Interconnection compensation rules are woefully out of date.

Connecting the Pieces

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TELECOMMUNICATIONS NETWORKS of many types are developing in today's information economy, and they all need to exchange traffic between each other smoothly. Where networks have local market power (for example, where customers have little or no choice of local carriers), regulators have imposed interconnection schemes under which the caller's network must pay the recipient's for use of its facilities. Unfortunately, economists have never before been able to suggest an efficient method for determining payments between networks. The payments are instead determined by a crazy quilt of inconsistent rules that do not reflect actual costs and bear little relation to today's market realities or tomorrow's needs. The resulting mischief and inefficiency are becoming serious problems for telecommunications.

In this article, we outline an efficient, market-based alternative that we call the "Split Capacity Incremental to Interconnection" rule, or "SCII" for short. SCII allows customers to choose among competing networks based on their respective costs and benefits. That choice is not possible under the current regimes, which co-mingle networks' costs and then redistribute them according to artificial regulatory distinctions. In 1996, Congress declared that we should move toward a competitive telecommunications market. Such a market cannot develop until customers can base their choices on competitors' true costs and benefits.

The current system, though inefficient, was sustainable as long as local carriers were monopolies that mostly provided a single type of communications (telephone calls). As soon as competitive carriers started offering various services, however, the system began to break down. Various parties are able to exploit the artificial distinctions in ways that harm efficiency, a process that has come to be known as "regulatory arbitrage." Those problems have recently become so severe that the FCC has issued a Notice of Proposed Rulemaking, asking for comments on alternative solutions, such as the one we outline here.

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EFFICIENCY AND NEUTRALITY

We believe that a good regime should result in competitively neutral, economically efficient inter-carrier compensation with minimum regulatory intervention. By "competitively neutral," we mean that the interconnection regime itself should confer no special advantage or disadvantage on any carrier or technology. Whatever advantages or disadvantages existed prior to interconnection should remain undistorted by the new regime. Achieving that would mean the correct pricing signals would be sent to networks making investment and make/buy decisions, and thus potentially also to consumers making subscription decisions.

Artificial rules In the past, legislatures and regulators shaped interconnection regimes largely to advance universal service, by having low-cost users subsidize users whose service is more costly to provide. Business users have subsidized residential users and urban users have subsidized rural. The cross-subsidies distort output in telecommunications; rates diverge greatly from true economic costs, and rate structures diverge from cost structures. The result is inefficient production and behavior that is rational only because of artificial rules. With the 1996 Telecommunications Act's move to have competitive markets replace regulated monopolies, Congress fundamentally altered that landscape. According to the legislation, "specific, predictable, and sufficient… mechanisms to preserve and advance universal service" are to replace hidden cross-subsidization. Universal service considerations are no longer to dominate interconnection policy.

Focusing on facilities If we focus our interconnection rules on allocating responsibility for the facilities needed, we can give customers an effective choice among carriers. Focusing on facilities tracks how networks actually incur costs. Most network costs depend on capacity rather than the level of usage. Yet the current regimes focus on usage and prevent an effective choice by mingling and distorting carriers' costs. Thus, customers cannot compare the true costs and benefits of alternative networks.

The current rules distort costs, and thus customers' choices, because they attempt two impossibilities. They try to allocate costs first among the various services that carriers provide, then between the parties to a call (or more precisely, between their networks). Because network services largely share the same inputs, most network costs are common costs.

Economists have never found a satisfactory way to allocate common costs efficiently. Only markets can make such an allocation correctly. As Hayek explained, regulators cannot possess the requisite specific knowledge of market conditions. Nor can regulators discern how to split the costs between the parties to a call efficiently, because they cannot know the relative distribution of benefits. The current rules arbitrarily assume that the caller's network should pay all the costs. In effect, the rules mean that one network pays an arbitrary share of another network's common costs. Customers cannot subscribe to one network without paying part of another's costs.

The current rules further confuse costs by averaging them among carriers, thus limiting customers' incentives to choose an efficient carrier. For example, interexchange carriers (IXCs) such as long-distance companies must purchase access from local exchange carriers (LECs) on both the originating and terminating ends of the calls. By law, IXCs must average the access charges when they bill their customers, so customers pay the same rate whether they call to (or from) a high-cost or a low-cost LEC. IXCs are not permitted to pass through the access charges incurred on a particular call to the customer who made that call. Even if IXCs could "de-average" access costs, transaction costs would make it very difficult for callers to persuade persons they call to choose efficient carriers. The effect is that customers are denied effective choices, because they are forced to pay part of the costs of all networks, not just the network they choose.

By redesigning the interconnection regime so that it focuses on facilities instead of the calls made by end users, we avoid those problems entirely. As we show below, the efficient allocation of interconnection costs between carriers is independent of how the calling and called parties bear the cost of a call. What is more, the balance of traffic between networks does not affect the efficient allocation of interconnection costs. Once we assign interconnection costs between the networks efficiently, customers can choose among carriers based on comparing their true costs and benefits.

MINIMAL INTERVENTION

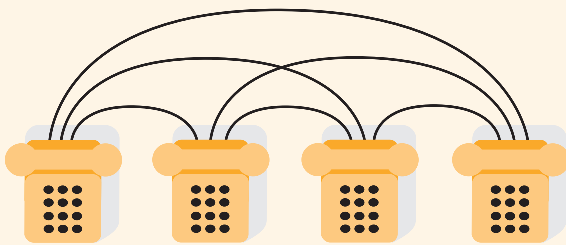
Regulation ideally should not only be efficient, but minimal. Without interconnection regulation, a dominant network may impose crippling disadvantages on potential competitors, exploit customers, and inflict significant ineffi-

EYEWIRE (2, UPPER RIGHT, LOWER LEFT), MIGUEL S SALMERON/FPG (CENTER)

Figure 1

Getting Connected

The simplest form of a four-party network.



ciencies on society. But, even if regulation alleviates those problems, does it create more difficulties than it resolves?

Regulation itself can impose significant costs, such as litigation expense, delay, uncertainty, and opportunities for "rent-seeking." There is also a real possibility of error, even if regulators are highly intelligent and benevolent. Significant harm can result when regulators "get it wrong," an outcome that is hardly unprecedented and is increasingly likely when a large amount of information is needed to "get it right."

An ideal regulatory regime, therefore, should minimize the information regulators need in order to "get it right." An interconnection regime that requires only a minimum of information for regulators and that is efficient and competitively neutral would encourage an efficient and competitive telecommunications system that would adapt rapidly and smoothly to changing technologies and market conditions.

In order to minimize information requirements, regulators could limit themselves to stating fairly simple rules and allow the parties to negotiate efficient solutions suited to their particular circumstances. In such a regime, disputes would be resolved primarily through negotiation and arbitration. Ronald H. Coase won the Nobel Prize in Economics in 1991 largely for his theorem that, as long as the rules are stated clearly and transactions costs are low, parties will negotiate efficient solutions to rights-allocation problems. Coase's Theorem has been gradually displacing the earlier view of economists who followed A.C. Pigou in holding that government had to set rates directly to achieve efficient results. With a simple rule for distributing interconnection costs, we believe telecommunications companies would handle the costs efficiently.

CONSTRUCTING A NETWORK

Real world networks are, by nature, quite complex. Economists have always developed their principles by abstracting from real world complexities to capture essential features, and we resort to that technique here. We begin with a simplified, highly abstract representation of a pair of interconnected networks to demonstrate the principles of economically efficient interconnection.

At the outset of our analysis, let us ignore scale economies, trunking efficiencies, and the many other engineering considerations that shape any real network. We will focus instead on the fundamental, underlying facilities requirements faced by each network in serving its subscribers. Let us assume that each network has access to the same technology and employs brilliant engineers who select cost-effective means of fulfilling the underlying facilities requirements. We will not be concerned with how the engineers perform their magic, only with the abstract, underlying facilities requirements.

A simple network Let us first imagine a small linear network with four subscribers. Using the minimum necessary facilities, we want our network to meet two requirements: Any two subscribers must be able to connect to each other, and there should be no calls blocked due to inadequate facilities.

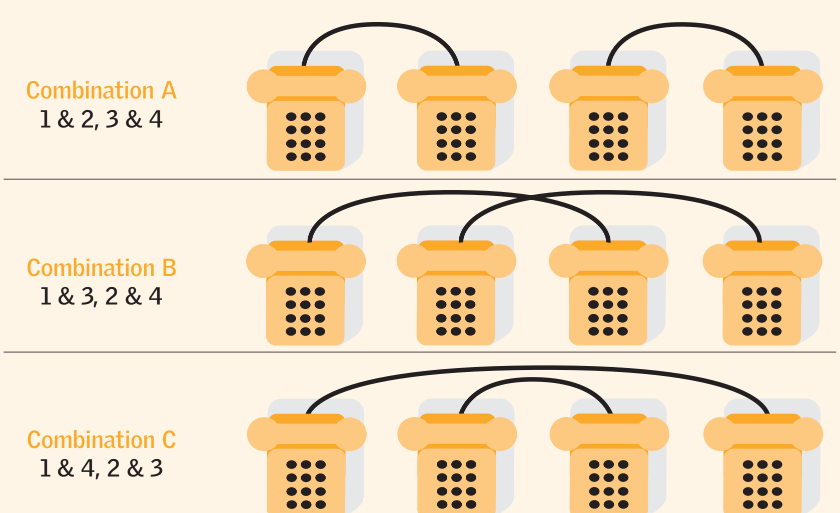
The simplest network that would satisfy those requirements would have the same structure as that of the earliest networks: A phone line would connect each pair of users. As shown in Figure 1, a network with such a structure would need six phone lines to connect four subscribers. For five subscribers, such a network would need ten lines, for six it would need 15. In general, for n subscribers, this type of network requires (n2 - n) ÷ 2 lines.

A more complex network Engineers, of course, do not construct real networks by stringing a line between each pair of subscribers; as the number of subscribers rises, the number of links becomes astronomical. Instead, engineers use var-

Figure 2

Reaching Out

Different caller combinations in a four-party network.



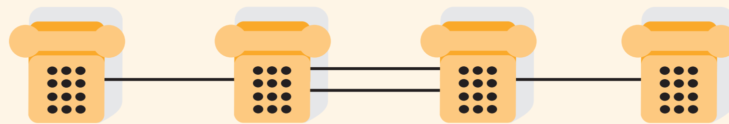
ious technological devices to reduce costs. For example, they can substitute switches that route traffic so that a separate link is not needed for every possible pair of users. In our examples, we assume that each link can only handle one call at a time, and that the links have enough switching capability to route traffic.

To see how such a network would be structured, consider the various possible combinations of phone conversations that could occur on a four-subscriber network in which all four subscribers are using their phones. As shown in Figure 2, there are three such combinations. In order for our four-subscriber linear network to accommodate the combinations and meet our requirements for full access with no call blocking, we would need a total of four separate links and the appropriate switches. Figure 3 shows the structure of such a network. Thus, a network of four subscribers would have a maximum of two simultaneous two-party conversations (the number of links across the center) and would require a total of four links to allow every possible two-party conversation to take place.

Figure 3

The Engineer's Magic

Facilities needed for a four-party linear network.



Two links are needed across the center and a total of four links are needed.

We can adapt that structure to accommodate a network of any number of subscribers. For a linear network of n subscribers, the maximum number of simultaneous two-party conversations is n ÷ 2. To ensure that any combination of n ÷ 2 conversations can occur simultaneously in a linear network requires $(n \div 2)^2$ links.

Adding subscribers Now, consider what would happen if additional parties were to join our network. If two more parties subscribe, the resulting six-party network would have the structure shown in Figure 4. Three simultaneous calls are possible on that network; so three links are needed across its center in order for it to meet our requirements that any two parties can connect and there is no call blocking.

Notice that the original four-party network had an average of one link per subscriber, but the addition of the two new parties increases that average to 1.5 links per subscriber. That suggests that each network subscriber, on average, bears the costs associated with 1.5 links. As more subscribers are added, the benefits of the network increase, but the number of links needed per subscriber also rises. The number of links per subscriber is always $(n \div 2)^2 \div n$, which equals n ÷ 4. The network will add new parties until there are no more potential subscribers or the average cost rises to the point at which some subscribers begin dropping off the network.

Of course, the structure and economics of our linear network is a deliberate abstraction. In the real world, a network could use a number of different architectures and technologies to economize further on links. What is more, networks may include additional, redundant links to improve reliability. However, for the purpose of this article, we will use our abstract linear network model to explain our interconnection reform proposal.

INTERCONNECTION

Now, suppose the two parties who joined our network in Figure 4 are instead subscribers to a separate network, Whitefon, that has only one link. Whitefon wants to interconnect with the four-subscriber, four-link network, Grayco. What is more, both networks want their interconnection to meet the same quality requirements as the phone networks that we constructed earlier.

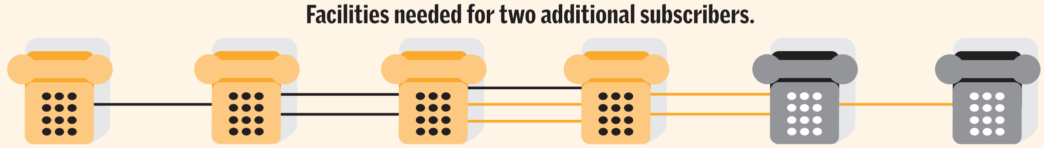
The architecture needed for the interconnected network would be the same as for a single six-subscriber network, as shown in Figure 5. That means that, in order for Grayco and Whitefon to interconnect in a way that meets the quality requirements, the two networks must install a total of four additional links: two between the two networks and two within the Grayco network (at the point that is at the center of the set of interconnected subscribers). The cost of those four links is the incremental cost of interconnection.

Proportional distribution How should the financial responsibility for the four incremental links of Figure 5 be assigned? Suppose each network were assigned a share proportional to its number of subscribers. Grayco, which originally had four links to accommodate its four subscribers, would pay for two-thirds of the four incremental links (2.67 links). That would mean that, on average, each Grayco subscriber would have to pay for 1.67 links, which is an increase from the pre-interconnection average of 1.0 links per sub-

Figure 4

A Growing Network

Facilities needed for two additional subscribers.

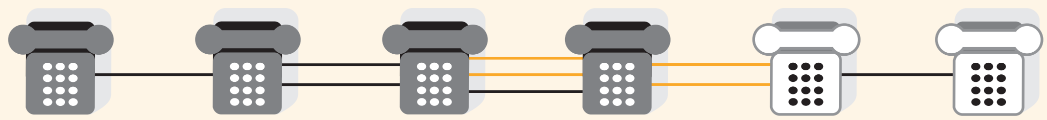


Adding two more subscribers requires five more links. —— New links scriber. Whitefon, which originally had one link for its two subscribers, would be responsible for 1.33 additional links. Hence, each Whitefon subscriber, on average, would have to pay for 1.17 links, which is an increase from the pre-interconnection average of 0.5 links per subscriber. Each subscriber on each network would thus pay the cost of an additional 0.67 links to achieve interconnection.

Figure 5

Joining Networks

Interconnection of a four-party network with a two-party network.



Black links are intra-network. Yellow links (4) are incremental to interconnection.

The problem with that distribution is that, though each subscriber of the two networks receives the same service (i.e., non-blocking access to the same subscriber list), the overall average cost for Whitefon's subscribers would be less than for their Grayco counterparts. Subscribers to Grayco would be better off if they switched to Whitefon, which gains an artificial advantage from the proposed regime. Hence, the proportional distribution regime is not a stable or competitively neutral solution.

Even distribution Suppose instead that interconnecting networks split evenly the responsibility for the incremental facilities required, regardless of their relative sizes. That is, Whitefon must provide the same number of incremental links as Grayco, even though Grayco has twice as many subscribers. That would mean that Whitefon's per-subscriber cost increase would be greater (from 0.5 to 1.5 links per customer) than Grayco's (from 1.0 to 1.5 links per customer). In exchange for the higher cost, Whitefon customers would gain access to four additional parties, while Grayco subscribers gain access to only two more parties.

Assigning each network responsibility for providing exactly half the incremental facilities required for interconnection yields the same average links per subscriber for each network. That is, the raw capacity burden per subscriber is the same on each network. Those results hold generally for any linear network as well as for other basic network forms. Once the incremental facilities are identified, the lowest bidder would provide them, and the costs would be split equally between the interconnecting networks. Therefore, in order to achieve a competitively neutral and efficient assignment of responsibility for incremental interconnection costs, each network should shoulder half of the expense.

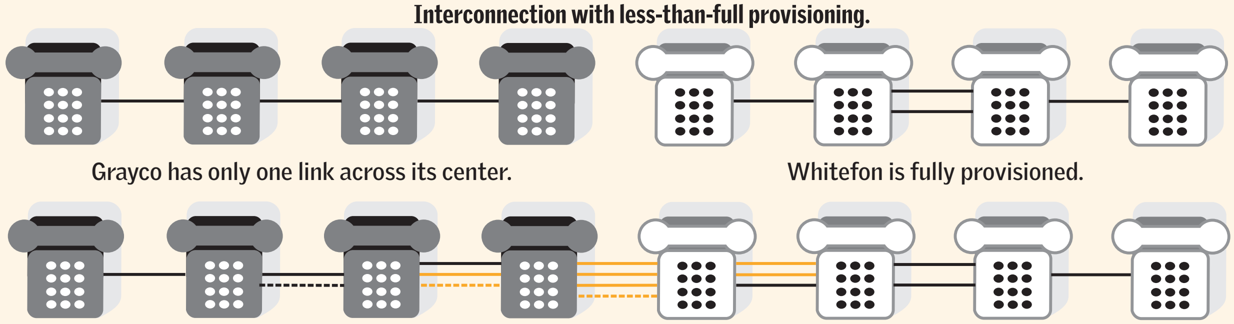
Note that we have achieved an efficient, competitively neutral allocation of costs between networks without any reference to how the costs should be distributed to the networks' end-user customers, or to the balance and direction of traffic between the networks. We thus avoid the intractable common-cost allocation problems and directionality problems encountered in the traditional approach.

The SCII rule We can now formulate a rule for interconnection cost distribution. Let us call the rule the "Split Capacity Incremental to Interconnection," or "SCII" rule. It has two parts: First, costs of capacity incremental to interconnection should be split equally between the two interconnecting networks. Second, each network must recover all its costs from end users. In particular, access rights to subscribers' lines should not be sold to interconnecting networks on a per-minute basis, as under current access rules.

Figure 6

Different Qualities

Interconnection with less-than-full provisioning.



The dotted yellow links cannot be needed for interconnection unless Grayco adds the second (dotted black) link across its own center.

Black links are intra-network. Yellow links are incremental to interconnection.

Instead, all access rights should be sold directly to end users on any retail basis the carrier chooses (subject to possible controls on dominant carrier rates). The end users may be a network's own subscribers or parties on other networks, but each network bears responsibility for its own billing.

In a world in which many different types of networks are possible, each network should recover its intra-network costs from its own subscribers. Not all subscribers have identical preferences regarding technology, service quality, additional features, price, and other aspects of network offerings. A single package is not likely to be optimal for every individual subscriber. Some subscribers may place a premium on very high reliability while others may accept occasional blockage, reduced voice or data quality, or even occasional outages in exchange for a lower price. Likewise, some subscribers may be willing to pay for the benefits of mobility offered by certain technologies while others may forego mobility for a lower price. Some subscribers may choose a lower monthly charge plus a usage charge, while others may prefer a higher monthly charge that includes unlimited usage. Splitting equally the costs that are purely incremental to interconnection and requiring each network to recover its intra-network costs from its own subscribers permits each network to offer retail packages of its choice. Each subscriber can then choose the combination of features and price that best suits her preferences without distortions caused by cross-subsidization.

A SCII interconnection regime should require very little regulatory intervention. At least in theory, network experts can implement a rule based on facilities. Further, when experts disagree, third parties can objectively evaluate which party is truer to the rule. We have thus framed the problem in a way that yields a clear, unambiguous solution. Experience shows that carriers have had little difficulty identifying incremental facilities required for interconnection. Once a clear rule is stated, negotiations between carriers would generally produce efficient solutions, as Coase predicts. Where parties disagree, first recourse could be to an arbitrator instructed to find the lower-cost interconnection proposal. We expect that regulators would rarely need to resolve such disputes.

Several networks In the case of more than two networks, the SCII rule would apply *seriatim*. That is, the initial interconnection forms an interconnected network. As additional networks join, the "newcomer" network would bear half of the incremental costs of the new interconnection, while the previously interconnected networks would together bear the other half. That allocation would produce an equal links-per-subscriber burden regardless of the order in which networks joined.

QUALITY LEVELS

If a SCII -type rule is to be implemented, it is essential to distinguish costs incremental to interconnection – which should be distributed evenly between the networks – from costs of improving service quality within a network. In order to distinguish between costs incremental to interconnection and costs incremental to intra-network service quality, we must drop our assumption that all networks are fully provisioned to be non-blocking.

In Figure 6, we show two networks that offer differing service quality levels: Whitefon is fully provisioned, but Grayco is not. For Grayco, call blocking will occur whenever more than one subscriber attempts a call across its center. Grayco offers something loosely resembling old-fashioned party line service, using only three links to serve four subscribers at an average cost of 0.75 links per subscriber. The Whitefon network, in contrast, offers completely non-blocking service at an average cost of 1.0 links per subscriber.

In a competitive market, we can presume that Grayco's lower quality is offered at a lower price. That could be a stable outcome if Grayco can attract subscribers who are willing to accept lower quality service in return for lower rates.

To see the incremental cost of interconnection for the two networks, it is helpful first to see what should not be included. If the networks interconnect and a second link is added across Grayco's center (making the network fully non-blocking), the total number of links added would be nine. If all nine added links were considered incremental to interconnection, then Grayco would pay for 7.5 links, or 1.875 per subscriber. Whitefon would pay for 8.5 links, or 2.125 per subscriber. Those cost assignments give Grayco an artificial advantage because one of its intra-network links is included in the cost of interconnection. Grayco could offer the same calling list and the same quality of service, but at a lower price. Whitefon would be "taxed" to subsidize Grayco. Including the intra-Grayco link would distort subscriber choices.

Maintaining different quality levels As a further illustration of that point, suppose the two networks want to maintain their differing grades of service. In that case, only six incremental links are needed for interconnection. There can never be enough traffic to require the dotted yellow links in Figure 6 as long as Grayco has only one link across its own center. Without a second link, the maximum simultaneous conversations possible between pairs of Grayco network subscribers is unchanged; only one conversation can cross Grayco's center.

In that case, only six links are required for interconnection. Applying SCII to the six incremental links assigns three more links to Grayco, for a total of six links for four subscribers, or 1.5 links per Grayco subscriber. Whitefon is now responsible for seven links, or 1.75 per subscriber. Note that Whitefon again has more links per customer and a higher quality of service (zero intra-network call blocking) than Grayco. In fact, the average cost difference is 0.25 links, precisely as before interconnection. That can be understood as the premium Whitefon subscribers pay for a higher (non-blocking) quality of service. Hence, interconnection under a SCII cost-assignment rule has not distorted the relationship between cost and service quality for the two networks.

The example enables us to distinguish clearly costs that are incremental to interconnection per se from those that are incremental to improving service quality within a network. In both cases, Whitefon is provisioned fully and will not experience any blocking whatsoever on calls within its own network or on any calls that arrive from Grayco. Grayco, however, does experience some internal blocking. Some intercarrier calls may also be blocked, but blocking can only occur on calls to or from Grayco subscribers. Costs of upgrading service quality for Grayco subscribers are not incremental to interconnection per se.

Interconnection increases the number of parties that each subscriber is able to call. It does not directly affect possible call blocking within the interconnecting networks. Thus, costs incurred to reduce call blocking on one network are not costs incremental to interconnection, and should not be split between the networks. We thus distinguish between costs incremental to *traffic* and costs incremental to *interconnection*. We believe our analysis demonstrates that, to achieve efficiency, the former should be assigned to the separate networks while the latter should be split equally between the two interconnecting networks.

Externality Someone may ask, does a network's decision to offer a lower quality of service impose an externality on the interconnecting network? The answer is no, as is implicit in the discussion above. Figure 6 shows that any call blocking that results from under-provisioning links will occur on the network that under-provisions, not on the interconnecting network. The only blockage experienced by subscribers to the fully provisioned network is on internetwork calls to customers of the under-provisioned network. The under-provisioned network bears the main impact itself, and the other network is affected only on some internetwork calls.

Non-linear networks and technology neutrality A second question that someone might ask is, does our SCII rule work on non-linear networks? In a formal paper to the Federal Communications Commission on our proposal, we show that SCII does work for other basic network forms. We also argue that there is a strong intuitive case that our results extend to most, if not all, real world network configurations. We conclude that the basic principles we have discovered here are robust. That is, a SCII -type rule is administratively simple and produces an efficient assignment of interconnection costs between networks.

A SCII -type rule is also competitively neutral with respect to differing technologies. Where technologies differ, of course, SCII does not produce equal link/subscriber burdens, but rather preserves the pre-interconnection relationship. It does not distort subscriber choices. That is important because interconnection between networks with differing technologies (such as wireless network and a wire line network) is becoming increasingly common, and presents serious problems under traditional interconnection regimes. A SCII rule does not distort whatever cost relationships would have existed without interconnection, and does not distort carrier decisions. Each network enjoys whatever scale or scope economies its engineers can find, employs whatever technology it chooses, and faces the resulting costs. SCII is a competitively neutral cost allocation method both with respect to firms and to technologies.

CONCLUSION

Reforming interconnection is becoming increasingly urgent. Technological and market developments are already undermining the current regimes. Expected improvements in the quality of IP telephony and demands by new carriers for compensation at rates based on their own costs are likely to increase the pressure. Severe market dislocations are likely unless a consistent, efficient interconnection regime is introduced.

Telecommunications firms that cannot be sure how future developments will interact with the inconsistent regimes may now be ready to support a "fair game." Unknown future technological developments may have unpredictable impacts under the current system. Other problems are arising as the concept of access charges is extended to carriers with very different costs. Substantial arbitrage opportunities are inducing inventors and entrepreneurs to find new ways of providing services. The availability of new services can be highly beneficial. To the extent that the offerings are motivated by artificial differences in regulatory rules, however, they can also result in substantial inefficiencies and disruptions.

A SCII interconnection regime could replace all current interconnection regimes with a simple, consistent, and efficient solution. The simple approach of identifying the incremental facilities needed and splitting their costs offers, for the first time, an efficient and competitively neutral solution to the interconnection problem. That means that customers could choose the types of networks they prefer, considering their true costs. R

READINGS

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