TRANSFORMING THE STRUCTURE OF NETWORK INTERCONNECTION AND TRANSPORT

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Regulatory policy in telecommunications is desperately in need of midlevel theory. There is widespread consensus that regulators should try to promote competition, but there is also bitter contention about what this implies for particular industry contest. As one industry observer stated, "Competition should be the policy. And code that enables competition should be the rule." But this same observer also argued that the Federal Communications Commission ("FCC") should regulate and require AT&T to allow customers to choose the internet service provider ("ISP") that furnishes service over AT&T's cable facilities. A pro-competition policy based solely on the premise that competition is good is fundamentally flawed, since it advocates a competition policy without analysis of the different structural possibilities for competition. Hence, "competition" becomes merely a rhetorical device. Policymakers must not consider just the costs of promoting competition, but also the profound implications on the industry structure. This is true regardless of whether the policy to be considered is mandating sub-loop unbundling, requiring line-sharing or allowing the use of unbundled network elements ("UNEs") for the provision of leased lines.

Regulators must make strategic choices among different structural possibilities that will promote competition. The common view that deregulation should occur once competition has developed is not a good framework for policy. Unlike antitrust policy, which acts to restore suppressed competition, pro-competitive regulation in a historically monopolized industry has to assess the merits of promoting new, different and often incompatible dimensions of competition. Waiting for competition to emerge before deregulating fosters the illusion that the existing regulation structure has no effect on the form and extent of the competition that later develops. Regulatory decisions must be based on an extensive consideration of the way the proposed regulations will later shape competition. Regulators, while staying alert, humble and flexible, need to ponder what feasible regulatory policies would bring about the most beneficial development in industry structure.

This article attempts to expand the discussion of this crucial question and forwards three propositions:

(1) Structural problems are constraining beneficial developments for internet services and voice telephony.

The challenges of defining meaningful products and establishing value-based interconnection relationships for internet services are slowing the development of new services that require different billing protocols, qualities of service and reliability. In voice telephony, pro-competitive regulation an unfortunate tendency to gravitate toward poles of self-glorification, such as Harvard's Lawrence Lessig, "we are, vis-à-vis the laws of nature in this new space, gods," or, like Peter Huber, of self-abnegation, "abolish the FCC." See Lawrence Lessig, Reading the Constitution in Cyberspace, 45 EMORY L. J. 3, 7 (1996); see also Tom W. Bell, The Common Law in Cyberspace, 97 MICH. L. REV. (1999) (analyzing Huber's book). See generally Peter Huber, Law and Disorder in Cyberspace: Abolish the FCC and Let Common Law Rule the Telecomso (1997).

The goal of regulation in a formerly monopolized industry is not just to restrain the monopoly power of the incumbent. Cf. Lessig, supra note 1.

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2 See id.

3 In considering the scope for strategic choice, there is
tion that does not adequately consider the costs and benefits of promoting different forms of competition may perpetuate costly, complex regulatory battles, and limit the scope for commercially driven business reorganization and service innovation.

(2) Development of competing, independently owned service interconnection points ("SIPs") will stimulate development of local facilities and wide-area services.

The development of SIPs would enable the separation of two different spheres of activity in telecommunications networking and stimulate more dynamic, decentralized industry growth. Telecommunications networking at its most abstract level can be separated into two activities. First, the connection of end-users to the network depends heavily on idiosyncratic, location-specific knowledge and equipment. In contrast, the second, the provision of network services, is almost inherently nonlocation specific, and relies upon standardized routines and equipment. Thus, independent businesses that interconnect these disparate activities would not only stimulate competition for the provision of both end-user connectivity and network services, but also for the SIPs themselves.

(3) Regulation of voice service interconnection should promote competing, independently owned SIPs.

Regulation should promote competing, independently owned SIPs by giving them the opportunity to have a privileged position for terminating voice calls. Existing regulatory authority and practice largely shape interconnection for voice telephony. While data traffic is growing much more rapidly than voice traffic, the value and bandwidth of voice traffic is still sufficient to influence strongly the overall structure of network interconnection. Preferential treatment for SIPs would stimulate competition for voice-telephony call termination within the current regulatory and industry structure.

These propositions suggest that feasible changes in the regulation of voice telephony interconnection would result in a much more competitive structure for the industry. Regulation thus far has treated telephony interconnection architecture from the perspective of technical feasibility and requests from particular competitors. Moreover, telephony interconnection regulations have almost exclusively been defined in terms of the incumbent operator's facilities and offices. Given the enduring economic importance of interconnection architecture, a broader perspective should be considered. The development of competing, independently owned SIPs would provide an industry structure conducive to better regulatory policy and more dynamic, decentralized industry growth.

I. STRUCTURAL LIMITATIONS TO THE INTERNET

A worrisome aspect of the current structure of internet services is that retail customers often have little idea of what they are actually buying. This is a recurring topic on internet user discussion lists: "I bought a T1 high-speed connection to the internet. How do I make sure that I'm getting the full service of the T1?" Deceptively simple, this query actually combines the customers two connectivity concerns: bandwidth and quality of service. When buying leased lines, such as a T1, customers are purchasing dedicated bandwidth defined in terms of the hierarchy of the particular company's telephony network. See 98/195/EC: Commission Recommendation of 8 January 1998 on interconnection in a liberalised telecommunications market, Official Journal L. 228, 30-34, Aug. 15, 1998.

The Peruvian regulator, OSIPTEL, has required the incumbent Peruvian operator, Telefonica del Peru, to provide at least one interconnection point in each of Peru's 24 departments. Thus OSIPTEL has made a choice about the geographic structure, but not the ownership or competitive structure, of interconnection points with Telefonica. See Legislacion en Telecomunicaciones, Decreto Supremo No 020-98-MTC, para. 39 (visited Apr. 10, 2000) <www.osiptel.gob.pe/marleg/cont/leg/leg/1998/ds20-98-mtc.htm>.

Leased lines are well-defined, established products, but they have low average bandwidth utilization and high network management costs.
between the customer's premises and the customer's ISP. When a customer purchases a T1 from an ISP, the customer typically gets a "T1's worth" of dedicated bandwidth from the customer to the ISP. But the physical connection is not the only attribute that the customer values; the customer also desires the particular connectivity services transported over the connection; and the customer expects particular quality, reliability and billing features in conjunction with those services.

A. Quality of service, reliability and billing: transactional, not technical challenges

ISPs currently face large challenges in attempting to differentiate their infrastructure-based services to customers based on quality of service, reliability and the availability of billing options. The unstructured and dynamic nature of interconnection on the internet itself makes establishing new types of infrastructure-based services difficult. The long and tortuous discussions about "upgrading the internet" from IPv4 to IPv6 illustrates the nature of the challenges. Lower-profile examples of infrastructure development problems include small but annoying and persisting incompatibilities in e-mail formats, the handling of extended ASCII characters and the treatment of e-mail attachments. The major weakness in the current structure of the internet services industry is that customers who need services not available using current, generic internet connectivity must incur high transaction costs because they must establish a variety of different forms of service-level agreements, such as virtual private networks and customized peering arrangements.

Looking at transactions between ISPs, some industry observers and participants have voiced concern that prevailing peering (interconnection) practices impede the internet's development at the wholesale level. As one noted in early 1998, "the extant non-policy peering policy [is] the biggest threat to the future of a competitive internet." One recent article declared:

Contrary to popular belief, the biggest impediment to a better, faster [internet isn't technological. It's politi-


Lack of mutual understanding and acceptance of peering terms has led to disputes about traffic routing, traffic balances and arrangements for international interconnection.10

These disputes over peering illustrate the problems posed in trying to allocate service value rationally among networks that are interconnected without an established service structure. For example, suppose that network A has many customers that it charges for internet access and network B hosts several servers that provide information over the internet. Network A passes server queries to network B, and network B returns the requested data to network A. The question is how to determine what each of these two networks owes the other for network services. Suppose that network B sends many more packets into network A than it receives. It can be proposed that network B should owe network A for the value of the interconnection. However, on the other hand, network A's customers, who pay for internet service only to network A, requested the information from network B, so perhaps network A should pay for the value of the transport of the information from network B. Note also that the content providers who hire network B to host their content may have advertisers who want network A's subscribers to see their advertisements, and may also be collecting content subscription fees from network A's access customers. Clearly, even this simplified market structure model provides little guidance as to how to rationally divide service value between networks. It is not surprising that negotiations over internet service interconnection are contentious.

Two additional factors further confound attempts to rationally allocate interconnection service value. First, the networks that participate in supplying a particular service are not predefined. The provision of a particular service for any particular end-user on a given network may involve network traffic traversing two or more other net-

works ad hoc, since the networks involved in routing the data can change rapidly in response to changes in overall network traffic patterns. Second, interconnection between networks is typically not negotiated on a service-specific basis but instead assessed in terms of packet transport because the internet is a platform for the provision of a wide variety of services. Thus, the simple form that packet-based peering agreements currently take constrains transaction costs within an industry structure, but does not offer any guidance for the rational allocating interconnection service value because they obscure the economic signals relevant to interconnection service value.

The difficulty that ISPs experience differentiating infrastructure services for their retail customers is directly related to the problem of allocating interconnection service value. Considered from the perspective of market supply, the poorly developed and differentiated market for interconnection services constrains the development of retail products that use interconnection services. From a demand perspective, the economic transactions that define the current internet industry structure generate only highly attenuated transmissions of consumer value to agents making relevant network investment decisions. The current industry structure, therefore, discourages competition and instead provides a strong impetus to consolidation because services provided end-to-end within one company's network face none of the transactional challenges outlined above.

Without structural change in the internet, small ISPs will have few or no opportunities to preserve and develop their businesses other than continually bargaining with a few large network operators. Current regulatory policy, then, fosters neither a dynamic industry nor decentralized innovation. Instead, small ISPs are likely to struggle to ensure their survival through political means. As an example, consider approximately 1,400 small, independent local telephone companies in the U.S., which benefit from special regulatory treatment. These companies have effectively organized themselves through associations such as the National Exchange Carriers Association ("NECA"), the National Telephone Cooperative Association ("NTCA") and the Organization for the Preservation and Advancement of Small Telephone Companies ("OPASTCO"). Under Sections 3(37)(B) and (C) of the Telecommunications Act of 1934 ("the Act" or the "Communications Act"), rural telephone companies are defined as any telephone company that is sufficiently small enough to meet the criteria under the Act, irrespective of where they are located. Rural telephone companies are extended special regulatory and universal service benefits.

B. Public policy for internet infrastructure: "don't change anything"

Public policy for internet infrastructure has not responded to these increasingly serious industry challenges. The U.S. regulatory framework for internet infrastructure was established fifteen to twenty years ago. The governing principle for internet regulation is "don't change anything." An FCC order in 1980 decided that enhanced services are not subject to common carrier regulation. Internet services have been classified as enhanced services, and hence, they have not been subject to the many regulations that govern interconnection for voice telephony. Moreover, based on a 1983 FCC decision, enhanced service providers are treated as end-users. Thus, ISPs can purchase flat-rated end-user offerings from local telephony companies and avoid a separate set of regulated prices, including per minute charges, that local telephony companies apply to switched voice telephony customers who are classified as "telecommunications carriers."

As argued above, the challenges associated with defining meaningful products and value-based interconnection relationships appear to be constraining the internet from developing even more impressively than it is now. However, attempts to address these issues directly have not been suc-

12 See id. § 153(37)(B)-(C).
15 See generally In re Amendment of Section 64.702 of the Commission's Rules and Regulations (Second Computer In-
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16 See UNREGULATION OF THE INTERNET, supra note 14, at 10–12.
cessful. For example, in the summer of 1999, former FCC Chairman Reed Hundt attempted to set up an industry forum to address internet interconnection. The forum’s goal: “to stave off potential government regulation of peering by determining how large internet service providers can fairly interconnect their networks with smaller counterparts.” The forum intended to address “financial settlements for interconnection and whether different charges should apply for different types of traffic.”

Several months later, Mr. Hundt was reported as saying:

‘What I’m finding everywhere is indecision,’ he [Hundt] says. ‘There’s a lot of interest, but no consensus.’ And that inability to find common ground is what concerns him. His original view was that peering would be settled in one of three ways: by a forum, market forces, or regulation. Now that the forum route seems not to be working, Hundt fears that regulators might step in.

A year earlier, another leading trade publication noted, “Talk of any type of government intervention, from the Justice Department or the [FCC], scares everyone in the game.” One might imagine that having a former Chairman of the FCC discuss these issues would heighten interests in resolving these concerns. If anything, the failure of this effort and others suggests that the great difficulty in resolving internet interconnection issues can only be corrected by a change in the regulatory and industry structure.

II. TELEPHONY REGULATION:
PROMOTING COMPETITION WITHOUT JUDGEMENT

Policy-makers around the world proclaim their determination to promote telecommunications competition. But backing this desire to promote competition in telecommunications requires answering the question of what specific scope and manner of competition should be promoted. Unfortunately, this “competition for what?” question has not been adequately considered or answered. The inability to answer this question by defining exactly what services should be open to competition and what that competition should “look” like has significant long-run costs: current voice telephony regulation may be unintentionally promoting an industry structure for competition that is much less beneficial than the alternatives. In a sense, policy-makers are flying by the seat of their pants and holding on for dear life, hoping that everything will turn out for the best wherever the plane happens to land.

A. Avoiding judgements about competitive structure

It is clear that despite the enactment of a broad range of pro-competitive policies, telecommunications policy analysts and policy-makers are reluctant to directly consider competition from a structural perspective. Instead, policy-makers have assumed responsibility for promoting competition for everything, everywhere. There is seldom any consideration of whether competition in any given industry segment is feasible or even desirable, although regulators are generally pledged to protect consumers from any unfortunate effects of competition. The policy concept of “competitive neutrality” appears to mean that the regulator, while promoting competition for everything, must ensure that regulation does not promote one type of competition more than another. Such rhetoric, while incoherent, emphasizes that regulatory considerations of competitive structure are preparations for exercising regulatory discretion. Regulatory discretion is considered an undesirable and unnecessary aspect of sound pro-competitive policy.


19 Id.


1. Failure of the technocratic approach

In traditional neo-classical economics and public utility theory, analyses of technology and demand provided the analytical basis for judgements about competitive structure. The key phrase in this approach is “natural monopoly.”

Based on estimates of the characteristics of production functions and consumer demand, the industry is partitioned into markets, and the markets are classified as either “workably competitive” or “naturally monopolistic.” Regulators promote competition in markets that are “workably competitive” and continue to regulate markets that are “naturally monopolistic.”

Unfortunately, this approach provides limited guidance for current pro-competitive policy. When telephony was a radically different business from cable service, when switching costs were not driven by development of the computerized switch, and when wireless telephony and the internet did not exist, economists analyzed whether particular parts of the telephone network were a natural monopoly. The fact that today’s industry is marked by convergence, dynamic demand and technological change makes this traditional analysis much more difficult.

More significantly, this approach obscures central policy considerations. First, it ignores the effects of regulation on the structure of competition. Interconnection regulation might mitigate economies of scope that would otherwise preserve a “natural monopoly.” More generally, the determination of a “workably competitive” market cannot occur prior to consideration of regulation. Second, the time frame of the development of competition should be a key regulatory concern. For example, a “workably competitive” market for facilities-based broadband connectivity to residences might develop over a time span that is too long to deliver benefits comparable to the imposition of a loop unbundling requirement on the incumbent telephony provider.

The technocratic approach largely fails to inform current telecommunications policy. Policymakers now generally ignore the technocratic approach to making judgements about competitive structure, not because of its weaknesses, but because they now largely attempt to avoid making judgements about competitive structure. A determination to promote competition everywhere in the telecommunications industry might be taken to imply the judgement that there are no natural monopolies in the industry. But policy-makers have not made that judgement.

2. Focus on incumbent monopolists’ products and networks

Pro-competitive policy attempts to avoid making judgements about competitive structure by assuming that the incumbent monopolists’ products and network elements define the realm of relevant competitive possibilities. The results of this crude reasoning leads to flawed conclusions that competition will lower prices but will not alter the industry or marketplace structure, or that an emerging technology, such as wireless communications service, will evolve to be the exact replacement of the incumbent services. In the case of wireless, this reasoning would invite the conclusion that wireless and wireline local exchange services were equivalent substitutes for each other. An example of a more sophisticated application of this reasoning is the FCC’s attempt to establish policies and rules for competition in switched voice transport to incumbent end-offices. The

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26 Id. at § 19.2a. The author thanks Mr. Tim Brennan, who provided substantive comment for this paragraph.
28 In 1980, for example, the FCC designed an access charge regime for interconnection between local exchange carriers and long-distance carriers in order to promote long-distance voice competition. Further encouraged by the Modified Final Judgement (“MFJ”) that separated AT&T’s long-distance services from the Regional Bell Operating Companies (“RBOCs”) local exchange services, industry developments led MCI and Sprint to build independent national networks that could effectively substitute AT&T’s long-distance voice services. See United States v. American Tel. & Tel. Co., 552 F. Supp. 131 (D. D.C. 1982). The MFJ placed a constraint on the further expansion of competition down into the RBOCs’ local exchange networks. Under the MFJ, the RBOCs were required through Sept. 1, 1991 to charge an equal amount per minute for all switched voice traffic originated and terminated for interexchange carriers (the “equal charge” rule). See id. at 233–34. Thus, for switched voice traffic, interexchange carriers had no incentive to interconnect with RBOCs at end offices rather than at tandems. See id. at 199. Competition for RBOCs’ interoffice switched
recent policies focused on extensive unbundling of the incumbents’ network elements. These policies implicitly sanction the view that competition will develop for elements of the incumbents’ networks, if competition develops at all. Twisted to another level, a recent paper implicitly proposes that unbundling should not be imposed to enable competitors to provide products that the incumbent operator does not provide.\textsuperscript{29}

3. The rise of the client-driven approach

Regulators also avoid considering the impact of industry structure on competition by taking a client-driven approach when formulating pro-competitive regulatory policy. For example, Company B, a competitive local exchange carrier (“competitive LEC”), argues that the regulator must require incumbent carrier, Company A, to do X so that Company B can provide service Y. In this scenario, Company A would be typically described as a monopolist, and X would be deemed as essential to the provision of Y. Moreover, service Y is a highly desired service by many end-users because it will be better or lower-priced than the current alternative. Responding to Company B’s request, the regulator requires Company A to do X in the interest of promoting competition. However, the regulator does not require Company B to actually provide Y, nor does the regulator require Company B to provide Y at a better or lower price than the identified alternative because doing so would be considered “intrusive” regulation. The disadvantages of this \textit{ad hoc} approach are clear. The scope and nature of the competition actually promoted by the regulation is highly dependant upon the nature of requested regulatory action and the regulator’s response to this request. Further, the development of competition is dependant upon what companies actually do with the regulatory rights and advantages that they gain.

The Telecommunications Act of 1996\textsuperscript{30} supports this approach, but it does not require it. Section 251(c)(3)\textsuperscript{31} of the Act identifies duties of incumbent LECs to provide access to network elements in response to requests from telecommunications carriers seeking to provide telecommunications services. Section 251(d)(2)\textsuperscript{32} gives the FCC the responsibility for defining the scope of these duties. Under Section 251(d)(2)(B),\textsuperscript{33} an “impair” limitation on access duties is set out in the context of a telecommunications carrier “seeking access to provide the services that it seeks to offer.” However, the “necessary” limitation on access duties in Section 251(d)(2)(A)\textsuperscript{34} is not put in this context. One might imagine a form of access that is necessary to provide a telecommunications service that a telecommunications carrier seeks to offer, but that is not necessary to promote a pro-competitive, deregulatory strategy for the industry. Moreover, Section 251(d)(2)\textsuperscript{35} sets out minimum access standards that the FCC must consider.\textsuperscript{36} Additional access standards associated with a broader vision for pro-competitive, deregulatory industry development appear to be permissible, but they have not been explored.


\textsuperscript{33}Id. at § 251(d)(2)(B).

\textsuperscript{34}Id. at § 251(d)(2)(A).

\textsuperscript{35}Id. at § 251(d)(2).

\textsuperscript{36}See id. at § 251(d)(2).
B. Unintentional aspects of emerging industry structure

Although policy-makers have been preoccupied with the extent of competition and its speed of development, industry performance also depends on other aspects of competitive structure. Even in a communications industry in which all product markets are workably competitive, at least two sorts of potential weaknesses could exist. First, the industry, although competitive, might not be capable of re-organizing itself quickly to adjust to changes in the technology or the scope of potential trades. Second, the industry, although competitive, might dissipate significant economic value as companies continually appeal to the regulator to decide narrow, complex issues concerning the distribution of value between companies. Aspects of pro-competitive regulatory policies for voice telephony may be contributing to the development of such weaknesses.

Current pro-competitive regulatory policies for voice telephony are increasing the cost of adjusting a geographic structure of incumbent end-offices that could be highly inefficient. The geographic structure of incumbent telephone operators’ end-offices was largely established prior to 1917. Given subsequent dramatic developments in switching and transport technology, this structure is likely to be highly inefficient. Pro-competitive regulation, however, is now deeply connected to the existing structure of incumbents’ networks. Such regulations have partitioned incumbents’ networks into elements defined in terms of incumbents’ existing end-offices. Regulated rates for interconnection have been defined in terms of tandem and end-office hierarchies. Competitors have been granted regulatory rights to collocate in incumbent end-offices. Given such regulations, changes in the structure of incumbents’ network are likely to occur much more slowly.

Moreover, collocation rules have created narrow, complex and enduring regulatory battles between companies. State regulatory commissions in the U.S. began to require collocation in incumbents’ offices as early as 1989. The FCC began to establish national collocation rules in 1992. Yet companies are still battling intensely over narrow issues that affect the value of collocation obligations. For example, a 1999 FCC order decided, among other issues, that collocating carriers are allowed to construct their own facilities for cross-connecting among themselves; and that incumbent LECs must provide “shared collocation,” “cageless collocation,” and collocation in adjacent controlled environments if collocation space is exhausted. The FCC also issued the following requirement:

[A]n incumbent LEC that denies collocation of a competitor’s equipment, citing safety concerns, must provide to the competitive LEC within five business days a list of all equipment that the incumbent LEC locates within the premises in question, together with an affidavit attesting that all of that equipment meets or exceeds the safety standard that the incumbent LEC contends the competitor’s equipment fails to meet.

A large number of other issues, at this level of detail, are emerging with respect to loop-sharing, managing interference among loops (“cross talk”), sub-loop unbundling, and the use of various combinations of wholesale network services or elements.

Attempts to implement unbundled access to the incumbents’ network have quickly led to the recognition that information systems for pre-ordering, ordering, provisioning, repair, maintenance and billing (“OSS”) determine the usefulness of the access gained to the physical facilities. Regulators must not only regulate access to the network physical plant, but also deal with issues...
relating to the incumbent carrier’s information systems capabilities and performance. The regulatory fight between incumbent and competitive carriers moves from argument over actual physical access to the network, to a dispute over the ease of access to the mandated unbundled elements. For example, both the parties and FCC noted that competitive carriers using BellSouth’s network must scroll through lists of products and services to fulfill particular customer orders. By contrast, BellSouth’s own retail interface allows its customer service representatives to find a product or service simply by typing the first few letters of the product’s name. A recent independent test done for regulatory purposes of Bell Atlantic’s OSS in New York State involved statistics for 855 test elements. But such tests have merely established a level of incumbent LEC performance and did not determine the ease of access.

The development of detailed regulation and litigation over the access to a network operators’ information systems will likely come at a high cost. While technology is rapidly driving down the cost of switching and transport hardware, the most important challenge to competition is to foster a wider range of network management capabilities and to promote quicker, more customized service. Any regulation requiring an incumbent network operator to provide nondiscriminatory access to its OSS could diminish the incumbent’s incentives to improve its OSS. There is nothing that would indicate that subjecting OSS systems to the litigation and the adversarial process would not make improvements to the incumbent’s systems more risky and problematic.

In regulated industries, companies and customers tend to acquire quasi-property rights in existing arrangements. Thus, as companies and customers make plans and investments based on the wide range of regulatory rights being established for telephony, the existing regulatory structure becomes entrenched and the possibility of deregulation in the future narrows. The regulator then would be called upon by the market participants to continually police the value of acquired rights. Emerging market opportunities, however, may gradually erode the value of rights acquired under telephony regulation and result in a market-driven, decentralized deregulation. For example, a telecommunications carrier has obtained the right to do “x” for price “p1.” If subsequent market development results in “x” being freely offered for price “p2,” which is less than the original price “p1,” then the communication carriers original regulatory right has become far less valuable to it and will be “liquidated.” This “liquidation” would also occur if a more cost-effective opportunity than “x” emerges or if for some other reason “x” is no longer a useful right.

However, this liquidation of regulatory rights will inevitably follow from industry growth and the development of competition. For example, if incumbent LECs’ end-offices become key network interconnection points, then collocation rights may endure long beyond the growth of competitive telecommunications networks. Regulated rights associated with complex information systems like OSS are likely to be difficult to liquidate because of the momentum of idiosyncratic investments necessary to establish compatible software and business practices. Thus, policy-makers and industry participants need to consider the possible

41 See Application of BellSouth Corporation to Provide In-Region, InterLATA Services in South Carolina, Memorandum Opinion and Order, 13 FCC Rcd. 593, 634, para. 174 (1997).
42 See id.
44 In 1998, software accounted for 40% of capital spending for MCI WorldCom, while switching and transport accounted for 6% and 19%, respectively. In contrast, in 1988 software accounted for 3% of MCI’s capital spending, while switching and transported accounted for 19% and 44%, respectively. MCI WorldCom expects that switching and transport will amount to less than 25% of capital spending per year within a few years. John Sidgmore, MCI WorldCom Vice Chairman, presentation to stock analysts (Spring 1999).
45 In 1998, MCI WorldCom’s cost for delivering one minute of voice traffic broke down as follows: OSS, 5%; switching, 3%; transport, 4%; operating costs, 26%; and access (interconnection fees), 62%. John Sidgmore, MCI WorldCom Vice Chairman, presentation to stock analysts (Spring 1999).
46 Under the Section 271 requirements of the 1996 Act, for OSS functions that are analogous to those operations that a BOC provides to itself, its customers or its affiliates, the nondiscrimination standard requires the BOC to offer requesting carriers access that is equivalent in terms of quality, accuracy and timeliness. The BOC must provide access that permits competing carriers to perform these functions in “substantially the same time and manner” as the BOC. In re Application by Bell Atlantic-NY for Authorization to Provide In-Region, InterLATA Services in South Carolina, Memorandum Opinion and Order, 13 FCC Rcd. 593, 593, para. 85 (1997) [hereinafter Bell Atlantic Application]. Such regulation lessens the competitive value to the RBOC of investing to improve its OSS.
ble significance of what economists call "hysteresis" or "lock-in" effects. Indeed, the parties themselves may encourage rapid growth of grandfather clauses to perpetuate the effects of legacy regulations long beyond the relevance of the policy concerns that motivated them. Competition will occur, but only in the context of regulations that hinder industry change and foster wasteful regulatory battles.

III. MAKING JUDGMENTS ABOUT PROPITIOUS INDUSTRY STRUCTURE

Careful analysis and industry observation can provide a basis for making useful judgments about industry structure. The intention is not to forecast the future, even less to provide a comprehensive development plan for the industry. The objective is to identify key economic distinctions that appear to be relatively stable, explore their implications for beneficial industry development and look for nascent industry trends that may provide a foundation for promoting such development.

A. Economic Analysis

Connecting end-users to a telecommunications network is a local business. Constructing these connections requires careful consideration of local topology and economic geography. Constructing these connections also requires careful consideration of local regulations and politics; wireline network operators need to secure extensive rights-of-way from local governments and wireless operators need to place antennae. Moreover, in the U.S. in 1990, approximately 28% of all housing units were multiple dwelling units, and the share of such units is significantly higher in other countries. To gain access to end-users, network operators often have to enter into highly location-specific, idiosyncratic negotiations with the owners of buildings, campuses and managed housing tracts. National regulation can play a role in addressing these challenging issues, and the FCC has been actively considering a variety of questions and regulations. Nonetheless, no national regulations are likely to be able to transform end-user connections into a standardized, nationally negotiated and managed service.

In contrast, providing network services is inherently a nonlocal business relying on standardized routines and infrastructure capabilities. The ubiquity of e-mail services depends on addressing, routing and formatting standards. Requesting and serving web pages requires additional widely implemented standards. The nature of such standards is largely independent of local knowledge and infrastructure, and the service provided is not related to any geographical location. Customers do not necessarily care where Amazon.com's servers are physically located. For products that it can deliver in electronic form, Amazon.com does not necessarily care where its customers are physically located either. Moreover, Amazon.com can expand its capacity to deliver electronic products to customers simply by installing additional standardized hardware. Stock market valuations for companies such as Amazon.com have soared largely because their business models readily scale to global commerce.

Dividing customer value between local connectivity and wide-area network services is a fundamental economic problem. While no amount of head-scratching and eye-gouging can resolve this issue, industry performance will depend heavily on the quality of the arrangements that are worked out. The most important resource for working out such arrangements is relevant information. The best way to generate such information is to have customers choose among different combinations of local connectivity and wide-area network services.


48 George Ford, formerly of the Competition Division of the FCC's Office of General Counsel and now at MCI WorldCom, has emphasized this point to me in discussions of industry economics.


51 A supporting electronic payment infrastructure, such as that for credit cards, is also necessary.

52 To the extent that customer support requires human interaction, this is an additional cost factor in scaling service.
B. Institutional Implications

The above economic analysis suggests that good industry performance is likely to depend on the presence of businesses that provide effective separation of local connectivity from wide-area network services. I will refer to businesses that serve this function as service interconnection points ("SIPs"). SIPs would compete locally in coordinating wide-area network services for local end-users. An SIP would lease local facilities providing connectivity to end-users and would host and interconnect to facilities distributing wide-area network services. To mediate effectively between local connectivity and wide-area network services within a relevant geographic location, an SIP should not be owned by either a local facilities provider or wide-area network service provider. This allows a local facilities provider in one area to own an SIP in an area in which the local provider does not provide local facilities. Similarly, a wide-area network service provider could own an SIP, as long as the SIP is not connected directly to other SIPs using the wide-area network service provider's facilities.

Competing, independently owned SIPs would effectively define the product and the value proposition for local facilities builders. The product for local facilities builders would be connectivity from end-users to SIPs; thus, this connectivity could be defined in terms of the types of attributes currently used to define end-to-end connectivity for leased lines. Competition among SIPs would allow the value of wide-area services to be transmitted to agents considering investments in local facilities. The higher the value to end-users of the wide-area services, the greater the amount SIPs would be willing to pay local facilities investors to connect end-users to the SIP. By helping to define a local product and value proposition for connectivity, SIPs would foster investment in local facilities.

Enabling localization of investment in communications facilities played a key role in the development of rural telephony. The U. S. Managers of the Bell System, which held Alexander Graham Bell's original telephone patents, believed that telephone service was primarily of value to business users in major cities. In 1894, after seventeen years of commercial activity, the Bell System had installed nearly 90% of its phones for business subscribers.\(^53\) Independent, locally financed commercial telephone companies, community-oriented mutual companies and farmers' cooperatives brought telephony to small agricultural cities and rural areas.\(^54\) By 1920, 38.7% of American farms had telephone service, whereas only 30% of American households did.\(^55\) Historical conditions fostered decentralized investment in local access facilities, which allowed telephone service to cover all of the U.S.\(^56\) The geographic structure of local exchanges that was established prior to 1917 still essentially defines the current geographic structure for current U. S. interconnection regulation.\(^57\) A set of competing, independently owned SIPs could recreate incentives for decentralized investment in local access facilities.

SIPs also would facilitate low-cost wide-area bandwidth transactions. Some industry participants foresee commodity markets emerging for bandwidth.\(^58\) Such markets could help provide appropriate signals for wide-area network investment and lessen the cost of rolling out new wide-area services.\(^59\) The development of such a market will depend on establishing a widely recognized set of nodes among which bandwidth can be traded. SIPs could serve effectively as nodes for a bandwidth market.

A well-developed layer of competing SIPs would

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54 See id. at Chapter 6.
55 See id. at 148.
56 See id. at 146–49.
57 In 1917, there were 19,550 local exchange offices in the U.S. See id. at 147. In 1998, local exchange carriers reported a total of 18,700 local exchange switches to the FCC. See 1998 Statistics of Common Carriers, at Table 2.10 (visited Apr. 7, 2000) <http://www.fcc.gov/Bureaus/Common__\_\_\_\_/Fcc-State_Link/SOCC/scc98idx.html>. The Oct. 1999 LERG lists 22,860 distinct office codes for incumbent LECs, of which about 4,300 appear to be multiple references to listed U.S. West offices.
59 The development of such a market should not be taken for granted. Attempts to establish commodity markets have historically had a high failure rate even among products with propitious characteristics. See generally D. G. Black, Success and Failure of Futures Contracts: Theory and Empirical Evidence (1986).
provide a lattice upon which new wide-area network-services could be implemented. The largest share of value in wide-area networks is likely to be associated with noncommoditized characteristics such as interconnection services, physical circuit diversity and reliability, and pricing and protocol options.\textsuperscript{60} By providing a lattice for implementing such services, SIPs would eliminate the need among competing wide-area networks for a new mode of interconnection in order to provide a new service ubiquitously. Such a lattice would lessen the importance of various forms of peering among wide-area networks and hence decrease industry tensions associated with internet interconnection.

C. Recent Industry Developments and Institutional Possibilities

SIP-like institutions are already beginning to emerge in the communications industry. One is PAIX, which began operating in 1996 as a center in California for exchanging traffic among ISPs.\textsuperscript{61} PAIX states that it is carrier-neutral, not owned by a telco or carrier, and not affiliated with any ISP.\textsuperscript{62} PAIX has announced plans to open six additional highly secure facilities for collocation and interconnection among ISPs in the U.S. within a year.\textsuperscript{63} Another company offering SIP-like institutions is Equinix, founded in 1998. Equinix builds and operates carrier-neutral and content-provider-neutral facilities it calls “Internet Business Exchanges” (“IBXs”).\textsuperscript{64} Equinix offers to network facilities providers, content providers and applications service providers a set of buildings with financial grade security, redundant power supplies, private and shared collocation areas, and a wide range of options for interconnecting within the building. Equinix currently has one IBX operational in the Washington, D.C. area and recently signed a $1.2 billion contract for constructing more than 30 additional IBXs in business, financial and internet hubs around the world.\textsuperscript{65}

Some real estate companies are beginning to provide SIP-like institutions. The Rudin family, developers and owners of one of New York’s largest privately owned commercial and residential real estate portfolios, is a prime example.\textsuperscript{66} They developed and own the New York Information Technology Center at 55 Broad Street, Manhattan, which houses a large number of communications and new-media companies, and have established similar facilities at 110 Wall Street and at the former Grumman Aircraft factory on Long Island. The Rudin family also recently bought a former AT&T Long Lines switching center at 32 Avenue of the Americas in Manhattan, which will be renovated and called the New York Global Connectivity Center and will house network transport providers, web-hosting companies, Internet companies and switch companies. This facility also will provide extensive support for in-building interconnectivity.

Most of the SIP-like institutions described above are located in major cities and do not provide services to end-users. In residential and rural areas, ISPs moving to offer their end-users a variety of network services may evolve into SIPs. Dial-up Internet connectivity has become for ISPs a low-margin, commodity service that cannot sustain their

\textsuperscript{60} Historically the heterogeneity of user needs spurred the development of private networks. See David Gable, Private Telecommunications Networks: An Historical Perspective, \textit{PUBLIC NETWORKS, PUBLIC OBJECTIVES} 35–49 (Eli Noam and Aine Nishuilleabhain eds., 1996) <www.xil.org/papers/citi509.htm>.

\textsuperscript{61} The PAIX center in Palo Alto, Cal., was set up by Digital Equipment Corp. Currently it is a subsidiary of Metopolitan Fiber Network, a seller of dark fiber connectivity. See Paix, Paix's Neutral Internet Exchange Model and Proven Track-Record Propels Growth to 100 Customers (visited Apr. 7, 2000) <www.paix.net/press_releases/2000_0105_paix100customers_new.htm>.

\textsuperscript{62} See id.

\textsuperscript{63} The locations for the facilities are Tyson’s Corner, Va.; Atlanta, Ga.; Dallas, Tex.; Los Angeles, Ca.; and an additional facility in Palo Alto, Ca. See Paix, Paix Announces Major Expansion Plans (visited Apr. 7, 2000) <www.paix.net/press_releases/102699-paix_expansion_new.htm>.

\textsuperscript{64} Unless otherwise noted, the information on Equinix given here is from Equinix’s website. See generally, Equinix <http://www.equinix.com>.

\textsuperscript{65} According to CNET News, in May 1999, the CEO of Equinix, Al Avery, indicated that Equinix planned to build 15 IBXs domestically. See Ben Heskitt, Start-up aims to house Net data exchanges, CNETNews.com (May 25, 1999).

businesses. ISPs are thus seeking to develop value-added businesses, such as web hosting, video-conferencing, e-commerce and a variety of other wide-area network services. An impediment to the ISPs’ ability to offer their customers new services is the lack of competition in local telephony in residential and rural areas. However, as ISPs assemble increasingly appealing offerings of network services, they will generate strong incentives for the entry of local facilities providers who can connect end-users to these services. Given that numerous ISPs provide local service in almost all regions of the U.S., they could be important to the development of competing, independently owned SIPs that cover all of the U.S.

IV. A FEASIBLE POLICY LEVER FOR IMPROVING INDUSTRY STRUCTURE

Changes in voice telephony regulation to promote the development of SIPs could help overcome the structural weaknesses that are appearing in internet and telephony competition. In particular, voice telephony regulation could seek to establish a geographically comprehensive lattice of competing, independently owned and certified SIPs. Becoming a certified SIP would involve gaining a privileged position for voice telephony call termination in exchange for adhering to certain ownership restrictions. All telephony service providers in defined SIP regions would be required by regulation to provide zero-price call (circuit-switched voice, fax and dial-up modem) termination for calls delivered to chosen certified SIPs in the SIP region associated with the called customer. The owner of a certified SIP would not be allowed to own facilities for local connectivity in the area in which the certified SIP is located. A certified SIP would also not be allowed to own network facilities connecting to other certified SIPs.

Further necessary decisions about certified SIPs would depend on institutional circumstances. One issue is the geographic areas associated with SIPs’ voice termination roles and transport facility ownership restrictions. In the U.S., a natural choice is LATAs. Each state regulatory commission might certify, for a fixed term of five years, three to five independently owned SIPs in each LATA in the state, with all local telephony operators in the state having responsibility to terminate calls from at least two of those SIPs. Since there are 236 LATAs covering the U.S., such a program would lead to roughly 750–1000 certified SIPs spread throughout the U.S. If all voice traffic, including local calls, passed through these SIPs, they would have to support 1.9–2.5 Gbps of voice traffic. This is about the volume of peak data bandwidth through a major U.S. internet interconnection point in late October 1999.

There is a range of institutional possibilities for facilities and ownership of SIPs. Independently owned internet or private network interconnection points might be candidates to be certified SIPs. Highly capable ISPs meeting the transport facility ownership restrictions might also be candidates to be certified SIPs. National network operators, many of whom are building large data centers, might be willing to divest transport facilities to some data centers in order to make them candidates to be certified SIPs. In addition, regulators or antitrust authorities could consider requiring large incumbent LECs to divest some tandem switching offices so as to create an interconnection structure more conducive to controlling incumbent LEC market power.

A. Considerations of policy feasibility

Changing voice telephony regulation is a much more propitious policy direction for influencing evolving industry structure than is establishing new regulations for internet peering. Large incumbent LECs are widely recognized to have market power in providing local telephony. In contrast, market structures for internet services are

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68 Calculation based on total voice bandwidth given in Table 1. Voice calls among incumbent telephony customers would not necessarily pass across SIPs.

69 Based on bandwidth for MAE East <208.234.102.97/MAE/east.aggr.overlay.html>.

70 AT&T, UUNet, PSINet, Qwest and Intel are talking about building about 25 new data centers each this year. See Kate Gerwig, Saving Future Services, Tele.com, Jan. 10, 2000 (visited Apr. 10, 2000) <www.teledotcom.com>. Level 3 has also built more than 25 data centers that offer a wide range of services to collocating customers.

71 Large incumbent LECs might, in fact, find it advantageous, from the perspective of transforming industry structure and maximizing asset value, to do this.
highly dynamic, and market power arguments with respect to internet services typically depend significantly on speculation about future developments. While there is widespread, deeply rooted hostility toward changing the regulatory framework for internet services, telephony regulation over time has gone through a series a major new regulatory initiatives. Associated with that history is the FCC's extensive knowledge and experience with implementing telephony regulation. There is no similar knowledge and experience with respect to regulating internet interconnection. Moreover, there is significant dissatisfaction with the current state of telephony regulation, and the Telecommunications Act of 1996 gives the FCC broad forbearance authority with respect to almost all of its regulations. Changes in voice telephony regulations that promote SIPs could be accompanied with a dramatic reduction in a wide range of other regulations that would no longer be part of this new implementation of a pro-competitive, deregulatory national policy framework for the industry.

While data traffic is growing much more rapidly than voice traffic, the value and magnitude of voice traffic is still sufficient to influence strongly the overall structure of network interconnection. The first data column of Table 1 shows total RBOC interoffice bandwidth in use. Subsequent data columns show the total bandwidth required for RBOC originated voice calls in different categories. Assuming that all local voice traffic travels between RBOC local exchanges, the total bandwidth of RBOC interoffice facilities in use for nonvoice services in 1998 was 2.4 times greater than bandwidth needed for voice services. Most of the nonvoice bandwidth is for leased-line services, whose bandwidth has been growing about 40% per year since 1989. Internet bandwidth in mid-1998 was probably about 110Gbps and it is growing about 100% per year. The most important point to take from Table 1 is that voice services still account for an important share of network bandwidth, although within a few years voice bandwidth will be insignificant. This means that becoming a distinguished interconnection point for voice telephone can play an important role in giving an interconnection point industry salience.

B. Some consideration of costs and benefits

A requirement that all local telephony providers in a defined geographic area provide zero-price call termination from at least two certified SIPs in the area has relatively small costs and large benefits. This requirement promotes the concentration of network traffic at certified SIPs and thus helps to promote SIPs' industry significance in future network development. This requirement also provides an administratively simple telephony interconnection regime that would allow network operators to provide flat-rated telephone service.

On the other hand, Coffman and Odlyzko's figure for private line and public data networks, 370 Gbps at year-end 1997, appears to be a significant underestimate.

Convergent Networks, a company that focuses on convergence networks, stated that AT&T's network carries 850 terabytes of voice traffic per day as compared to 33 terabytes of data traffic. See Om Malik, "Telecom Titans," Forbes.com, Sept. 8, 1999 (visited Apr. 10, 2000) www.forbes.com/tool/html/99/sep/0908/cat.htm (reporting comments of Bing Yang, chief technology officer and cofounder of Convergent Technologies). The specific nature of these measurements is unclear. Nonetheless, it is worth noting that utilization rates for long-distance switched voice circuits (33%) are almost an order of magnitude greater than utilization rates for data circuits (3-5%). See Andrew Odlyzko, "The Internet and other networks: Utilization rates and their implications," AT&T Labs—Research, Sept. 12, 1998 (visited Apr. 10, 2000) wwwresearch.att.com/~amo>. The interoffice bandwidth data in Table 5 refers to the bandwidth of circuits in use, not the volume of traffic passing through those circuits.

It would eliminate major battles such as those that have occurred in the U.S. over reciprocal compensation for switched circuit minutes associated with dial-up internet connections. Competition in local telephony by itself will shift more voice traffic into interoffice networks. Traditionally, local exchange offices were designed around local calling communities so that local calls could be completed without the need for interoffice transport. When neighbors are connected to competing local telephone companies, local calls require interoffice transport. As the figures in Table 1 suggest, because local call volumes are high relative to intraLATA and interLATA toll calling, competitors shifting even a small share of an incumbent LEC’s local call bandwidth to interoffice transport can result in a large percentage increase in interoffice voice transport.

In a competitive industry, reducing interconnection management costs is probably more important than reducing the demand for interoffice voice transport. Given the magnitude of total interoffice bandwidth, doubling or tripling the amount of interoffice voice transport would not require a major re-dimensioning of the over-all network. On the other hand, managing interconnection involves exchanging traffic predictions at each interconnection point and coordinating the installation and maintenance of new interfacing bandwidth. Such processes are administratively complex, error-prone and not subject to rapid technological improvements like those driving down bandwidth and switching costs. Nonetheless, industry experience thus far shows incumbents often seeking to require competitors to interconnect with them at a relatively large number of local offices.

New local telephony providers terminate calls to their customers from relatively few publicly advertised offices. Consider Table 2, which documents some aspects of telephony network structure in the greater New York City metro area (LATA 132). The first data column in Table 2 gives the number of rate centers served. Rate centers are a historically determined geographic partition of an area: the number of rate centers served is a rough index of the scope of a telephony provider’s coverage. The second data column of Table 2 shows offices advertised in the Local

<table>
<thead>
<tr>
<th>Year</th>
<th>interoffice bandwidth</th>
<th>interLATA toll</th>
<th>intraLATA toll</th>
<th>Local</th>
<th>total voice</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>6,291</td>
<td>217</td>
<td>54</td>
<td>1,602</td>
<td>1,874</td>
</tr>
<tr>
<td>1997</td>
<td>4,128</td>
<td>221</td>
<td>61</td>
<td>1,540</td>
<td>1,822</td>
</tr>
<tr>
<td>1996</td>
<td>3,376</td>
<td>206</td>
<td>58</td>
<td>1,501</td>
<td>1,766</td>
</tr>
<tr>
<td>1995</td>
<td>2,762</td>
<td>194</td>
<td>66</td>
<td>1,456</td>
<td>1,716</td>
</tr>
<tr>
<td>1994</td>
<td>1,654</td>
<td>172</td>
<td>65</td>
<td>1,396</td>
<td>1,633</td>
</tr>
<tr>
<td>1993</td>
<td>1,304</td>
<td>156</td>
<td>64</td>
<td>1,340</td>
<td>1,560</td>
</tr>
<tr>
<td>1992</td>
<td>934</td>
<td>142</td>
<td>64</td>
<td>1,299</td>
<td>1,505</td>
</tr>
<tr>
<td>1991</td>
<td>729</td>
<td>135</td>
<td>66</td>
<td>1,256</td>
<td>1,457</td>
</tr>
<tr>
<td>1990</td>
<td>493</td>
<td>133</td>
<td>56</td>
<td>1,217</td>
<td>1,407</td>
</tr>
<tr>
<td>1989</td>
<td>346</td>
<td>157</td>
<td>55</td>
<td>1,174</td>
<td>1,386</td>
</tr>
</tbody>
</table>

Notes: Interoffice bandwidth calculated based on data in RBOC price cap annual filings. Telephony bandwidth based on FCC SOCC call volumes, estimated call times and 9000 minutes/month/per 64 Kbps circuit.

76 To lower their customers’ phone bills for dial-up internet access, some ISPs have sought to become “virtual neighbors” of their customers. They do this by acquiring a number for each local calling area for which they provide dial-up internet access and having their communications provider terminate all these numbers to the same physical point. One result is that the incumbent operator sees more local call minutes traveling through its interconnection trunks.


78 Bell Atlantic-New York asked the New York Public Service Commission (“NY PSC”) to require that interconnecting LECs establish a geographically relevant interconnection point (“GRIP”) in every rate center that the LEC serves, unless the interconnecting carriers negotiate alternative arrangements. See NY PSC, Case 99-C-0529, Opinion No. 99-10, pp. 48, 62–3 (Aug. 26, 1999) (rejecting the use of GRIP).
Exchange Routing Guide ("LERG") as delivery points for calls to the provider's customers. New local telephony providers cover a significantly larger number of rate centers per call delivery point than does Bell Atlantic. This suggests that new local telephony providers are not seeking to economize on transport costs by having telephony providers deliver calls to them close to their end customers.

The time and cost of establishing points of presence is not hindering the ability of new local telephony providers to establish more termination points for calls to their customers. Through July 1999, Bell Atlantic—NY ("BA") had provided 750 physical collocation arrangements in 175 central offices. Of these collocation arrangements, 137 are in the greater New York City area (LATA 132). Nonetheless, as Table 2 shows, new telephony providers are using only 13 collocations in BA offices in LATA 132 as points for collecting calls from other networks. When such arrangements are used, the larger new local telephony providers use exclusively BA tandem offices. This fact further suggests that the geography of interconnection points for terminating voice telephony has thus far been determined by the historical location of a relatively few, large incumbent offices.

Policy that requires voice telephony call termination from certified SIPs represents a dramatic change only in the sense that it shifts voice telephony interconnection to a nonadversarial environment, i.e. competing, independently owned SIPs.

V. CONCLUSION

Policy analysts and policy-makers should consider the merits of different competitive structures in the telecommunications industry. Significant weaknesses in industry structure are apparent in the internet and in the development of local telephony competition. Pro-competitive regulation for voice telephony is not adequately considering over-all industry structure; instead, it appears to be largely driven by particular, narrow requests for pro-competitive interventions. Nonetheless, voice telephony regulation will have an enduring effect on industry structure even when voice telephony is a relatively unimportant network service. Armed with an understanding of the challenges confronting both internet services and voice telephony, such a legacy can become a tool for improving industry performance.

### Table 2

<table>
<thead>
<tr>
<th>Local Telephony Provider</th>
<th>Rate Centers</th>
<th>Delivery Points</th>
<th>Ratio</th>
<th>Colo's in BA Offices</th>
<th>Colo's in BA Tandems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bell Atlantic (wireline)</td>
<td>126</td>
<td>167</td>
<td>0.8</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>AT&amp;T (wireline)</td>
<td>50</td>
<td>13</td>
<td>3.8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MCI WorldCom</td>
<td>32</td>
<td>7</td>
<td>4.6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nextlink</td>
<td>28</td>
<td>1</td>
<td>28.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Allegiance</td>
<td>23</td>
<td>5</td>
<td>4.6</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Cablevision Lightpath</td>
<td>20</td>
<td>7</td>
<td>2.9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>RCN</td>
<td>20</td>
<td>6</td>
<td>3.3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>American Network, Inc.</td>
<td>18</td>
<td>1</td>
<td>18.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Frontier</td>
<td>18</td>
<td>5</td>
<td>3.5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>WinStar</td>
<td>15</td>
<td>1</td>
<td>15.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Level 3 Comm.</td>
<td>15</td>
<td>2</td>
<td>7.5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>all other than BA</td>
<td>83</td>
<td>77</td>
<td>13</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

Note: Based on LERG data current for 10/1/99. AT&T (wireline) consolidates entries for ACC National Telecom, AT&T Local and Teleport. MCI WorldCom consolidates entries for Brooks Fiber, MCIMetro and WorldCom.


81 Calculated based on LERG data on LATA's and wire centers, and Bell Atlantic's list of offices where collocation has been provided <www.bellatlantic.com/tis/bacolloc.htm>.