together. Traditionally, the loop consisted of a single unbroken pair of twisted copper wires between the end user and the central office. However, in some cases (usually where loops are long), telephone companies have begun to create mixed copper/optical fiber loops through the use of DLC technology.

This technology creates intermediate nodes of aggregation at remote terminals, so that a single switch serves tens or even hundreds of remote terminals. Pairs of copper wires run from the

³² See Lathen, *Broadband Today* at 27 (cited in note 1), citing Bank of America Securities, Equity Division, *Wireline Telecom Services* 3 (Apr 1999).

end user to the remote terminal where they terminate on a DLC. Signals are then aggregated together and carried on high-capacity lines (usually optical fiber) to the switch.

Provision of DSL service over lines using DLC technology essentially requires that more of the electronics related to the DSLAM function be moved out to each remote terminal. In a sense, then, the "broadband network" begins at the remote terminal instead of at the switch. Many of the ILECs are deploying equipment to provide DSL service to lines served by remote terminals.

It is likely that the use of DLC technology will become more prevalent for at least two reasons. First, the best strategy for the ILEC to provide broadband connections to end users currently served by loops longer than twelve thousand feet appears to be for the ILEC to install enough remote terminals to reduce the lengths of copper runs to less than twelve thousand feet. Second, and perhaps more importantly, achieving faster transmission speeds through DSL may require even shorter runs of copper than twelve thousand feet. Therefore, ultimately, the best technological solution to providing broadband connections over the ILEC network may involve replacing significant amounts of copper with fiber.

Approximately 20 percent of currently installed loops use DLC technology.³³ However, another 36 percent of currently installed all-copper loops are longer than twelve thousand feet in length.³⁴ Therefore, even if existing transmission speeds are viewed as adequate, DSL broadband connections to 56 percent of all loops will have to be created over loops using DLC technology. If higher transmission speeds require even shorter runs of copper, perhaps ultimately almost all broadband connections over the ILEC network will occur over loops using DLC technology.

This technology has implications for the FCC's existing policy that requires ILECs to unbundle whole loops and make space available at their central offices for other firms to collocate DSLAMs and other necessary equipment to access loops. A natu-

³³ See Third Report and Order in the Matter of the Implementation of Local Competition Provisions, 15 FCC Rec 3696 at n 419 (1999).

³⁴ See Sanford C. Bernstein, & Co and McKinsey and Co, *Broadband!* Exhibit 4 (cited in note 1) (reporting that, on average, 44 percent of current loops are addressable in the sense that they are both less than twelve thousand feet in length and do not use DLC technology). Therefore, 56 percent of loops either use DLC technology and/or are longer than twelve thousand feet. Since 20 percent of loops use DLC technology, 36 percent must be longer than twelve thousand feet.

ral extension of that policy would be for the FCC to require the ILEC to unbundle the portion of the loop between the end user and the remote terminal and to allow other firms to collocate DSLAMs and other necessary equipment to access these loops at the remote terminal. The FCC has, in fact, recently passed such a regulation and uses the term "sub-loop unbundling" to describe this obligation.³⁵

However, there is a serious potential problem with this approach. There are considerably more remote terminals than switches, and this adversely affects the economic case for having multiple independent firms install their own electronics at every node where pairs of copper wires terminate. Instead of replicating the ILEC's DSLAMs at every central office, CLECs would now have to replicate DSLAMs at perhaps one or two hundred times as many remote terminals and would also be responsible for transport of the multiplexed signals beyond every remote terminal. ILECs have historically built very small and relatively inaccessible remote terminals, which allowed them to "tuck them away" in very small areas and construct them at low cost. It would be more expensive to build larger and more elaborate remote terminals that could allow collocated equipment.

In its initial regulatory efforts, the FCC has not yet addressed the issue of whether or not it will require ILECs to build (and rebuild where necessary) remote terminals that allow collocation. Rather, the FCC has simply required ILECs to allow collocation where this is "feasible," but has declined to offer any sort of definition of "feasible." In particular, it has not yet addressed whether it will force the ILEC to build remote terminals that allow collocation. If the FCC required the ILEC to build remote terminals that allowed collocation and required the ILEC to bear the same share of costs for this as it was allowed to recover in prices charged to other firms, there would be a level playing surface for all DSL providers. However, if it was very costly to build these larger terminals and to collocate multiple DSLAMs in each of them, it might well be that DSL providers would suffer a fatal blow in their competition with other broadband providers such as cable firms. Therefore, the issue is not simply that regulation might increase costs for the ILEC that will be passed on to consumers. The issue is that regulation might force one type of firm out of business and therefore reduce the prospects for competition.

³⁵ See Third Report and Order, *Deployment of Wireline Services Offering Advanced Telecommunications Capability*, 14 FCC Rec 20912 (cited in note 24).

The FCC has not yet thoroughly investigated the issue of how much it would cost to require ILECs actually to make sub-loop unbundling generally available and whether or not it makes sense to do this.

If the FCC ultimately decides that the ILEC does not have to implement DLC technology in a way that makes sub-loop bundling possible, it will create a whole new set of perverse incentives. Namely, the ILEC will then have the incentive to add fiber to its system simply to avoid the unbundling obligation. In fact, it is possible that the Commission is already creating such perverse incentives simply by saying nothing. Firms currently installing DLC technology are under no obligation to design remote terminals or make technology choices that facilitate sub-loop unbundling. I doubt very much that ILECs are taking affirmative actions to facilitate sub-loop unbundling in the absence of such directives from the FCC. Therefore, at the moment, it may well be the case that ILECs believe they can escape the unbundling obligation by replacing copper with fiber, and are acting to do so.

Rather than requiring the ILEC to allow collocation at remote terminals, another possible solution would be to attempt to define some notion of "raw transmission capacity" between the end user and the central office that the ILEC could be forced to unbundle and make available to competitors even if no physically separate pair of copper wires running all the way from the end user to the central office existed any more. This concept is usually referred to as requiring unbundling of a "virtual loop." The idea would be to require the ILEC to make the equivalent functionality of a separate pair of twisted copper wires available to other firms that collocate at the ILEC's wire centers.

Although many of the issues regarding whether and how this could be implemented are purely technical, there is at least one very important economic issue that must be kept in mind. If we require unbundling of virtual loops, we will be asking the ILEC to provide unbundled access to facilities and equipment that are yet to be built and that may well require significant amounts of investment and innovation. Therefore, requiring unbundling of virtual loops will not create good incentives for innovation directed towards advances in broadband technology related to the loop side of the switch. If this factor was thought to be important enough, this would increase the relative desirability of a policy of not requiring unbundling and instead, of simply relying on competition between the ILEC and cable firms.

In summary, the FCC's policy of requiring loop unbundling strikes me as having unambiguously positive consequences for the 44 percent of all loops in the country that are less than twelve thousand feet in length and that do not use DLC technology. The more difficult question concerns the remaining 56 percent of loops that are either longer than twelve thousand feet or use DLC technology. It is less clear whether or not it makes sense for the FCC to affirmatively require ILECs to choose technologies and construct facilities that make sub-loop unbundling possible or to require that some sort of virtual loop be unbundled. Here, I have settled for raising some of the important issues rather than attempting to draw any conclusions. The entire issue of how the FCC deals with the loop unbundling obligation in the presence of mixed fiber/copper loops obviously needs considerably more attention from the FCC in the near future.

VI. ASYMMETRICAL REGULATORY TREATMENT OF ILEC AND CABLE FIRMS MAY BE APPROPRIATE

For cable and wireless providers, there is no analog to the ILEC's existing network of copper loops that can be made available to alternate providers and is separable from the additional investments that have to be made to provide broadband access over the cable network. Therefore the unbundling question boils down to whether or not some sort of "virtual circuit" should be made available at regulated prices to competitors. Requiring that cable companies provide access at regulated prices to the broadband network they are designing and constructing would raise the same problems as requiring ILEC's to provide unbundled access to their new investments associated with mixed fiber/copper loops. Providing broadband connections requires massive new investments, innovations, and upgrades in the physical plant connecting end users to the network (the analog of the loop). Regulating these facilities (either through regulating retail prices or mandating some type of unbundled access to other providers at regulated prices) would blunt incentives for investment and innovation.

Therefore, I believe that the asymmetrical treatment of ILECs and cable/wireless providers may be justified at this time, at least with respect to the obligation to provide unbundled access to copper loops.

CONCLUSION

Industries where innovation is important and where there appear to be monopoly bottlenecks generally pose a difficult dilemma for policy makers. Cost-based regulation provides very poor incentives for innovation. On the other hand, when there is a natural monopoly bottleneck, consumers may require protection from the exercise of monopoly power. The principle of regulating narrowly defined input bottlenecks instead of outputs essentially identifies a set of circumstances where regulators can finesse this dilemma. If the product in question requires production of a number of distinct sub-products, and if the need for innovation is concentrated in a different group of sub-products than those for which significant monopoly bottlenecks exist, policy makers can attempt to simultaneously accomplish both of their objectives by deregulating the price of the final product and instead requiring the incumbent monopolist to provide its competitors with access to the monopoly bottleneck inputs at regulated prices.

Through applying this principle to the case of broadband telecommunications services, I conclude that at least in the near future, the FCC can increase the diversity and incentives for innovation of providers of broadband access by requiring ILECs to make their copper loops available at regulated prices to other providers of DSL. While it is true that some competition for the ILEC would still be provided by cable, wireless, and satellite alternatives, if we let the ILEC be the sole user of its copper loops, allowing multiple providers of DSL to use the ILEC's copper loops would provide a tremendous increment to diversity and competition. Allowing such access would not damage the ILEC's incentives in any important way, because the existing copper network is already largely in place and can be used without significant changes.

An important qualification to the above argument is that this will only create competition on the approximately 44 percent of loops that are less than twelve thousand feet long and do not use DLC technology. Even many of these loops might ultimately be replaced by mixed copper/fiber loops in order to increase transmission speeds. There are two potential approaches to attempting to provide competitors with some type of unbundled access to mixed copper/fiber loops.

The first approach, called sub-loop unbundling, would require the ILEC to construct remote terminals and choose technologies so that competitors can gain access to the copper "tails"

extending from remote terminals to end users. This approach might also entail requiring the ILEC to provide access to fiber transmission facilities between the remote terminal and the central office. The potential problem with this approach is that requiring the ILEC to construct remote terminals and choose technologies that allow collocation at all remote terminals may simply make broadband offerings over the ILEC network uncompetitive with broadband offerings over the cable network.

The second approach, called virtual loop unbundling, would require the ILEC to make the functional equivalent of a separate pair of copper wires available, even when it uses a mixed copper/fiber loop. The main problem with this approach is that it may not create sufficient incentives for the ILEC to innovate or invest in new loop technologies.

In cable systems, there is no analog to the already existing, physically separate pairs of copper wires in the ILEC network that are separable from any additional investment that is required. Therefore, the only approach to unbundling in the cable world is essentially to define some sort of virtual loop that must be made available at regulated prices. This would have the same undesirable effect in the cable world as it would have in the ILEC world. Namely, it would reduce incentives for innovation and investment in loop technologies. Therefore, imposing somewhat different unbundling requirements on ILECs than on cable firms seems justified at this time.

