OPEN INTERCONNECTION AND THE ECONOMICS OF NETWORKS: AN ANALYSIS AND CRITIQUE OF CURRENT POLICY

Milton Mueller

Working Paper Series. 1988.

Center for Telecommunications and Information Studies, 809 Uris Hall,
Graduate School of Business, Columbia University,
New York, New York 10027.
(212) 854-4222

OPEN INTERCONNECTION AND THE ECONOMICS OF NETWORKS: An Analysis and Critique of Current Policy.

Presented at the 16th Annual
Telecommunications Policy Research Conference
Airlie, Virginia
October 31, 1988

Milton Mueller
405 N. 33rd St.
Philadelphia PA 19104
215-243-0160 (h)
215-898-7041 (o)

University of Pennsylvania
Annenberg School of
Communications

Introduction.

This paper investigates one of the fundamental assumptions underlying contemporary telecommunications policy. The assumption in question is what I will call the principle of open interconnection, and includes a cluster of beliefs about the interconnection of competing carriers and the effects of the same on telecommunications markets. In essence, this view holds that the once-monopolistic public telecommunications network can be made as competitive as the neighborhood grocery store if all carriers are required to interconnect with each other according to uniform technical standards and nondiscriminatory tariffs. Interconnection is believed to open telecommunications markets to free competition by ensuring that neither compatibility standards nor network externalities can work to reinforce the dominance of an established network. A carrier's refusal to interconnect its network with other systems is seen as an inherently anticompetive exercise of monopoly power.

It is no exaggeration to say that interconnection policy is the keystone of the contemporary response to the problem of monopoly.[1] With roots in older antitrust and common carrier principles, the ideal of open interconnection has been applied with increasing consistency from the days of the MCI decision in 1969 to the Equal Access and ONA proposals of the 1980s. Yet the principle itself and the economic assumptions underlying it have never been subjected to much critical scrutiny.

From a historical standpoint, open interconnection is a major policy innovation. In the "bad old days" of telephone competition in the early 1900s, competition meant that telephone subscribers were fragmented into two or more unconnected systems. Those who wanted access to everyone had to buy duplicate subscriptions. By 1910 the country was faced with what appeared to be a tough choice. Competition, with its innovation and price constraints, could only be purchased at the price of fragmenting subscribers. Monopoly could bring universal interconnection of telephone users, but eliminated price competition and the technological dynamism of the market. The perception that there was an inherent, irreconcilable conflict between universal service[2] and competition was the primary motive behind the choice of regulated monopoly as the institutional framework of telecommunications. Today's open interconnection policy, however, appears to sidestep the whole dilemma. It promises competition without fragmentation; universal access without monopoly or rate regulation. It almost sounds too good to be true.

It may be. This paper challenges much of the conventional wisdom concerning interconnection, competition and monopoly. Using historical cases, it demonstrates that interconnection tends to make networks complements rather than competitors, and can easily preempt network competition rather than promote it. Conversely, the noninterconnection of alternate networks can be both procompetitive and socially beneficial in certain ways. Much of the theory supporting open interconnection, in fact, is based on an incorrect reading of telephone history.

The paper reviews the theoretical literature supporting open interconnection and shows how it fails to recognize a crucial distinction between the effects of interconnecting networks and the effects of mandating compatibility in equipment. Networks have a special economic trait, which I call nonhomogeneity, that makes the effects of mandated interconnection more problematical than the standardization of equipment interfaces.

The paper is cast as a critique of some of the assumptions underlying current policy. It does not attempt to propose a full-fledged alternative policy or theory. It is intended to raise questions rather than to answer them; to stimulate debate over issues that have not been adequately considered rather than to define a new direction.

I

Theoretical Foundations of Open Interconnection

Two distinct but closely related bodies of theory provide the foundations of the current approach to interconnection. One group focuses on the competitive effects of standardization and compatibility in system-selling industries. The other group analyzes the competitive consequences of the "network externality," a name coined by economists to describe products that become more valuable as more people use them.

Competition and compatibility.

The literature on the economics of standardization sprang into existence in the mid-1970s in connection with the IBM and AT&T antitrust cases, and has been steadily expanding ever since. It ranges over subjects as diverse as bank cards, railroad gauges and the effects of standardization on product quality. I will be concerned here only with those works that deal with the strategic uses of compatibility in a competitive environment.

Much of this theory is a rather straightforward application of the concepts of tying and vertical foreclosure in antitrust law. According to this view, a seller with market power in one commodity can require its users to purchase a second good by tying or bundling it with the first, or by refusing to permit consumers to use competitively-supplied complementary goods. Both activities are believed to injure buyers by restricting competition in the market for the second good, and injure other sellers by acting as a barrier to entry.

In the mid-70s, economists discovered that technical compatibility relations could be used as tying mechanisms and barriers to entry. By deliberately designing products so they would not work with the components or systems of other manufacturers, a producer could lock buyers into his product line and shut other producers out of the market. They also observed that businesses with large market shares exerted disproportionate influence over the process by which industrywide standards were set. A successful standard-setter thus occupies the "dual role of rival and rulemaker"[3] and is well-positioned to exploit

compatibility as an anti-competitive weapon. Examples were provided by studies of the behavior of IBM in the 1970s[4] and of Kodak's dominance of the photography industry.[5]

This line of analysis lent itself to clear policy prescriptions. System markets dominated by a single producer with the power to unilaterally establish (and strategically manipulate) standards could be opened to free competition by setting uniform, public standards. Standardizing the interface between computer components, for example, permitted manufacturers who could not compete with IBM in the production of complete computer systems to enter the market for individual components. It also allowed consumers to "mix and match" the products of various manufacturers. The literature contains some recognition that competition between complete systems is possible without compatibility,[6] but puts overwhelming emphasis on the procompetitive effects of compatibility.

The same logic was readily applied to telecommunications. Indeed, the theory recognizes no qualitative distinction between telecommunications networks and computers, cameras or any other kind of equipment. The telephone network was viewed as a big, publicly extended "system" like a computer, with the local exchange, terminal equipment and long distance as its "components." AT&T's refusal during the '60s and '70s to permit the connection of rival long distance networks or terminal equipment was the economic and moral equivalent of IBM's use of incompatibility to thwart competition. It extended monopoly control from one market, the local exchange, to other, potentially competitive

complementary goods.

Of course, economists recognized that compatibility per se was not the issue in this case. The rival networks and terminal equipment were capable of working with the AT&T network, but the dominant carrier was unwilling to connect them. AT&T's behavior amounted to vertical foreclosure rather than tying.[7] The economic analysis identifying this behavior as "anticompetitive," however, was identical to that which had supported the standardization of computer component interfaces.

Network externalities.

A product is said to possess "positive consumption externalities" when one consumer's utility is enhanced by an increase in the number of other consumers of the same product.[8] The concept is particularly applicable to networks of communication, the value of which directly depends upon how many other people join the same network. This aspect of telephone service was recognized long before economists formalized the concept,[9] and was often used in conjunction with arguments for a monopoly telephone system.[10]

Because their value as a means of coordinating product design depends upon how many other producers use them, industry-wide compatibility standards are strongly characterized by network externalities. The literature on compatibility standards and network externalities thus overlaps to a significant degree.

Competition in markets with network externalities has special characteristics. Because much or all of the value of the

product is derived from the fact that everyone else is using it, competition can become a battle for mutually exclusive control of all of the market rather than for a profitable share of the market.[11] For example, the manufacturers of competing AM stereo equipment seek to establish their AM stereo format as the de facto standard. Should one of them succeed, the equipment of the losing manufacturers will become obsolete because of its incompatibility with the dominant standard.

Network externalities give the competitive process a "bandwagon effect;" consumers will wait for a product or network to establish a clear lead over its competitors and then collectively flock to it, making its success self-reinforcing. Once dominance is attained, moreover, it can become self-perpetuating. The continued use of the QWERTY keyboard design despite the availability of more efficient layouts is a common example of what Farrell and Saloner call the "excess inertia" of an established standard.[12]

From a policy standpoint, the network externality concept appears to point clearly in the direction of universal interconnection. Dividing subscribers reduces the value of communications networks. The theory also suggests that large, established networks have inherent advantages that cannot be overcome without resort to compulsory interconnection with smaller rivals. Refusal to interconnect gives the larger network the full benefit of its superior size while imposing risks and costs on those who might choose to switch. Interconnection neutralizes the competitive advantage gained through the network externality and makes

competition a matter of price differences.

The received economic wisdom regarding interconnection can be summarized as follows:

A) The competitive issues raised by network interconnection are no different than those raised by equipment compatibility. Both are treated within the framework of the tying and vertical foreclosure concepts, which emphasize the procompetitive effects of breaking up integrated systems into compatible-component markets.

B) Requiring a dominant carrier to interconnect with its rivals promotes competition by eliminating vertical foreclosure and overcoming the inertial advantage created by the network externality.

C) A dominant network provider will refuse to interconnect with a competitor except under legal compulsion. Refusal to interconnect can always be interpreted as anti-competitive, and has no socially redeeming features.

If we were writing a television commercial for the policy, we could claim that it opens "bottlenecks," prevents "lock-in," and stops "leverage."

II

History vs. Theory

Much of the prevailing theory about interconection has its roots in historical analysis. The conclusion that dominant systems or networks will not interconnect with smaller ones, and that the effects of this practice are anticompetitive, is supported by reference to AT&T's early history. The standard interpretation holds that AT&T's refusal to interconnect its long distance lines and local exchange facilities with the independents undermined the viability of the competition and eventually brought them to their knees.[13] The actual history of Bell's interconnection practices, however, tells a different story.

Bell's interconnection policy went through a gradual process of relaxation from 1902 to 1913. Table 1 sets out the various stages and shows how they are related to the status of independent competition. The Table and the accompanying statistics show that the relationship between interconnection and competition is almost the opposite of that posited by the conventional theory. The independents flourished under the most restrictive interconnection practices and declined as Bell policy was liberalized. Furthermore, much of the change was driven by market rather than political pressure.

From 1894 until about 1902, Bell exchanges would not connect with any independent, period. This policy was totally ineffective at containing independent growth, as is evident from a glance at the statistics. During those years 6,608 independent

exchanges were established and the number of nonconnected independent subscribers grew to 970,000, about 47% of the total telephones in the U.S. The independents took root in the smaller towns and rural areas that had been neglected by Bell. As they gained momentum, however, they increasingly set up exchanges in cities already occupied by Bell. By 1898 32% of all Bell exchanges in cities with populations over 5,000 had competing independent exchanges operating alongside them; by 1902 the number had grown to 56 percent.[14] In negotiations with city governments, the upstarts often used their exclusive access to independent exchanges in surrounding areas as a compelling argument for a second franchise.

Interconnection as cooptation: the sublicensing policy.

After absolute noninterconnection failed to stem the rising tide of competition, Bell in 1902 turned to the policy of "sublicensing" independent exchanges.[15] In the sublicense contract, Bell agreed to interconnect its toll lines and exchanges to an independent local exchange, subject to three conditions: the independent had to be located in a community with no Bell exchange, it had to lease Western Electric-manufactured instruments, and it had to agree not to connect with the toll lines of Bell's competitors. In return, Bell promised not to set up a competing exchange.

Sublicensing was an important departure from its prior belief that Bell and Bell alone ought to control the nation's telephone network. In the internal debates over the new policy,

its advocates pointed out that it was better to relax the interconnection policy and gain access to communities where there was no Bell exchange than to allow nonconnected and potentially competitive networks to develop.[16] In other words, sublicensing was a method of pre-empting exchange competition and undermining the long distance development of the independents, and was immediately recognized as such by the financial and ideological leaders of the independent movement.[17]

For the next eight years, sublicensing proved to be one of the most effective means of checking the spread of independent telephony. In 1903, the Bell company in the Ohio, Indiana and Illinois region had 114,000 subscribers of its own and was connected to 20,000 sublicensed subscribers. It was widely perceived as being on the verge of collapse in the face of the intense competition. A new manager, L.G. Richardson, took control in May and began to emphasize sublicensing. "We have a well-organized force of men in the field working on the sublicense proposition all the time," he wrote to national headquarters.[18] By January 1, 1908, the number of Central Union subscribers had grown to 188,000, a respectable increase--but the number of Central Union sublicensee subscribers had surged to 192,000.[19]

Connecting with independent exchanges took the wind out of the sails of independent long distance companies, which could offer exclusive connections to fewer and fewer locations. Significantly, however, Bell was forced to relax the conditions it attached to interconnection. Eventually it abandoned both the

demand that Bell instruments be employed and even the stipulation that no other long distance company could terminate in the exchange.[20] Table 1 shows the dramatic increase in the percentage of noncompeting independents who agreed to connect with Bell as its policy was liberalized. Starting with only 12% in 1902, Bell by 1909 had won over 79% of the independents in communities with no Bell exchange.

The story so far conflicts with the conventional wisdom on several counts. First, the refusal of an established network to connect with its competitor does not necessarily make survival of the competitor impossible, even when the established network has a 20-year head start and dwarfs the newcomer in size. Second, a larger competitor may interconnect with smaller competitors without legal coercion if it fears that failure to bring them into its system will isolate it from significant markets and/or will provide the nucleus of a larger competitive system. In other words, smaller competitive networks do have appreciable bargaining power in their relations with larger networks, especially when the established network is unable to develop the market fully. Third, and most important, interconnection can be a powerful method of preempting competition between end-to-end systems. Networks have a natural incentive to enter the same territories and markets and compete when they are not connected, because the absence of interconnection forces them to build duplicative facilities to gain access. When they are connected, they tend to cooperate and divide territories and markets.

Equal Access precedent.

My next example is an "equal access" case that is directly comparable to our present policy, except that it took place 80 years ago, between 1908 and 1912.

Sublicensing notwithstanding, until 1906 the Bell system steadfastly refused to connect with independent exchanges in towns where there was also a competing Bell exchange. In response, the United States Telephone Company was organized in 1900 to serve as a long distance company connecting the many independent exchanges in Ohio. U.S. Telephone's toll contracts called for exclusive connecting rights with independent exchanges for 99 years. In this respect, they were no different from the Bell System's contracts with its licensee companies, which also established exclusive connecting rights with the parent company, except for the fact that U.S. Telephone usually did not acquire an ownership interest in the connecting company.

By 1908, U.S. Telephone was furnishing long distance service to several hundred independent exchanges reaching 325,000 telephones.[21] Because of its success, Bell was forced to reverse its policy of refusing to make toll connections with competing local exchanges. In late 1906, it began to actively compete with U.S. Telephone for the long distance business of independent exchanges directly competing with Bell System exchanges. In Richmond Indiana, for example, its local exchange had 109 subscribers and the independent Home Telephone Company had about 2,500. Bell proposed a connection agreement with the Richmond Home Co. that would give its long distance lines access

to the independent exchange and vice-versa.

Connecting with both Bell and Independent long distance lines clearly made all but the most ideologically anti-Bell local exchange managers happy;[23] they received connections to the subscribers of both systems. But just as clearly, it threatened the viability of the U.S. Telephone Co. In 1908 the independent long distance company sued four local exchanges in Ohio for breach of the connecting contract, and won an injunction from the Ohio Common Pleas Court. The case was appealed by the Bell interests to the Ohio Supreme Court, and went from there to the highest federal court in the state, the U.S. Circuit Court of Appeals.

The Court's decision, made in January of 1913, prohibited U.S. Telephone's exclusive toll connecting contracts as monopolistic and against public policy. Its reasoning will sound familiar to any contemporary advocate of the anti-tying view:

> The local company has tied up its long distance business. It cannot take general advantage of competition from time to time arising, no matter how advantageous to it or its patrons, and it cannot expand its own business beyond its then existing limits into competition with the long distance company, no matter how advisable such extension and competition might prove to be.[24]

The court held, in effect, that only equal access to the local exchange could preserve competition in long distance. The court's belief that exclusive tying contracts suppress, and that nondiscriminatory access to the exchange promotes, competition is still the prevailing view. In point of fact, however, striking down the exclusive toll connecting contracts was a major factor

leading to the elimination of competition between Bell and the Independents in Ohio and Indiana. Once it was assured of access to independent local exchanges, the Bell System had no need to maintain duplicate exchanges in locations where the independent was stronger. In cities where Bell was stronger, the independent exchange could not benefit from being the exclusive avenue for making toll connections to other independent exchanges in the region. Frequently, they sold out and left a local monopoly to Bell. At the same time, the U.S. Telephone Co. was in no position to compete with Bell's extensive long distance lines without exclusive access to independent exchanges. The independent long distance company sold out soon after the decision.

The collapse of independent long distance competition at this time was followed by demands for open access to AT&T's Long Lines, and created the political pressures that led to the Kingsbury Commitment in December of 1913. Far from preserving or aiding independent toll competition, the Kingsbury Commitment was tantamount to its obituary. It signalled the independents' willingness to rely on the Bell system as the nation's backbone network and the end of their attempts to compete with it.

The Table 1 indicates that interconnection was more effective at eliminating competition than acquisition. The percentage of Bell-owned telephones only increased from 49% in 1902 to 55% in 1913, while the percentage of subscribers in noncompeting independent exchanges connected to Bell went from 12% to 89% in the same period.

Network competition and unequal access.

At both the local and long distance levels, interconnection quickly resulted in complementarity, not competition--in interconnected monopolies in separate territories, rather than in competitive rivalry conducted by overlapping systems. That the actual consequence of interconnection was to eliminate rather than promote competition is clear; the historical record leaves little room for doubt about this. What is less clear is why this should be so. The explanation is that the fundamental force driving telecommunications competition at that time was not differences in technology or costs, but differences in access; i.e., in who was connected to whom. The very thing that sustained multiple, rivalrous, overlapping telephone companies was the fact that none of them had universal, nondiscriminatory access to all the telephone users or exchanges in the area. Consequently, one telephone company could use its so-called "bottleneck" control of some exchanges to win subscribers and business in the territory of another telephone company. By the same token, its "bottleneck" status assured that anyone who wanted to compete with it had to build duplicate facilities in the area it controlled if it wanted to be able to reach subscribers there. Unequal access was the prime mover of competition.

Looking back on this experience, the tendency now is to emphasize the costs of this kind of competition--the need for businesses to take out duplicate subscriptions, the fragmentation of subscribers into unconnected networks, the unstable financial conditions brought on by competition.[25] There are, however,

positive social benefits that should not be overlooked.

The experience of 1894-1913 shows that competing networks that are not interconnected have a powerful incentive to be as universal as possible. The network externality places a premium on universality and turns competition into a race to connect as many subscribers and locations as possible. Where the networks overlap, competition takes the form of attracting new subscribers with lower rates or better service, thus overcoming the alleged underproduction incentive created by the network externality. In this kind of competition, there is no potential for creamskimming; each network must strive to duplicate the facilities of its rival. The Bell policy of maintaining exchanges in unprofitable locations for the sake of universal service emerged during these years.[26] Had there been interconnection between Bell and its rivals, either network could have relied on other networks to service the unprofitable areas.

The U.S. achievement of universal telephone service must be attributed in large part to the rapid development that occurred during the competitive era,[27] and particularly to the structural characteristics of competition between nonconnected, end-to-end systems. Superior universality was AT&T's greatest advantage in the competitive battle. While the benefits of telephone competition in this period have been amply documented by other writers, they have not realized how many of those benefits were contingent upon the rival networks not being connected. Instead, following current doctrine, they tend to suggest that interconnection would have aided competition.[28]

III

Contemporary Applications

Does interconnection have the same effects on competition today? On the face of it, it would appear not to. The emergence of long distance competition and local exchange bypass has taken place alongside--some would say because of--open interconnection. On closer inspection, however, the pattern of complementarity emerges. Consider first the case of long distance competition.

At the time of the FCC's Specialized Common Carrier decision in 1970, the new private line carriers said that they intended to build their own local distribution facilities. Some preferred to assume end to end responsibility and had no interest in interconnection with Bell.[29] Others planned to rely on interconnection with AT&T's local facilities in some cases, but the record gives the impression that they viewed this as a temporary expedient.[30] Whether the alternative carriers could have survived without interconnection is a moot point, however, for the FCC made AT&T supply connecting facilities to them from the beginning. The new carriers were authorized to provide private line service alone, which involved connections with a few large customers and comprised only about 3% of the total market. This made the interconnection issue appear to be less important than the need for specialized services which, according to an abundance of testimony, AT&T was not adequately supplying.

MCI's surreptitious entry into switched MTS service in 1975 abruptly changed all that. By combining its own microwave

network with local Bell switched services, MCI was able to avoid the separations and settlements process and offer discounted switched long distance service to a mass business market. Once its right to do so had been decisively upheld by the courts,[31] the policy of open interconnection of competing carriers was partially operative in the long distance market. It became fully operative following the divestiture and the implementation of equal access.

Clearly, the fledgling specialized carriers of the early '70s could have been a major force in the development of alternative local distribution facilities. Equal access interconnection, however, made it unnecessary for them to do so. As a result, today, ten years after Execunet, interexchange carriers rely on BOC local exchange facilities to carry 99.9% of their interexchange traffic and to reach 99.9999% of their customers.[32] Interconnection has produced complementarity rather than competition. It has allowed competitors to exploit the artificial gap between prices and costs in the long distance arena while leaving the job of terminating traffic to the Bell companies.

Open Network Architecture affords another example of the not-so-competitive effects of open interconnection.[33] The program is intended to unbundle basic network service elements in order to allow enhanced service providers equal access to the public through the BOCs' "bottleneck" local facilities. Yet the BOCs themselves openly view ONA as a way of discouraging the development of alternatives to their networks. Enhanced service

providers have various technological alternatives to the local exchange, ranging from FM subcarriers to CD/ROM discs delivered through the mail.[34] By opening up their network to facilitate its use by enhanced service providers, the RBOCs aim to keep them on the public network, and to increase the utilization of their network.[35] The BOCs also realize that they have many valuable services to offer enhanced service providers, such as billing and joint marketing arrangements. As with sublicensing in the early 1900s, interconnecting suppliers tends to make them complementary rather than competitive.

Interconnection does prevent an established network from deriving a competitive advantage from its control of access to subscribers. But by doing so it largely abolishes competition in the production of access itself. Indeed, the existing regulatory process not only gives telecommunications companies the <u>right</u> to interconnect, but also considerable influence over the terms and conditions of interconnection. The equal access and ONA programs amount to nothing less than a publicly administered reconfiguration of the local exchange network to suit the needs of large users. Why, given these conditions, would anyone bother to construct an alternative local exchange? Competition becomes a matter locating cost and rate disparities in discrete markets.

IV

Networks and Homogeneity

In the preceding section interconnection was analyzed largely in terms of historical cases. The next section attempts to give the analysis a theoretical grounding. In what follows, I will elaborate on the subject of the homogeneity of networks and show how it is central to interconnection policy.

Interconnection is normally discussed by economists as if it were a straightforward compatibility issue. In terms of the economic and competitive issues it raises, the interconnection of telecommunications networks is supposed to be no different in principle from the standardization of the interfaces between computer components, photography equipment, or telephone CPE. Farrell and Saloner, for example, use the equal access program as an example of "standardization."[36]

There is a difference between the two, however. The importance of that difference can be ascertained by contrasting the FCC's CPE registration program, which standardized the interface between terminal equipment and the AT&T network, with the interconnection of local and competing long distance networks brought about by the divestiture and the equal access program.

CPE compatibility did exactly what the economists said it was supposed to do. It abolished tying between AT&T's network facilities and its terminal equipment, thereby allowing hundreds of equipment manufacturers to compete fairly on the basis of price and design. The result was lower prices, greater product

variety and an almost total replacement of regulation by market forces. The CPE registration program was also relatively easy to implement and enforce.

The attempt to create an analogous "standardized interface" between the local and long distance networks was anything but simple. It required ripping apart the telephone company, technically redesigning the whole local-long distance interface, and completely revising the flow of revenues in the telephone system. The process did not decisively replace monopoly with competition; it merely shifted the problem of monopoly from the long distance (interLATA) level to the local (LATA) level. Ironically, all of the same problems that led to the breakup of AT&T still exist in the LATA. Nor did divestiture replace regulation with market competition; most of the old system of utility regulation is still in place, while new forms of regulatory intervention have been added as a result. The local and long distance rates of AT&T and the BOCs are still regulated, the FCC has become heavily involved in the design and standardization of network interfaces, and severe line-of-business restrictions have been placed on the BOCs.

Why has standardizing the interface between competitive networks proved to be so recalcitrant compared to our experience with equipment standardization? Some blame the stubbornness of Judge Greene or the failure of politicians and the FCC to deliver on the implicit promise of deregulation after the divestiture. Others blame the general incoherence of the multilayered telecommunications policymaking process in the U.S. All of the above may be contributing factors, but the real causes are the unique economic characteristics of networks.

Networks as inherently nonhomogenous goods.

Competition as we normally define it requires that the products of rival producers be substitutes for each other. Enhanced substitutability accounts for much of the pro-competitive effects of standardization. Once full compatibility exists, an Epson printer is a substitute for an IBM printer. Likewise, once the interface between the network and terminal equipment is standardized, a Panasonic telephone is a substitute for an AT&T telephone. By enhancing substitution, standardization intensifies competition and expands the consumer's range of choices.

On the other hand, the MCI and Sprint networks are not full substitutes for the AT&T network, nor are local exchange bypass facilities full substitutes for the BOC network. By themselves, the alternative networks provide communications access to only a small portion of the people and locations served by the dominant carrier. In these cases the competitive alternatives are only partial, imperfect substitutes; in fact, their commercial viability relies very heavily on the access channels supplied by their rival.

Economists who have studied networks have failed to recognize both the uniqueness and the importance of the substitution issue. Katz and Shapiro's model of network competition is based on the assumption that networks are homogenous goods if they are of equal size.[37] This means that consumers will view any two networks as perfect substitutes as long as their gross number of subscribers is equal. When applied to real-time access networks, such an assumption is more than unrealistic; it obliterates a

crucial feature of competition. Two telephone networks can be of equal size but serve completely different subscribers or locations. In this case the two networks are not perfect substitutes but entirely different products. Even when two equally-sized networks contain some duplicating subscribers or overlapping service areas they are still only partial substitutes.

The only way multiple networks can compete as homogenous products is for each of them to offer access to the exact same subscribers. Here we confront the central paradox of network economics. Only by interconnecting multiple telecommunications networks can we make it possible for them to offer a homogenous product. Yet interconnecting rival networks tends to make them complementary rather than duplicative, and thus imperfect substitutes for each other. This point requires some elaboration.

Assume, first, two competing, noninterconnected telephone networks, A and B. Because they are not connected, anyone who subscribes to B alone will not be accessible to the subscribers of A, and vice-versa. Only those subscribers who value universal access enough to pay extra will purchase subscriptions to both networks, and hence will be available to the customers of both networks. In order for the two networks to offer a homogenous product, 100% of all telephone subscribers would have to buy subscriptions to both A and B. That degree of duplication, however, is virtually impossible as long as the cost of a subscription is greater than zero, for two reasons. First, there will be low-usage subscribers on both networks who will not value universal access enough to pay for two subscriptions. Second,

even if there was no such economic barrier, 100% duplication is self-negating. If all of the subscribers to A also subscribed to B, then any subscriber could cancel his subscription to one of the networks without losing access to anyone. In other words, 100% duplication would require each person on each network to pay twice for a subscription when they could already call all other telephone users through only one of the networks. Thus, duplication will never reach 100%; noninterconnected networks will always offer access to different subscribers and hence will be more or less imperfect substitutes.

Now suppose that A and B are interconnected. Will this give us homogeneity? It will certainly make the networks perfect substitutes in terms of the people and places accessed. But as we have seen, interconnecting rivalrous networks eliminates the incentive for them to duplicate each other. It allows network A to construct access facilties only to the places where it has a cost advantage over network B while relying on B to provide access to the rest. It also permits either network to refuse to compete in markets which they feel cannot sustain both businesses. Direct rivalry will be confined to a few choice markets and locations. Or, in cases where there is a universal monopoly beset by new entrants, competition will emerge in network segments that are undersupplied or overpriced, but the new entrants will still rely on the dominant carrier to supply access to all other segments. Once interconnected, networks behave more like complements than substitutes.

The nature of substitution in telecommunications can be clarified by the following representation (see Figure 1). This simple model represents the network as a matrix, with each network terminus assigned a row and column. The letters A - n represent subscribers or locations. The values in each cell are arbitrary values chosen to represent the amount of traffic or information transmitted between the two points. The object of representing a network this way is to show how tricky it can be to define the "components" of a network. Each individual cell and every possible combination of cells in the matrix represents a separate region within which substitution can take place. Each cell (and every combination thereof) differs from every other in economically important ways.

FIGURE 1

Components of a network connecting A - n points.

	A											
B	1	B										
C	1	2	C									
D	1	3	1	D								
E	2	2	3	1	E							
F	6	8	5	2	1	F						
G	1	4	1	2	5	9	G					
H	2	12	7	6	5	3	1	H				
I	4	18	9	8	4	4	3	3	I			
J	8	2	8	20	11	2	1	5	3	J		
K	16	7	13	50	9	4	6	9	12	2	K	
n												n

Suppose that B represents a corporation's office in Los Angeles, H represents a branch office of the same corporation in San Francisco, and the business is comparing the costs of constructing a private network with the costs of using the public switched network. In this sense, the private system "competes" with the public switched exchange for the market represented by the shaded cell in Figure 1. But the type of substitution going on here is not the same as making a choice between two brands of dog food or two types of computer components. The "market" in which the buyer shops is not something generic and homogenous like "local exchange" or "long distance" service. It is very specific, and unique to that particular buyer. In terms of both required circuit and switching capacity and distance, the cost of linking those two points will be different from the costs associated with linking any other two points on the map. If any other points are added, e.g. if the business considers adding G to its private network, the whole cost calculus changes. Telecommunications networks are not a single product but bundles of many complementary products, none of which are identical.

Considered in isolation, each cell represents a potentially homogenous good. If multiple carriers vie for the traffic represented by each individual cell, and none of them combine the operations required to serve that cell with any other cell, perhaps something similar to what economists define as perfect competition can take place. But merely to raise this as a possibility is to demonstrate its impossibility. There will always be economies of scale involved in aggregating and

concentrating traffic from more than one cell, especially when low density cells are involved. The most likely result of open interconnection is a patchwork of nonhomogenous networks with competitive substitution confined to a few high-density cells. The networks involved will be mostly complements, and only partly competitive substitutes.

IV

The Policy Dilemmas of Nonhomogeneity.

With the foregoing in mind, we can begin to analyze why the interconnection of competitive telecommunications networks poses more problems than mandating compatibility in equipment markets.

Current economic doctrine defines the components of a system as complementary goods, and holds that tying or anticompetitive pricing can be eliminated by unbundling the components via standardized interfaces. Unbundling lowers barriers to entry and intensifies competition by allowing substitution to occur in each component of the system. Interconnection has a similar effect on telecommunications networks. It allows competitive substitution to occur along specific routes or lines rather than between complete systems. But that is where the similarity ends. The "components" of a network are not identical, mass produced objects like computer printers or dog food. They are hundreds or even millions of communication links whose economic and physical

characteristics are all different. The components of a communications network cannot be defined in generic terms. There are as many different components as there are combinations of users.

The local-long distance interface provides an excellent example of how this nonhomogeneity throws a monkey wrench into attempts to apply compatible-component thinking to networks. Economists have managed to convince themselves that local and long distance are separate components of the network.[38] No hard and fast boundary between the two can be defined, however; the distinction is purely a matter of degree. The exchange business has always included the provision of toll service to suburbs and nearby cities. Historically, the Bell operating companies were responsible for regional long distance development. Sometimes the people connected by a network will be close together and sometimes they will be far apart, but there is no objective basis for dividing service components.[39]

In attempting to draw component boundaries where none exist, the legal and regulatory system came up with Local Access and Transport Areas (LATAs). Predictably, LATAs are utterly arbitrary, being limited to one metropolitan area in some cases and encompassing entire states in others. As an attempt to distinguish local from toll business, they are a total failure; close to 40% of all toll calls are made within LATAs. If local and long distance are separate but complementary goods like cars and gasoline, why is it such an artificial matter to determine

where one ends and the other begins?

The arbitrary nature of the line would not be bothersome if, once it were drawn, it resulted in free competition for homogenous goods. Precisely because it is arbitrary, however, the line will not stand up in an open market but must be guarded by regulation. The MFJ prevents the BOCs from carrying traffic between LATAs; thus, in the name of competition seven of the nation's most likely competitors were removed from the market. Significantly, no such restrictions were necessary in the CPE market once the interface between the network and terminal equipment was standardized. Robust, deregulated competition was possible almost immediately, despite AT&T's overwhelming share of the telephone equipment market.

The divestiture's fictitious boundary will continue to be operative even if Judge Greene allows the BOCs into long distance in the future. The equal access program has created a de_facto line of business restriction by arbitrarily designating the LATA as the basis of dividing telecommunications service components. There may be more efficient ways to organize service, but once the system is engineered and regulated to ensure that local exchange carriers cannot integrate their inter- and intra-LATA networking in ways that give them a competitive advantage, there is little to be gained from their entrance into long distance anyway. The attempt to standardize the elements of a nonhomogenous product has a tendency to enforce artificial boundaries between telecommunications markets.

Open Network Architecture is a more radical and in some ways less arbitrary approach to unbundling. Once again, however, the absence of homogeneity poses obstacles to standardization. A network architecture with standardized interfaces for transmission, switching and signalling and completely unbundled service elements can be defined on paper, of course. But the concreteness of real networks prevents uniform application of these criteria. Spatial relationships, the thickness or thinness of traffic, the extent to which traffic from various points can be concentrated, etc., are all decisive influences on the economics of supply. The physical heterogeniety of networks often makes it most efficient to combine functions and service elements. A set of unbundling requirements that makes sense in a New York city central office may be uneconomical in many other locations. No single set of specifications will work for a network that consists of more than one switch. Instead, the process will require a series of judgment calls and continuing regulatory oversight, as did equal access. There are already some disturbing signs that conformance to ONA requirements can result in arbitrary interventions in telecommunications markets.[40]

Conclusion.

Open interconnection may not be the key to unlocking monopoly that it appears to be. As I have shown in this paper, interconnecting rival carriers can act to preempt full-fledged competition in the supply of access by making it unnecessary for carriers to duplicate each other's facilities. Telephone competition in the early 1900s brought the U.S. to the threshhold of universal service precisely because the contestants were not connected with each other. Current policy, in contrast, fosters competition in high-density business routes only, where markets are undersupplied or overpriced due to rate averaging. Increasingly open interconnection policies allow new companies to leave the task of providing universal service to the established network, thereby making it highly unlikely that the benefits of competition will ever reach the bulk of the population.

The root of the problem is our failure to understand the unique economic characteristics of networks. Economic analysis derived from markets composed of identical, homogenous goods have been applied as if by reflex to the telephone system, resulting in an ill-fated attempt to standardize the unstandardizable. Concepts of pricing and competition must be revised to account for networks' inherent lack of homogeneity. Any further attempt to cram the square peg of network economics into the round hole of compatible-component thinking will only result in more regulatory intervention, not less, and a less efficient network.

ENDNOTES

1] See, for example, Comments of Commissioner Eli M. Noam, New York State Public Service Commission, in FCC CC Docket No. 88-2, Phase I:
"For two decades now we have witnessed the erosion of a centralized and uniform monopoly network. ... What is emerging is a system of great institutional, technical and legal complexity which may be best described as a network of networks, serving different regions, user types and software layers. In such an environment, the rules of interconnection of newcomers to the public network becomes perhaps the most important tool of structural regulation. Whoever controls the rules of interconnection controls the network system itself."

2] In the early 1900s, the term "universal service" meant universal interconnection of all subscribers rather than a telephone in every home. The concept was a response to the fragmentation of subscribers caused by the competition between nonconnected telephone companies and the technical limits on long distance transmission. It did not acquire its present implication of 100% subscribership, to be obtained via government-subsidized access, until after World War II.

3] Adams, Walter and James W. Brock, "Integrated Monopoly and Market Power: System Selling, Compatibility Standards and Market Control." Quarterly Review of Economics and Business 22:4 (Winter, 1982), p. 31.

4] Gerald Brock, "Competition, Standards and Self-Regulation in the Computer Industry," in Richard Caves and Marc J. Roberts, eds., Regulating the Product (Cambridge, MA: Ballinger, 1975).

5] James W. Brock, "Market Control in the Amateur Conventional Photography Industry," Ph.D. dissertation, Michigan State University, 1981.

6] Franklin M. Fisher, "Diagnosing Monopoly," Quarterly Review of Economics and Business, 19:2 (Summer, 1979); Adams and Brock (1982) op cit, p. 35-36.

7] Gerald Brock, The Telecommunications Industry (Cambridge MA: Harvard, 1981) p. 18; Gerald Faulhaber, Telecommunications in Turmoil (Cambridge MA: Ballinger, 1987), p. 121-123.

8] Jeffrey Rohlfs, "A Theory of Interdependent Demand for a Communications Service," Bell Journal of Economics and Management Science 5:1 (Spring 1974) 16-37.

9] See for example, the minutes of the National Telephone Exchange Association Second National Convention, April, 1881, in which the participants discuss the increase in usage and value that occurs with subscriber growth. Practically every public statement of telephone business people from the 1880 to 1920 included some recognition of "the network externality."

10] Theodore Vail, 1910 AT&T Annual Report, p. 39, argues that only monopoly can give universal interconnection.

11] Joseph Farrell and Garth Saloner, "Competition, Compatibility and Standards: the Economics of Horses, Penguins and Lemmings," in H. Landis Gabel, ed., Product Standardization and Competitive Strategy (North-Holland, 1987)., p. 7.

12] Joseph Farrell and Garth Saloner, op cit, p. 10-11; Paul David, "Clio and the Economics of QWERTY," American Economic Review, 75, May 1985, 332-336.

13] See, for example, Comments of Commissioner Noam, op cit, p. 5: "The old Bell system achieved predominance by denying its local exchange competitors interconnection to the Bell local networks and to its long lines system, until it was forced to open up." See also Richard Gabel, "The Early Competitive Era in Telephone Communication, 1893-1920," Law and Contemporary Problems, 34, 340-359 (1969); Gerald Brock (1981) op cit.

14] Data from Bell Labs archives, Warren NJ.

15] A few Bell licensee companies especially hard-hit by competition had surreptitiously initiated sublicensing in 1900, but it did not become a common practice until it was sanctioned as official Company policy in 1902.

16] "...telephone companies established in regions which we do not occupy, if doing a successful business, ...become starting points for attacks upon our system in other places where such opposition is extremely undesirable. In short, if people are willing to venture their own money and do business in a territory we have not occupied, we should regard them and endeavor to have them in fact as allies, and not as competitors." G.W. Leverett, AT&T General Counsel, to Frederick P. Fish, October 17, 1901. Box 1375, Bell Labs archives, Warren NJ.

17] Independent publications such as Telephony contain many attacks on and warnings against sublicensing, calling it a "Judas-like scheme." Telephony, December 1905, p. 422; June, 1907, p. 368.

18] L.G. Richardson to Theodore Vail, February 27, 1908, Box 1357, Bell Labs archives, Warren, NJ.

19] Ibid.

20] "Gradually, the terms [of the sublicense contract] were relaxed and Bell officials conceded point after point. The duration of the contract was reduced from 99 years to 5, to 3, and finally to one year. The number of [Bell-manufactured] instruments to be rented was reduced from an exclusive total to a meager 100, or 25, finally to one set. The exclusive connection clause was ignored so that the toll circuits of the various competing companies were tacitly allowed to remain in the same sublicensee switchboard." M.D. Atwater, History of the Central Union Company (Bell Labs archives) p. 136-7.

21] U.S. Telephone Company, Annual Report, December 31, 1908. Box 36, Bell Labs archives.

22] L.G. Richardson, President, Central Union Co., to Theodore Vail, July 3, 1908. Box 1357, Bell Labs archives.

23] "Our plan of having all toll lines entering our city on one switchboard has been so pleasant and satisfactory to our patrons that I think that when the [court order] requiring us to remove them becomes known to our patrons, I would not be surprised if some demonstrations on their part would take place expressing their disapproval of being compelled to go back to the old and unsatisfactory way of having more than one toll station in the city." William Shumaker, President, Butler Telephone Co (Independent) to L.N. Whitney, Central Union Co., December 1, 1908. Box 1357, Bell Labs archives.

24] United States Telephone Co. v. Central Union Telephone Co., et. al. 202 Federal Reporter 66-75 (January 10, 1913).

25] A notable exception is Robert Bornholtz and David S. Evans, "The Early History of Competition in the Telephone Industry," in Breaking up Bell (New York: North-Holland, 1983). Bornholtz and Evans explicitly defend the feasibility and value of competition between nonconnected telephone systems.

26] "A telephone system...must cover with its exchanges and connecting lines the whole country. Any development which is comprehensive must cover some territory which is not, and may never become, profitable in itself but must be carried at the expense of the whole." Theodore Vail, 1909 AT&T Annual Report, p. 23. This grand statement comes after 15 years of independent competition. Prior to competition, Bell refused to establish exchanges in small communities; only 10% of the communities with populations under 5,000 had Bell exchanges in 1895.

27] During the years of Bell-independent rivalry, the telephone penetration rate in the U.S. skyrocketed far beyond that of every other country, going from one telephone for every 225 persons to a telephone in every third household and virtually all business establishments.

28] E.g. Gabel (1969), op cit p. 354: "...had there been full interconnection during the early years of competitive rivalry, it may be hazarded that the structure of the telephone industry would have been more equally balanced."

29] The comments of Datran indicated that that company preferred to assume end to end responsibility by allocating 11 Ghz frequencies to a local distribution service. First Report and Order, Specialized Common Carrier decision, 29 FCC 2d 870 (1970) at 955.

30] MCI commented that "local distribution does not present any truly serious problem and...with flexibility of approach, local loop facilities will be available in one form or another." Ibid at 952. MCI filed a related petition to allocate 38.6-40 Ghz radiofrequencies to a Carrier Distribution Service. The petition was supported by Martin Marietta, Resalab, MITEQ, AT&T and Western Union.

31] MCI v. FCC U.S. Court of Appeals, D.C. Circuit. 561 F.2d 365 (1977).

32] Huber Report, p. 3.9, Table IX.5.

33] Open Network Architecture was sanctioned as the future direction of telecommunications policy in the FCC's Third Computer Inquiry, 104 FCC 2d.

34] Personal interview with Michael Cicciano, NYNEX Corp., White Plains, NY, May 17, 1988.

35] CommunicationsWeek, April 25, 1988, p. 32.

36] Farrell and Saloner (1987), op cit, p. 8.

37] Michael Katz and Carl Shapiro, "Network Externalities, Competition and Compatibility," American Economic Review 75:3 (June 1985) 424-440. See also John T. Wenders, The Economics of Telecommunications, Cambridge, MA: Ballinger, 1987, p. 171-190. Wenders compares the market for local exchange and long distance service to the markets for dog food and bread in order to show that an attempt to subsidize the former from the latter could not work in a competitive market.

38] See Wenders (1987) op cit; Leland Johnson, Competition and Cross-subsidization in the Telephone Industry, Santa Monica: RAND Corporation, R-2976-RCNSF, December, 1982.

39] The toll-local switching hierarchy is a more efficient way to organize traffic and network resources, not a boundary between separate products. The whole county could be served by one exchange if we were willing to pay for extremely long access lines. Switching conserves on line facilities and allows trunking economies of scale to be exploited. On the other hand, long distance companies can and sometimes do bypass the local exchange and deliver traffic directly to the doorstep of their customers.

40] A representative of AT&T has written that "To fulfill the Commission's [ONA] requirements, substantial modifications of AT&T's network would have to be made to produce discrete elements with protections that would ensure the technical integrity, reliability and security of AT&T's network. At great expense, AT&T would have to construct new walls and interfaces within the network without knowing whether the demand exists or whether enhanced service providers or end users would be willing or able to pay for these unbundled components." Frank Ianna, "Open Networking in a Competitive Environment," Telecommunications, January 1987 p. 57.