Peering, Transit, Interconnection: Internet Access In Central Europe[1]

Terrence P. McGarty[2]

Abstract

This paper presents a review of the alternatives for Internet access in Central Europe and the evolution of the market, the regulation, and the technology. The change in peering, the reduction in transport costs, the reduction in transit costs have dramatically changed the overall supply side of the market for Internet services in Central Europe. This paper assess the current market and how these regulatory and technological changes are accelerating the demand side as well and how such alternative paradigms for interconnection may impact other regional markets.

Contents

1. INTRODUCTION 2
- 1.1 A Brief History of Interconnection and Access Fees 3
- 1.2 Peering and Transit 5

2. ARCHITECTURES AND DEFINITIONS 5
- 2.1 Definitions 6
- 2.2 Disaggregation 7
- 2.3 Service and Meet Points 8
- 2.4 Access Pricing Implications 9
- 2.5 Applications to Internet Pricing 11

3. MARKETS 12
- 3.1 Current Structure 12
- 3.2 Regulatory Environment 14

4. MARKET EXAMPLE: CENTRAL EUROPE 14
- 4.1 Poland. 15
- 4.2 Czech Republic and Slovakia 15
- 4.3 Greece and Balkans 16
- 4.4 Demand and Revenue Projections 16
- 4.5 A Case Study 17
- 4.6 Implications 19

5. ARCHITECTURES 19
- 5.1 The Service Infrastructure 19
- 5.2 Elements 19
- 5.3 NAPs 20
- 5.4 MAEs 21
- 5.5 NIXs 22

6. CONCLUSIONS 22

7. REFERENCES 28

8. UUNET POLICY 30

---

[1] Presented at MIT Internet & Telephony Consortium meeting in Cambridge, January 17, 2002.

[2] Dr. McGarty is the Chairman and CEO of the Telmarc Group, LLC, a venture capital company. tmcgarty@telmarc.com.

1. INTRODUCTION

Interconnection of networks in an economic sense has been a concern of regulators, economists, entrepreneurs, and customers for many years. All too typically, the regulators rely upon the economists to create models to justify certain regulatory decisions. The entrepreneurs try and find ways around these artifacts that allow competitive markets to thrive. The customers really just want to buy a price competitive quality service. The consumers are also even willing to put their total end to end service together buy purchasing the elements separately.

At the time of the breakup of the Bell System in 1984, the Press had many articles as to how difficult it was for the poor consumer to deal with the purchase of a physical telephone, the purchase from their local telephone monopoly and the selection of one of two or three long distance carriers. Now, almost twenty years latter, we change long distance carriers at the drop of a hat, we have more phones in our homes, cars, briefcases than electrical outlets in our houses, we have ten digit dialing just to keep up with all of the growth, we have Internet carriers, cable carriers, DSL lines, and a panoply of other disaggregated services and suppliers. The cries have been muted by the benefits provided. The only thing that has not changed has been the dominance of the local monopoly carrier.

Interconnection, oftentimes also termed access, is the process of connecting one network to another and transferring traffic of some form. It may be voice traffic, IP traffic, data traffic, video content, or whatever. The issue is that one network owner always feels that the other is getting a free ride. Thus there is a great deal of effort developing access or interconnection pricing schemes. These have taken a life of their own in the economic literature and as we shall demonstrate the life typically revolves around a view dictated by the incumbent. It almost always ignores the subscriber. Perhaps a reason for this is that this issue was originally faced in the 19th Century with railroads, where the tracks were owned by many separate companies and rates to traverse such tracks were developed, and the mindset focused on the 19th Century capitalist railway owners, consumers were not even invented then.

Interconnection can be stated in a very broad context, consider any type of network, providing services to end users. The networks may be local telephone networks, long distance networks, IP networks, CATV networks, wireless networks. Let us assume that each provides a selection of service such as voice, video, data, IP transport. Let us assume that each supplies services directly or indirectly to end users, and that the end users can identify the provider and the service, either by a market presence or via some billing mechanism. Let us assume that there is a meet point, some artifact that allows one network to interconnect with any other and allows for the transparency of service provision from one end user to another. The question then is what should one service provider or network operator or ultimately any end user pay at the meet point to the other network for the services provided to effect completion of service provision. How does one pose the problem so that it benefits the consumer in the long run and in the short run. That, I believe, is the interconnection problem.

Before we begin, let us consider a simple thought experiment. Consider a consumer in New York who chooses to call his friend in California. The New York consumer has chosen the lowest cost local telephone carrier to get him to the lowest cost long distance carrier. His choices up to this point have determined the "cost" of the call. However his friend in California has no interest in cost savings, and he has selected the highest cost carrier. One of two things could happen, if incoming calls to California are charged to the caller then the New York penny pincher will be forced to pay an exorbitant rate for the final part of the call. If however, the "meet point" for the service is where the long distance company meets the California local carrier and the California friend pays for everything to and from this meet point, then the costly selection will remain a cost of the California friend and will not burden the New York penny pincher. This simple experiment is from the perspective of the consumer, and quite frankly cares little if anything about the economics of the carriers. This is not how economists generally think, they are still focused on railroad barons of the 19th Century and the lack of selection by end users.

1.1 A Brief History of Interconnection and Access Fees

The following is a brief chronology of interconnection in telecommunications, its theory and its implementation. The book by Coll is still the best standard to read to understand the context in which this issue evolved. Namely the development of MCI and the struggles of Bill McGowan against the entrenched monopolist AT&T. The following are merely highway markers along the road of opening the network. They apply to all elements of information interconnectivity.

Consider first what was written by a Bell System scientist in 1977 at the 100th anniversary of the Bell System at MIT. The author was John R. Pierce, Executive Director at Bell Labs, who stated:

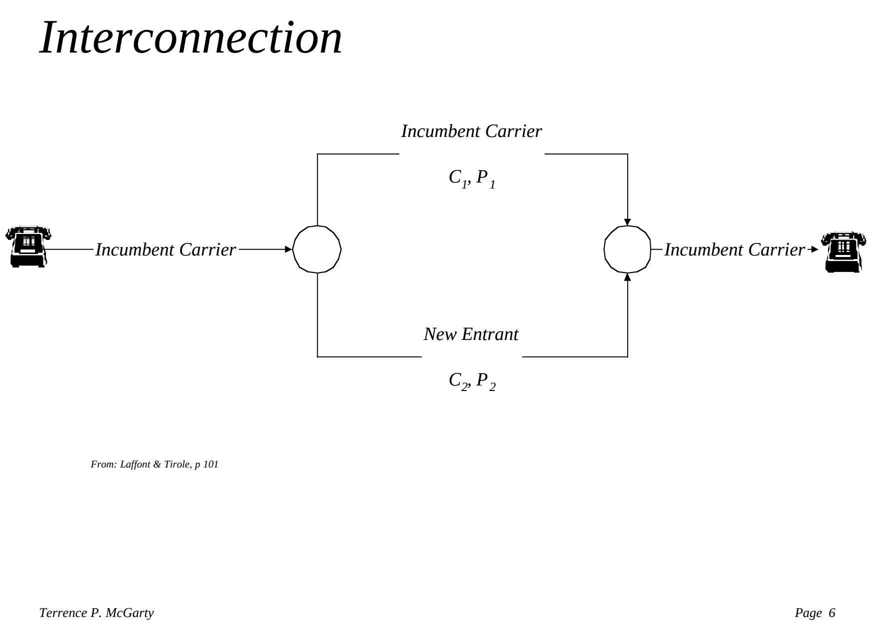
" Why shouldn't anyone connect any old thing to the telephone network? Careless interconnection can have several bothersome consequences. Accidental connection of electric power to telephone lines can certainly startle and might conceivable injure and kill telephone maintenance men and can wreak havoc with telephone equipment. Milder problems include electrically imbalanced telephone lines and dialing wrong and false numbers, which ties up telephone equipment. An acute Soviet observer remarked: "In the United States, man is exploited by man. With us it is just the other way around." Exploitation is a universal feature of society, but universals have their particulars. The exploitation of the telephone service and companies is little different from the exploitation of the mineral resources, gullible investors, or slaves." (de Sola Pool Ed, Pierce, pp 192-194).

The reader should note that this was written nine years after the Carterfone decision and five years before the announced divestiture. Pierce had a world view of an unsegmentable telephone network. The current view is of a highly segmentable communications system. The world view of the architecture has taken us from "exploitation" of Pierce to the freedom of the distributed computer networks of today. This however was the way the most enlightened viewed networks twenty five years ago.

In the context of this world view and in the context to the potential opening of the AT&T network with the presence of the then small MCI, regulators and economists were working on ways to “price” this right to interconnect. One of the landmark players in this was Willig who in 1979 presented a theorem for Efficient Component Pricing, the ECPR. Simply, the theory goes as follows, let us assume that there is a consumer and that that consumer has some welfare function, say keep as much money as possible. The, assume there is an incumbent who has things called network externalities, valuable things resulting from his monopolistic position. Assume that a new player comes into the market, what should the new player pay the incumbent to keep the consumer happy, but, and here is the kicker, assuring the incumbent adequate return on their assets. The constraint is on the incumbent getting a return, not the new entrant. The new entrant must make money by being much more efficient than the incumbent, despite the fact the allegedly the incumbent was a monopolist because they had tremendous scale economies. This paper started off the mathematical binge on enhancing on extending this theorem. The work of Willig was formalized in conjunction with Baumol and became the bulwark for many interconnection schemes. It was an extension of what had been created in 1979. The Baumol Willig Theorem can be stated as follows[3]:

Consider a local carrier and two long distance carriers, one of which is owned by the local carrier. What should the new entrant pay the local incumbent for access to that network. The network is drawn below:

[3] This is taken from Laffont and Tirole, p. 102. It is presented by those authors in the context of Ramsey pricing. It essentially reflects the Baumol Willig rule.



In the above example, which can and will be used again for Internet interconnectivity, the theory states that the New Entrant, who has costs C_2 and Price P_2, as compared to the incumbent with costs C_1 and Price P_1, should pay the incumbent a fee, α, for access. Note all fees and costs and prices are per minute of access. The Baumol Willig approach states as follows: Assume that there is a consumer surplus, or welfare function, that measure consumer benefit, that is $S_0(p_0)$ for the local loops and $S(p_1,p_2)$ for the long distance. Assume that the profit of the incumbent is measured as π (p_0, p_1, p_2) . Then the access fee should that which maximizes:

$$\max_{\{p_0, p_1, p_2\}} \left\{ S_0(p_0) + S(p_1, p_2) + \lambda\pi(p_0, p_1, p_2) \right\}$$

subject to

$$\pi(p_{0,} p_1, p_2) \geq 0$$

Namely, choose the access which benefits the consumer subject to insuring the incumbent is always profitable. It states that quite frankly, who cares about the new entrant. This is what all interconnection theory states up until late 2000, other than some few writers who were strongly opposed.[4]

The new Telecommunications Act was signed into law in February 1996. In it there was no algorithm or process for interconnection only rules requiring it. There was however the new element of unbundling.

The FCC OPP in September 2000 issues one of its working papers entitled “Connecting Internet Backbones”. This paper states that interconnection of IP backbones should be open. This is driven not by any new breakthrough of economic theory or policy but due to the fact that the ILECs are getting hit by ISPs dumping traffic on them via Internet schemes. For example, if a CLEC gets an ISP as a customer, all the CLEC then has to do is collect the interconnect fees from the RBOC since all the ISP customers will be

[4] See McGarty papers on access; 1993-1996.

calling that number. This then places s great cost on the ILEC. Under the guise if IP interconnectivity, the FCC moves. It will need a second shoe to drop to make it final.

December 2000. FCC OPP Paper on "Bill and Keep at the Central Office As the Efficient Interconnection Regime". The FCC OPP issues a second working paper and this is the second shoe. It now recommends that bill and keep is really the best way to go. Now the ILECs will not have to pay the CLECs and the bill and keep approach accrues to their benefit. This now is consistent with the McGarty (1993) request and totally rejects others. So much for consistency. It really is about whose ox is gored and who has the regulatory muscle to influence results.

In November 2001[5], Verizon states that it "is worried that saboteurs masquerading as technicians from competing company could gain access to and damage a large central office" This is a restatement of the Pierce complaint at the 1977 symposium. Namely there are great dangers from the likes of CLECs and they must be banned. The corollary is that all ILEC employees are better and more trustworthy than CLEC people. This was a totally uncalled for use of the tragedy of the September 11, 2001 attack on the United States. It was another step in attempting to eliminate unbundling.[6]

1.2 Peering and Transit

The issue of interconnection in an IP framework is described by the terms peering and transit. Peering is usually a bilateral business and technical arrangement, where two providers agree to accept traffic from one another, and from one another's customers (and thus from their customers' customers). Peering does not include the obligation to carry traffic to third parties. Transit is usually a bilateral business and technical arrangement, where one provider (the transit provider) agrees to carry traffic to third parties on behalf of another provider or an end user (the customer). In most cases, the transit provider carries traffic to and from its other customers, and to and from every destination on the Internet, as part of the transit arrangement.

Peering thus offers a provider access only to a single provider's customers; transit, by contrast, usually provides access at a defined price to the entire Internet. Peering is done on a bill- and- keep basis, without cash payments, where both parties perceive roughly equal exchange of value; however, there is often an element of barter.

2. ARCHITECTURES AND DEFINITIONS

The ability to deal with interconnection requires the establishment of a set of definitions. Consider the following Figure. It shows four types of carriers; Local Exchange, CATV, wireless and IP. There is a meet point. Let us assume that each carrier has users at one end and that these users desire to connect to users at the other end. Let us also assume that the users want to connect with something called a service. A typical service could be a voice conversation. Interconnection then addresses the following types of issues:

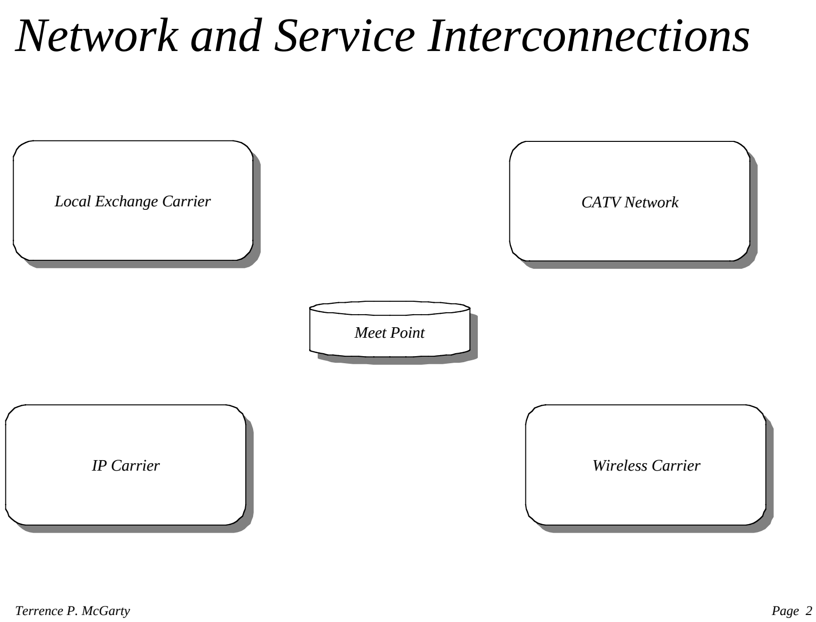
What characterizes the meet point from a technical point of view. Namely if it is IP to classical LEC, is there an SS 7 conversion to TCP/IP conversion occurring somewhere?

What does the individual carrier customers pay for, what are they expecting to pay for. For example, does the user separate connect time from content. Does a service level of connect time demand price differences. More importantly consider the following example. If a consumer on a LEC side has a dial up connection, and if he orders a movie from a customer of the CATV network, let us assume that the customer would pay for his local LEC connection plus the movie content plus whatever connection costs the content provider

[5] NY Times, p. B5, "Attacks at Hubs Could Disrupt Phone Lines", Simon Romero.

[6] Again Hausman has written recently on the unbundling of CATV assets. McGarty had addressed this in a TPRC Paper on the Gilder Conjectures in 1994. In that paper it was shown that the Gilder conjectures, relating to wireless or CATV were false in part and the conclusion that either bandwidth for wireless or CATV could be treated as disaggregatable utility element were false.

pays, plus overhead and profits. Should the consumer see one or two or even more bills. Now he sees generally 2.



2.1 Definitions

The theory of network disaggregation has been developed in several areas. Let us start by providing a set of definitions. [7]

Service is defined as the set of offering that a provider or ***network operator*** provides to the customer or end user for a certain price. The service may be voice, Internet interconnection, video, data, or any collection including such SS7 services such as number identification, or IP services such as security or QoS.

Customer or ***end user*** is a non network owner or network operator who uses the services provided by the network operator.

System is the set or collection of ***elements*** that have been integrated in some fashion by the network operator to provide the services.

Elements are segmentable or separable physical units, systems, or processes which can be provided by or to a service provider and which when interconnected or integrated can cumulatively or collectively ensure the provision of the service. Such elements are fiber strands, copper pairs, network management, sales

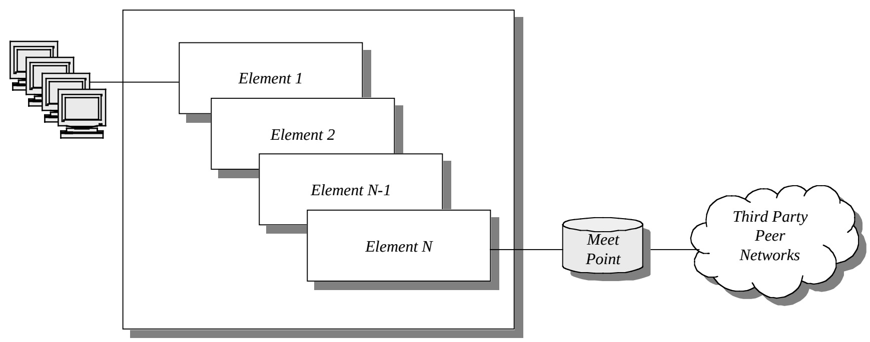
[7]See McGarty, Columbia Paper, March, 1996, Disaggregation. In that paper the author develops the theory of disaggregation. Also see McGarty, Federal Communications Law Journal, in which this theory is extended. *"What the theory states is simply: The theory of disaggregation states that technology and industry has developed in such a fashion that it is possible to effect all elements of a business in a virtual form by obtaining all functions necessary to deliver a service by purchasing them from third parties each of whom has themselves other similar customers and thus each of whom can deliver their element of the functionality in a minimal marginal cost manner. The disaggregation theory then concludes with the result that in many technologically intense services business, a virtual company can exist wherein all the functions can be purchased from third parties or capital equipment may be purchased in a fully interconnected fashion so as to achieve near equality between average and marginal costs from the very commencement of the business. The Disaggregated Company is the embodiment of the virtual business."*

channels, billing systems, provisioning systems. These may be self contained or outsourced from third parties.

Per User Elements are sets of or partitions of elements which can be used discretely to provide services by a network operator. A twisted copper pair is a per user element. A CATV unit of bandwidth may or may not, generally it is not. This is a key differentiator which makes ILECs unbundeable but CATV entities not unbundleable.[8]

The following Figure conceptually depicts the aggregation of elements into the provision of service.

Service Provision Elements



Terrence P. McGarty *Page 5*

2.2 Disaggregation

The theory of disaggregation can be stated as follows. There exists a set of elements, the collection of which make for the provision of service. Each of these elements are separable but integrable. A service provider has access to these elements in a fully open and competitive market. The service provider in a fully open and competitive market will select those elements which it can produce at lowest costs itself and will procure those elements from third parties who can produce at costs lower than the service provider can produce on its own. Telecommunications is an open and interconnectable bundle of services which requires standardization for full interconnectivity. Full interconnectivity and standardization create services and service elements which are commodicizable, namely generally indistinguishable from one to another. The consumer or end user will select a service provider in a commodicizable market based solely or total price, which is the service providers prices and any switching costs.

If we now apply this concept to telephony and then to the Internet we can better understand the issue of interconnection or access pricing.

Let us first apply to telephony. Disaggregation applies not only to the producer but to the consumer. Let us first start with the producer. Assume there is a CLEC, a new entrant, who desires to provide local telephone service. To do so the entrant needs the following elements; local loop, switch, billing, network management, provisioning, and sales. He desires to buy the local loop from the ILEC, the incumbent. He will produce the switching, network management and provisioning, and will outsource the billing to a third

[8] See discussion in McGarty paper on Gilder Conjectures.

party and the sales will be done by some third party sales force. Why does he do this, because the marginal costs of the loop is lower than anything he can achieve, because the marginal billing is lower since the billing company has scale and the sales force is already dealing with the customer bases and the start up costs are lower. At least that is the way the argument is to work. Note that in assembling the elements to deliver his business service none of the four providers charge him a fee that reflects anything other that the costs of the services he is buying, there is not externality fee involved.

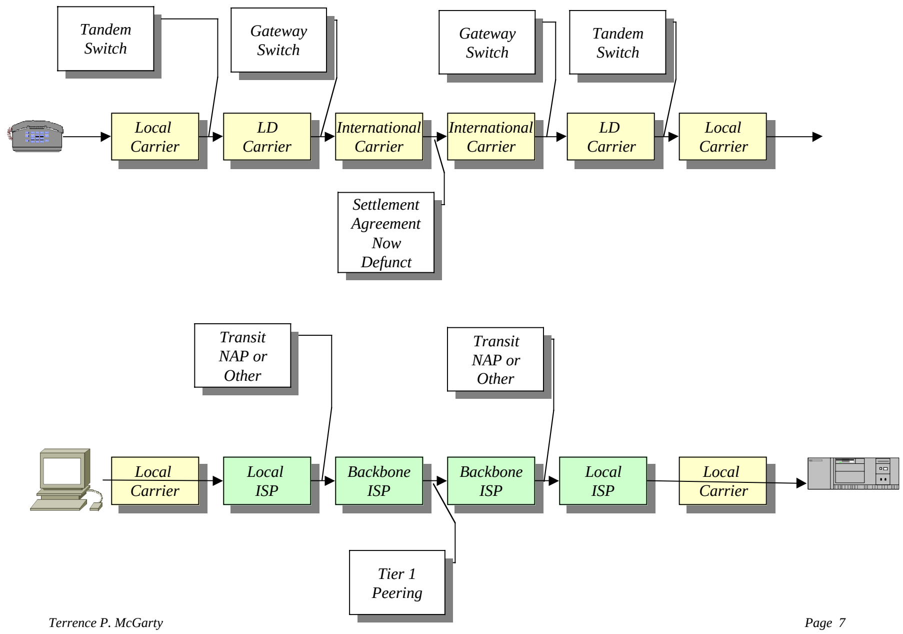
Let us now consider the consumer. In today's world he also chooses to assemble his elements. First he buys the phone from Staples. This is a one time cost and he perceives it to be the lowest. He places the phone in his home and he then expects that from this meet point in his home, the wall jack, the local telephone company will provide it services. Then he chooses a local independent or competitive local exchange carrier to connect him to the network and place local calls. His expectation is that this local carrier will take care of everything up to the next meet point. He then selects a long distance carrier. He expects that he is paying the long distance carrier only for long distance. Namely the costs associated with the long distance carrier are those that reflect those services only and do not reflect any third party, say some other incumbent telephone company. He further expects that any person he calls also has taken care to connect to a meet point with his long distance carrier. He expects than that person has paid their local telephone company for any and all costs for getting to and from that point and that he should not pay for that. E likewise assumes that he does not pay for any subsidy of the local telephone set in the home of any party he calls, despite the fact that it may become part of a call he makes. Those costs, the local telephone and the local telephone network are expected costs to be borne by anyone desiring to receive as well as place calls.

Thus in this world of disaggregated expectations, access is not an issue if one defines meet points, in fact access or interconnect is non existent. The consumer rules and their expectations are met. The Baumol Willig rule states that we no longer care about anyone's profits and access goes to zero.

2.3 Service and Meet Points

The service can be described as one way to establish a meet point. For example, user interconnection, local phone service, long distance service, and international service. These four elements are then characterized as follows; the telephone, from the telephone to the near tandem switch, from the near tandem switch to the near international gateway, from the near international gateway to the far international gateway, from the far international gateway to the far tandem switch, from the far tandem switch to the far telephone. This is generally a well established set of services, billed separately, technically well specified, and each can be provided by a separate carrier or entity. Each in turn is disaggregatable.

Let us now try and consider the same approach as applied to the IP or Internet world. Remember that we focus on the customer or end user view as the nexus to bind all elements together. We do not, as economists are like to do, look at carrier in isolation of embodiment of a business. Consider the following example; an end user has a computer, they use a dial up ISP who provides access from the home to a backbone ISP, say UUNet. The end user desires to connect to a company to purchase a product. The end user sends out a packet with the address of the company, it goes through the local ISP, then through UUNet but the company has its address on Genuity. Thus it goes through a peering point at Genuity, through Genuity, and then to the ISP used by the company, and then to the company's server. The example is similar to the telephone case. We draw the examples in the following Figure.



In the telephony world the meet points and the relationships are well defined. It has taken almost 20 years to get through the understanding which has led to bill and keep. Much of that is a result of economic theory justification of monopoly rents, looking at the world from the view of the incumbent and retaining their profits. This legacy has not been part of the IP world. However, the history of Tier 1 ISPs and the hegemony of the dominant US Tier 1 carriers has left a residue. We have shown in the above slide the "shadow" presence of the Local Carrier in the IP world. That shadow presence and the need for "bill and keep" by the FCC is a result of the local ISPs using arbitrage of access against the local ILEC.

We have argued, and will further develop the argument, that in the telephony world, access is to be open between Local and LD. Does this mean that access is open between Local ISP and Backbone ISP, if so how does the buyer "pay" for the backbone. In telephony this is separate. In IP there is a bundling, namely the end user does not get at this time in most cases the choice of the backbone provider. Thus this cost is bundled. However, backbone to backbone is not the same, this is connecting or pari passu networks. It is in essence a peering. The end user can choose amongst several local ISPs, which in turn should reflect several backbone costs. This paper does not fully answer this question of local and backbone.

2.4 Access Pricing Implications

The cost model for the effects of the proposed access pricing structures on the development of the technological infrastructure have been developed below. Specifically, recognizing the proposed bilateral access structure, the model that depicts the results. This section summarizes those results. The model for the pricing is shown below. Here we assume that P is the price and that C are costs. A is the local allocation of costs to price and T is the transfer allocation. Specifically, the price charged by Carrier 1 is the sum of an allocation of the costs of Carrier 1 plus a transfer of the Costs of Carrier 2. The same holds in the Prices for Carrier 2. We assume that Carrier 1 is the new entrant and that Carrier 2 is the incumbent.

This model of access is what has been proposed by the FCC. We shall show that this form leads to the strong possibility of predatory pricing on the part of the existing monopolist and thus is a per se violation of the antitrust laws.

Let the prices charged to the customer be given by:

$$P_1 = A_1 C_1 + T_{1,2} C_2$$

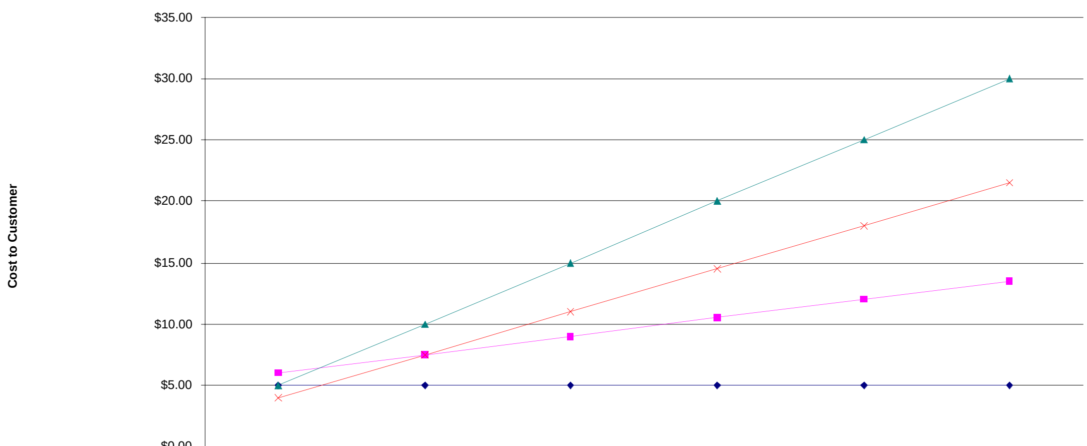
$$P_2 = A_2 C_2 + T_{2,1} C_1$$

$$T_{1,2} = 1 - A_2 , T_{2,1} = 1 - A_1$$

In the Case shown below, we assume that the efficient carrier is allowed to place only 10% of its base in an access charge, and the inefficient carrier places 30% of its base in access charge. The Figure depicts a very important finding. Namely, if the inefficient carrier is allowed to place an excess amount in the base assigned to access, then it is possible for the inefficient carrier to have a lower price to the consume, and in turn drive the price of the efficient carrier above theirs by means of the cross linking of access.

The following Figure depicts the fact that until the inefficient carrier is almost twice the efficient to that the inefficient is less than the efficient. This market distortion goes to the heart of where technology and rate base allocations are for access. The new entrants have been attempting to eliminate access fees through technology as well as other means. If the fees are kept, even as reciprocal, but based on underlying technology, the inefficient technology may drive out the efficient, a form of Gresham's Law of technology.

Figure: A_1=0.9, T_{12}=0.3, A_2=0.7, T_{21}=0.1



	$5.00	$10.00	$15.00	$20.00	$25.00	$30.00
Cost per Sub 1	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00
Allocated Cost per Sub 1	$6.00	$7.50	$9.00	$10.50	$12.00	$13.50
Cost per Sub 2	$5.00	$10.00	$15.00	$20.00	$25.00	$30.00
Allocated Cost per Sub 2	$4.00	$7.50	$11.00	$14.50	$18.00	$21.50

Cost Base Carrier 2

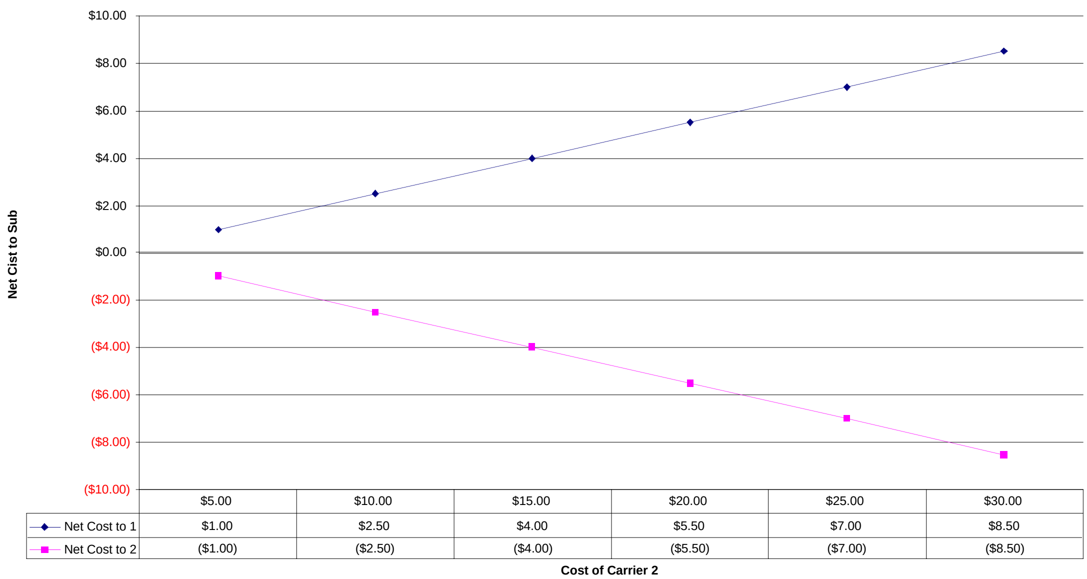
The conclusion of this is obvious;

Under equal allocations of base and percentage, the inefficient carrier is penalized by the inefficiencies of the inefficient carrier.

Under the case of misallocated costs, the inefficient carrier may actual use the efficient carriers costs to price below the efficient, thus driving the efficient out of the market.

The driving of the efficient from the market by the inefficient, occurs only in those market situations wherein an imbalance via government regulations occur. These markets are not cleared and reflect dramatic distortions.

The following Figure depicts the effective taxes and subsidies provided the customer of the incumbent versus the customer of the new entrant.



	$5.00	$10.00	$15.00	$20.00	$25.00	$30.00
Net Cost to 1	$1.00	$2.50	$4.00	$5.50	$7.00	$8.50
Net Cost to 2	($1.00)	($2.50)	($4.00)	($5.50)	($7.00)	($8.50)

2.5 Applications to Internet Pricing

We can now take the above discussions of telephony and apply to Internet pricing. Assume that Internet Carrier 1 and 2 desire to meet at some well defined meet point. Clearly the definition of carrier and meet point will need to be well determined. For the present we can use the same definitions that we applied to the telephony case. Let us consider a simple example. Let us assume that a collection of countries desire to collaborate in establishing an Internet backbone. Let us assume that they further desire to meet other dominant carriers at one or more points. In today's world, if they do so in a transiting type agreement the cost to the new carrier would be:

$$C_{New} = C_{Transport} + \sum_{i=1}^{N} C_{Transit,i}$$

which is the sum of transport and transit. It must be noted that the cost of transport is dropping at a tremendous rate. For example the cost of an STM-1 (155 Mbps) from New York to London has gone from $150,000 per month to $6,000 per month as of the date of this paper. Note that this means that the transport cost, except for routes with limited fiber, is a de minimis element of the total cost. The main reason for forcing transit costs was the alleged backhaul costs incurred by the IP carriers. The market has driven the costs below marginal levels.

Now the Transit costs are:

$$C_{Transit,i} = C_{i,Mbps} T_i(mbps)$$

Here the transit costs is the cost per Mbps times the peak traffic offered. For example if the cost per Mbps is say $500 and the peak traffic is an STM-1, say 150 Mbps, the monthly fee is $75,000 per month at that meet point.

However, if the Carrier agrees to peer with certain Internet Carriers, thus incurring zero cost except for transport, and transit with a few, the Carrier may choose the transit carrier in some minimal cost fashion. For example, for any peer/transit carrier, we set a parameter π_k equal to zero for a peering and one for transiting. It must be remembered that one must incur an incremental cost for the peering connection if we seek to peer with all, since the meet point may not be as convenient for all. The Internet cost minimization problem may then be described as follows:

The cost C must be minimized by choosing the set of π_k to minimize C where pk is the percent of total traffic going to any connecting carrier.

$$C = \sum_{k=1}^{N} \pi_k C_{k,Mbps}^{ExcessTransport} p_k T(Mbps) + \sum (1-\pi_k) C_{k,Mbps}^{PeerTransport} p_k T(Mbps) + \sum_{k=1}^{N} \pi_k C_{k,Mbps}^{Transit} p_k T(Mbps)$$

Generally this can be accomplished by an 80:20 rule, namely 80% of traffic goes to 20% of carriers, namely top 3-5 are peers and the rest transit.

The question is must the Tier 1 ISPs, such as UUNet peer. The answer is yes for the same reason that access fees should be zero. The peering is between “equals” and for traffic on their networks to traffic on the others. Transit covers all other options. The question however is also how does one create a long distance company in Internet world, the answer may be it is a non-sequitur perforce of TCP/IP. The question however is what are the requirements for peering, who should set them, what are the implications in foreign policy and regulatory policy, and does the US Tier 1 ISPs have the right unilaterally to set policy. We discuss these issues as part of this paper.

3. MARKETS

The “Internet” is actually a set of independent networks, interlinked to provide the appearance of a single, uniform, network. Interlinking these independent networks requires interconnection rules, open interfaces, and mechanisms for common naming and addressing. The architecture of the Internet is also designed to be neutral with respect to applications and context, a property we refer to here as transparency.

3.1 Current Structure

Currently the control, management, and development of this overall interconnection scheme is held tightly within the United States, controlled by a closely knit group of twelve entities, six commercial and six U.S. government entities, called Tier 1 ISPs. This group is composed of the set of original ISP carriers and excludes such groups as AOL/Time Warner and other major players. It also excludes all major non-US carries and companies. This white paper discusses the opportunities for expansion of this set of relationships especially as regards to Central Europe.

To support these customer expectations, an Internet service provider must have access to the rest of the Internet. Because these independent networks are organized under separate administration, they have to enter into interconnection agreements with one or more other Internet service providers. The number and type of arrangements are determined by many factors, including the scope and scale of the provider and the value attached to access to its customers. Without suitable interconnection, an Internet service provider cannot claim to be such a provider, being part of the “Internet” is understood to mean access to the full global Internet.

Connections among Internet service providers are driven primarily by economics—in essence who may have access to whom with what quality of access and at what price—but all kinds of considerations are translated into policies, frequently privately negotiated, that are implemented in the approaches to interconnection and routing. A significant feature of today's competitive Internet service marketplace is that direct competitors must reach interconnection agreements with each other in order to provide the overall Internet service that their customers desire.

These business agreements cover the technical form of interconnection, the means and methods for compensation for interconnection based upon the services provided, the grades and levels of service to be provided, and the processing and support of higher level protocols. Interconnection also requires that parties to an agreement establish safeguards, chiefly in the form of rules and procedures, to ensure that one provider's network is not adversely affected by hostile behavior of customers of the other provider.

Approximately twelve entities, six commercial and six U.S. governmental entities[9], provide the backbone services, running over communications links with capacities measured in many gigabits, or billions of bits per second, that carry a majority of Internet traffic. These providers, termed "Tier 1," are defined as those providers that have full peering with at least the other Tier 1 backbone providers.

Tier 1 backbones by definition must keep track of global routing information that allows them to route data to all possible destinations on the Internet, which packets go to which peers. They also must ensure that their own routing information is distributed such that data from anywhere else in the Internet will properly be routed back to its network.

Tier 1 status is a coveted position for any ISP, primarily because there are so few of them and because they enjoy low cost interconnection agreements with other networks. They do not pay for exchanging traffic with other Tier 1 providers; the peering relationship is accompanied by an expectation that traffic flows, and any costs associated with accepting the other network's traffic between Tier 1 networks, are symmetrical. Tier 1 status also means, by definition, that an ISP does not have to pay for transit service.

Much of the Internet's backbone capacity is concentrated in the hands of a small number of Tier 1 providers, and there is some question as to whether it is likely to become more so, in part through mergers and acquisition. Concerns about market share in this segment have already emerged in the context of the 1998 merger between MCI and Worldcom, at that time the largest and second largest Internet backbone providers. In that instance, European Union regulators expressed concerns about the dominant market share that would have resulted from such a combination.

In the end, in order to get approval for the merger, some of MCI's Internet infrastructure as well as MCI's residential and business customer base was sold off to Cable & Wireless and the merger went forward.[10] Some of the advantage held by the very large players is due to their ability, owing to their large, global networks, to provide customers willing to pay for it an assured level and quality of service. Part of this dominant position also stems from their Tier 1 status, which assures customers (including tier 2 and tier 3 ISPs) of their ability to provide a high quality of access to the public Internet. In addition, Tier 1 providers, by determining how and with whom they interconnect, also affect the position of would-be competitors.

Below Tier 1 sit a number of so-called second and third tier service providers, which connect corporate and individual clients (who, in turn, connect users) to the Internet backbone, and offer them varying types of service according to the needs of differing target marketplaces. This class also includes the networks of large organizations, including those of large corporations, educational institutions, and some parts of government. These ISPs cannot generally rely on peering alone and enter into transit agreements and pay for delivery of at least some of their traffic.

The bulk of the Internet providers sit in these lower tiers. These include both a small set of very large providers aimed at individual/household customers (e.g., AOL) as well as a large number of smaller

[9] ATT, MCI/Worldcom (UUNet), Sprint, PSI, C&W, Microsoft, as well as, NASA, DoD, DoE, NAS, and other government agencies.

[10] See, for example, Mills, Mike. 1998. "Cable & Wireless, MCI Reach Deal; British Firm to Buy Entire Internet Assets." *Washington Post.* July 14, p. C1.

providers. These include providers of national or regional scale as well as many small providers offering dial-up service in only a limited set of area codes.[11]

3.2 Regulatory Environment

In September 2000, the Federal Communications Commission (FCC) and the International Telecommunication Union (ITU) expressed concern about the power and resulting anti-competitive behavior with respect to peering of the large Tier 1 backbones in the United States. The ITU was looking for some sort of governance to mitigate the situation, while the FCC (and the developed countries) was happy with letting the market decide who peers with whom. The FCC put out a report in September 2000 (FCC OPP Working Paper, September, 2000) that said, among other things, that there are certain valid reasons why a large Tier 1 backbone provider (which has made significant investment into its network) would not want to interconnect with a smaller backbone.[12] The FCC said there could be valid competitive reasons why this would be the case, and if the reasons were anti-competitive, the anti-trust laws would take care of them. In 1997, UUNet, followed by other large backbones, invoked competitive reasons in its attempt to end peering with a number of smaller backbones and instead charge them for transit. The increasing transparency of peering requirements since September 2000 was likely in response to this; the Tier 1 carriers attempted to show that when they denied peering to smaller backbones, they were doing so because of competitive--and not anti-competitive--reasons.

At around this same time, Level 3 was coming into the picture. Sprint refused to peer with Level 3 a few years prior to 2000, spurring Level 3 to became the champion of transparent peering requirements. Level 3's president and chief operating officer Kevin O'Hara said in September 2000, "We believe openly-published, specific and objective interconnection policies serve the Internet industry's best interests. We also urge all providers in the U.S. and internationally to follow our code of conduct - a self-regulated approach by our industry will lead to continued success and growth of the Internet."

Therefore, the publishing of peering requirements by Level 3 and Genuity (another of the first to publish), was probably in part an attempt to take away some of the market power of the big players. Level 3 was apparently having difficulties negotiating peering agreements when it first started doing so at the time their network was nearing completion. It wanted to take potentially anticompetitive options away from its largest rivals, the large backbones. It did so by putting pressure on them to publish their requirements and thereby (i) letting Level 3 know exactly what they needed to do to peer with the big players while (ii) making sure the large backbones couldn't exercise their market power by forcing small backbones (who may have demanded to peer with Level 3) to pay transit fees to them.

In summary, in September 2000, significant pressure was brought upon the large (mostly US-based) backbones by the FCC and ITU. The large backbones, preferring self (as opposed to government) regulation of their business responded to the FCC's suggestion that under some circumstances, they would have valid reasons for denying peering to smaller backbones--thus being able to charge them transit fees. Smaller backbones, at that time, saw it in their interest to have industry-wide transparency in peering requirements and hence published theirs to set precedence. Pressure on the large backbones to (i) avoid government regulation, (ii) preempt anti-trust accusations, and (iii) meet the standard of transparency set by an industry newcomers, led many of these players to publish their peering requirements.

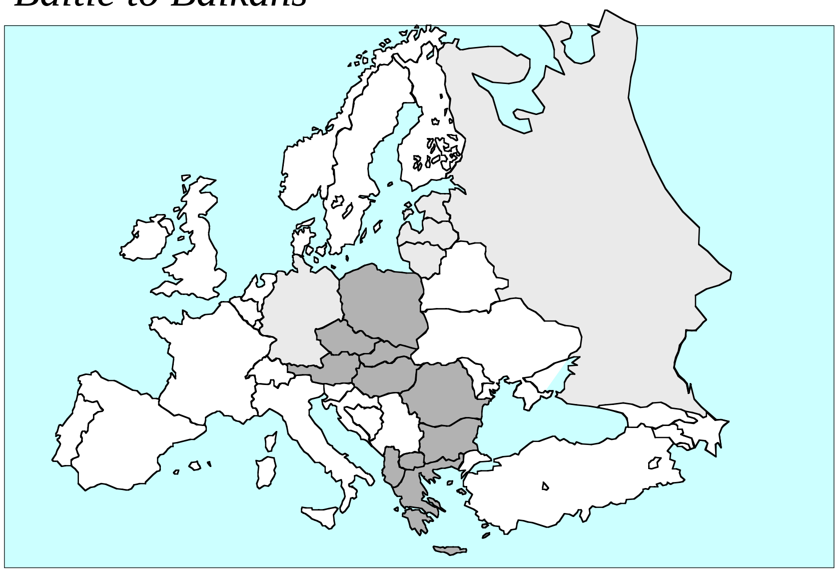
4. MARKET EXAMPLE: CENTRAL EUROPE

The Central European market is an interesting example for consideration. Size is almost that of the United States, penetration is about 5-8%, and growth is currently 40-80% per annum. It was where the US was ten of twelve years ago. The market goes from the Baltic to the Balkans. The countries to be surveyed are shown the map below.

[11] Richtel, Matt. 1999. "Small Internet Providers Survive Among the Giants." *New York Times.* August 16, p. D1.

[12] See FCC OPP Report No. 32 issued September, 2000 by the Federal Communication Commission. It details the US regulatory history.

Baltic to Balkans



4.1 Poland.

Poland, with a population of 38.7 million and teledensity of 22%, has the largest volume of outgoing international telecommunications traffic in Eastern Europe. In 1999, Poland's outgoing traffic amounted to 850 million minutes; the top destination was Germany, with more than 38% of the minutes, as compared to less than 5% destined for the United States. The total outbound traffic from Poland to all the other countries in which Zephyr currently has a presence amounted to about 400 million minutes in 1999. Total inbound traffic amounted to over 4 billion minutes. The Polish telephone network is estimated to be growing at a rate of 15% per year. Planned investments in the telecommunications sector are USD 14 billion from 2001-2005 and an additional USD 17.5 billion by the year 2010. Poland's PTT, Telekomunikacja Polska S.A. ("TPSA") is currently in the final stages of preparing for privatization, which is scheduled to be finalized by end of 2000 or beginning of 2001. Domestic long-distance service was de-monopolized in 1999, with international long-distance to be liberalized in 2003. Under the current Polish Telecom Law, IP Telephony is excluded from the definition of telecommunications services that is regulated. The Company believes that the ongoing liberalization of the telecommunications services market in Poland offers attractive opportunities for the Company.

In 1999, it is estimated that 5.6 million Poles had access to the Internet, with approximately 2 million active users. The number of Internet hosts grew from 74,000 in 1997 to 154 thousand in late 1999 at a CAGR of 44%. Internet users are classified as businesspeople, specialists and students. Internet is used mainly at universities/schools (38%) and at work (36%), with home users representing 22%. Most Internet users are 24 or younger (30%), or between 25-29 years old (29%). The commercial use of the Internet is becoming more popular in Poland. While in the past the Internet users were mainly interested in e-mail and only 40% of them used the World Wide Web (WWW), currently over 90% surf the web. Over 80% percent of companies and institutions with Internet access also maintain their own web pages in the Internet and the remaining declared an interest in creating their own service information in the near future.

4.2 Czech Republic and Slovakia

Strategically located in the heart of Central Europe, and increasingly aligned with Western Europe, the Czech Republic currently maintains a favorable attitude toward foreign investment and a large and growing western business presence. The Czech Republic, with a population of 10.3 million and teledensity of 27%, had total estimated outbound traffic of 400 million minutes in 1999, with the largest destinations being Germany and Slovakia with 25% and 21% respectively. Total 1999 inbound traffic is estimated at about 1 billion minutes. The incumbent telecommunication operator in the Czech Republic (SPT Telecom) still maintains control over ILD telephony services. SPT has an exclusive license for long distance and international calls until January 1, 2001 for public telephony. There were an estimated 700,000 users of the Internet in 1999, or 7% of the population. The number of Internet hosts grew from 45,000 in 1997 to 105,000 in 1999, at a CAGR of 53%. Currently, Internet is used for e-commerce, e-business including business information and advertisement and for the e-mail traffic. About two-thirds of e-commerce consists of business-to-business transactions, and that share is expected to grow.

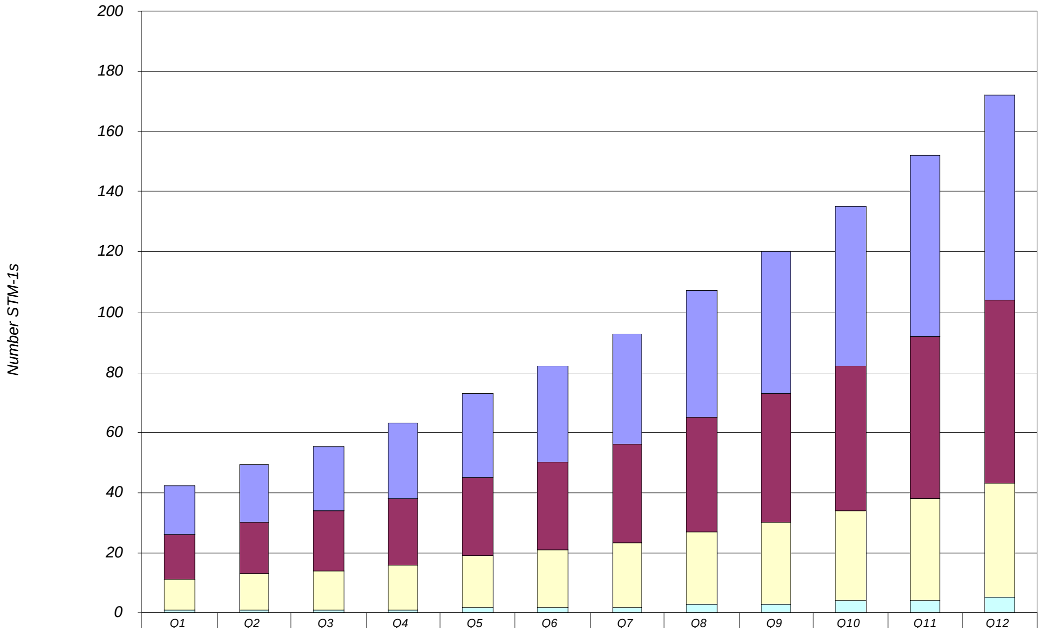
Slovakia, with a population of 5.3 million and teledensity of 23%, is a rapidly growing market for telecom services. Total international telecommunications traffic outbound from Slovakia in 1999 was 200 million minutes, with 42% of that traffic going to the Czech Republic and 12% to Germany, the two largest destinations. Total inbound minutes was estimated at about 500 million minutes. Slovak Telecom is wholly owned by the state and has a monopoly on basic voice services. The government's Liberalization Agenda provides for competition starting from January 1, 2003 at the latest. In 1998, the government took some steps towards competition, allowing private companies were allowed to build and utilize their own telecommunications networks for commercial purposes. Estimates as to the number of Internet users in Slovakia range from 230,000 to 510,000. The number of Internet hosts grew from 6,000 in 1997 to 21,000 in 1999 at a CAGR of 83%.

4.3 Greece and Balkans

Greece and the Balkans, with a total population of 56 million and an average teledensity of 21% is one of the largest and most lucrative markets for Zephyr. In 1999, Greece alone had total international outbound telecommunications traffic of about 850 million minutes, growing at over 15% per annum, with the largest destinations being Germany (16%) and United Kingdom (14%). The fastest growing market for telecom traffic in the Balkans is Albania, growing at 33% per year. EU pressure has resulted in the Government of Greece's decision to deregulate most value added services in the telecommunications sector. The monopoly telecom players in the rest of the Balkans are rapidly undergoing privatization, and the telecom sector is getting de-regulated. Internet penetration remains relatively low in the Balkans; the number of Internet hosts in Greece and Romania grew from 34,500 in 1997 to 86,000 in 1999, at a CAGR of 60%.

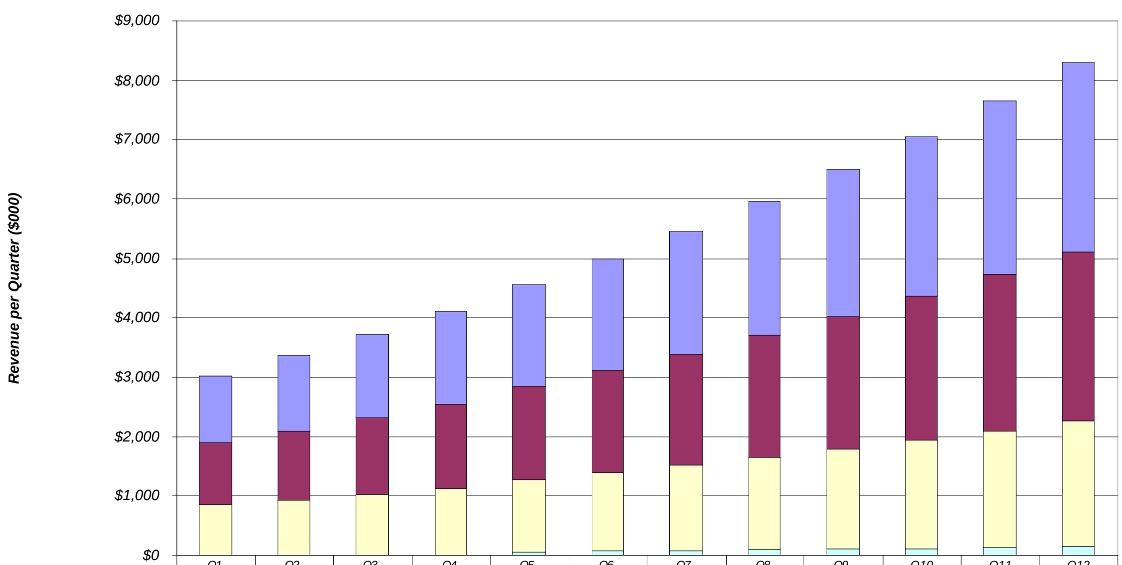
4.4 Demand and Revenue Projections

Using ITU and other market projections, we have determined by Quarter the monthly demand for international non-regional peering for Central Europe. This is shown in the Chart below. It grows from about 42 to almost 170 STM-1 per month on average. This is a four fold growth over three years.



	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
Czech & Slovakia	16	19	21	25	28	32	37	42	47	53	60	68
Poland	15	17	20	22	26	29	33	38	43	48	54	61
Greece. Italy & Balkans	10	12	13	15	17	19	21	24	27	30	34	38
Other MAE	1	1	1	1	2	2	2	3	3	4	4	5

Then using the current market pricing ($300 per Mbps peak per month) and projecting quarterly reductions consistent with the current rates, which actually may be high, the total cost of interconnection, or access, of the ISPs in this region at the backbone level is shown in the following chart.



	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
Czech, Slovakia, Hungary	$1,134	$1,268	$1,403	$1,558	$1,715	$1,886	$2,071	$2,266	$2,470	$2,690	$2,926	$3,178
Poland	$1,042	$1,159	$1,288	$1,416	$1,565	$1,714	$1,876	$2,052	$2,236	$2,428	$2,634	$2,855
Greece, Romania, Bulgar	$840	$930	$1,016	$1,113	$1,215	$1,320	$1,431	$1,553	$1,679	$1,812	$1,956	$2,106
Other	$8	$7	$7	$7	$64	$72	$80	$95	$106	$122	$132	$149

4.5 A Case Study

The following is a case study of the TPSA market using the current means of interconnection and the proposed change. Specifically:

1. TPSA generate about $50 million annually for ISP revenues.
2. TPSA needs 4 STM-1 which it leases to connect Warsaw to Frankfurt
3. TPSA interconnects with UU Net in Frankfurt with 4 STM-1 Internet connections for peering outside of Poland.
4. The Cost of Transport is $400,000 per month
5. The Cost of peering is $1,600,000 per month.
6. If TPSA were to join a consortium, it would save $1 million per month, which would go directly to the bottom line.
7. The growth rate in Poland is 40% per annum. The $1 million per month can be compounded at that rate.

The following is the detailed table for the analysis of the revenue impact.

Cost Element	*Current Business*
Retail	
Minutes per month Retail	960
Revenue per Minute	$0.0100
Internet Share Revenue	30%
Net Retail Revenue per month per Customer	$2.88
No MP/mo Retail	56,700,000
Retail Revenue/MP	$0.0508
Revenue Retail per Mon	$2,880,000
Commercial	
No MP/mo Commercial	8,100,000
Commercial Rev/MP	$0.1852
Net Commercial Revenue per E1 per month	$3,000
Revenue Commercial per Mon	$1,500,000
Total Revenue per Month Company Customers	$4,380,000
Cost per Month per STM-1	$150,000
No STM-1	4
IPL Circuits	$600,000
Peering Cost per STM-1 Frankfurt	$400,000
Peering with Tier 1	$1,600,000
Interconnection Cost per Mon	$12,000
Cost per MP per Mon	$0.000
Backbone Network Costs	$0.000
Total Cost of Service	$2,212,000
Gross Margin	$2,168,000
Gross Margin %	49%

4.6 *Implications*

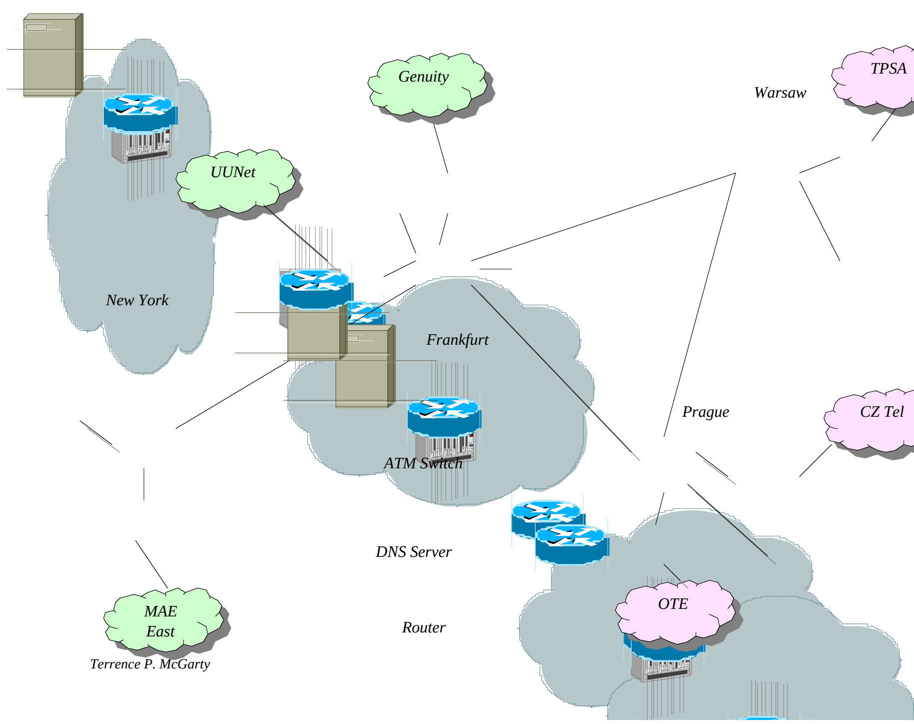
Clearly Central Europe because of its lack of agglomeration pays a premium to transit when it could be peering. The premium is really a payment to US companies such as UUNet which in many ways is a tax on Central European users and a subsidy to US users.

5. ARCHITECTURES

This section presents a summary of the structural elements of International Internet interconnectivity focusing on Central Europe.

5.1 *The Service Infrastructure*

The overall architecture of the backbone network is shown below. It is composed of various access points which are locations for interconnection, peering, transiting, and switching. The network is frequently ATM based to allow virtual IP connections to maximize utilization and quality of service, however all IP backbones using MPLS are common. There are six key elements to the overall service: routers, ATM Switches, DNS Servers, backbone networks, External Peering Points, these are peering elements with Genuity, UU Net and other Tier 1 ISPs, Internal Peering Points: These are the peering points for member entities and are for intra network peering.



The overall architecture of the MAE Europe construct is shown below. It consists of NAPs which are interconnected as a distributed single entity. These NAPs then interface with other NAPs and MAE East and West, as may be required.

5.2 *Elements*

It is best to start with a set of Definitions:

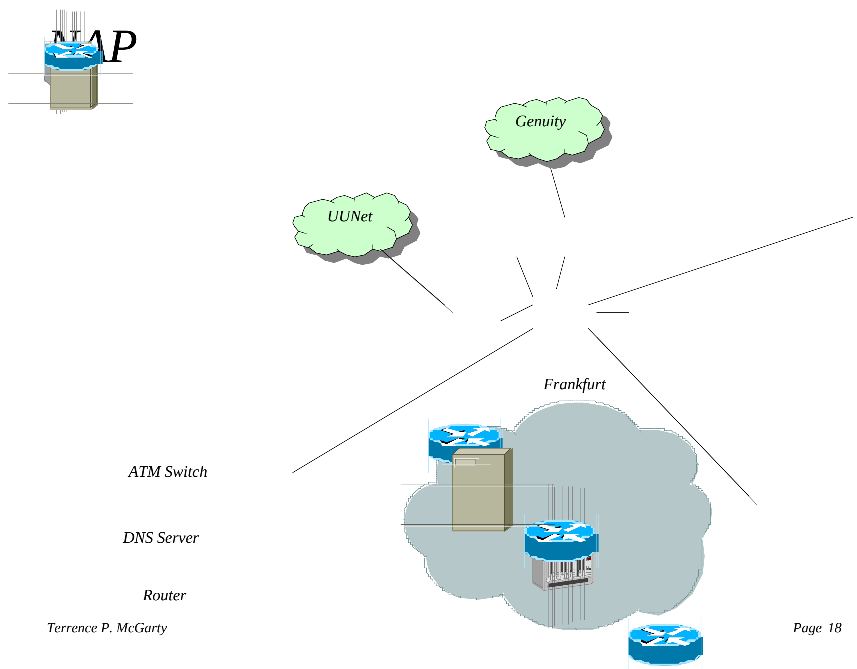
MAE East/West is a point at which multiple Tier 1 ISPs have agreed to interconnect. These points are interconnected by the broadband Internet backbone network. At the MAEs, one in Reston Virginia and on in San Jose California, the Tier 1 Carriers agree to both inter-exchange traffic as well as provide IP address switching facilitation. For a customer on ISP to connect to a provider on ISP 2's network, the two must agree to share addresses and allow interconnection.

Network Access Points (NAPs) are one of several locations where ISPs interconnect their networks. A NAP also includes a route server that supplies each ISP with reachability information from the routing arbiter system.

Domain Name Systems (DNS) are the on-line distributed database systems used to map machine names into IP addresses. DNS servers throughout the connected Internet implement a hierarchical namespace that allows sites freedom in assigning machine names and addresses.

5.3 NAPs

The Network Access Point is an inter/intra country or region point for ISP interconnectivity. A typical example is shown below.



The original system of peering has evolved over time. Initially, most exchange of traffic under peering arrangements took place at the NAPs, as it was efficient for each backbone to interconnect with as many backbones as possible at the same location, as shown in the example in Figure 2. Each backbone must only provide a connection to one point, the NAP, rather than providing individual connections to every other backbone. The rapid growth in Internet traffic soon caused the NAPs to become congested, however, which led to delayed and dropped packets. For instance, Intermedia Business Solutions asserts that at one point packet loss at the Washington, D.C. NAP reached up to 20 percent. As a result, a number of new NAPs have appeared to reduce the amount of traffic flowing through the original NAPs. For example, MFS, now owned by WorldCom, operates a number of NAPs known as Metropolitan Area Exchanges(MAEs), including one of the original NAPs, the Washington, D.C. NAP known as MAE-East, as well as MAE-West in San Jose, and other MAEs in Los Angeles, Dallas, and Chicago.

Another result of the increased congestion at the NAPs has been that many backbones began to interconnect directly with one another. This system has come to be known as *private peering*, as opposed to the public peering that takes place at the NAPs. Backbones *A* and *B* have established a private peering connection through which they bypass the NAP when exchanging traffic for each other, they both only use the NAP when exchanging traffic with backbone *C*. This system developed partly in response to congestion at the NAPs, yet it may often be more cost-effective for the backbones. For instance, if backbones were to interconnect only at NAPs, traffic that originated and terminated in the same city but on different backbones would have to travel to a NAP in a different city or even a different country for exchange. With private peering, in contrast, it can be exchanged within the same city.

This alleviates the strain on the NAPs. At one point it was estimated that 80 percent of Internet traffic was exchanged via private peering. Because each bilateral peering arrangement only allows backbones to exchange traffic destined for each other's customers, backbones need a significant number of peering arrangements in order to gain access to the full Internet. UUNET, for instance, claims to "peer with 75 other ISPs globally." As discussed below, there are few backbones that rely solely on private or public peering to meet their interconnection needs.

The alternative to peering is a transit arrangement between backbones, in which one backbone pays another backbone to deliver traffic between its customers and the customers of other backbones. Transit and peering are differentiated in two main ways. First, in a transit arrangement, one backbone pays another backbone for interconnection, and therefore becomes a wholesale customer of the other backbone. Second, unlike in a peering relationship, with transit, the backbone selling the transit services will route traffic from the transit customer to its peering partners.

Those few large backbones that interconnect solely by peering, and do not need to purchase transit from any other backbones, will be referred to here as *top-tier backbones*. Because of the non-disclosure agreements that cover interconnection between backbones, it is difficult to state with accuracy the number of top-tier backbones; according to one industry participant, there are five: Cable & Wireless, WorldCom, Sprint, AT&T, and Genuity (formerly GTE Internetworking).

In addition, as noted above, transit gives a backbone access to the entire Internet, not just the customers of the peering partner. In order to provide transit customers with access to the entire Internet, the transit provider must either maintain peering arrangements with a number of other backbones or in turn must pay for transit from yet another backbone. In other words, a backbone providing transit services is providing access to a greater array of end users and content than it would as a peer, thereby incurring correspondingly higher costs that are recuperated in the transit payments. In a competitive backbone market, transit prices should reflect costs and should not put entering backbones at a competitive disadvantage.

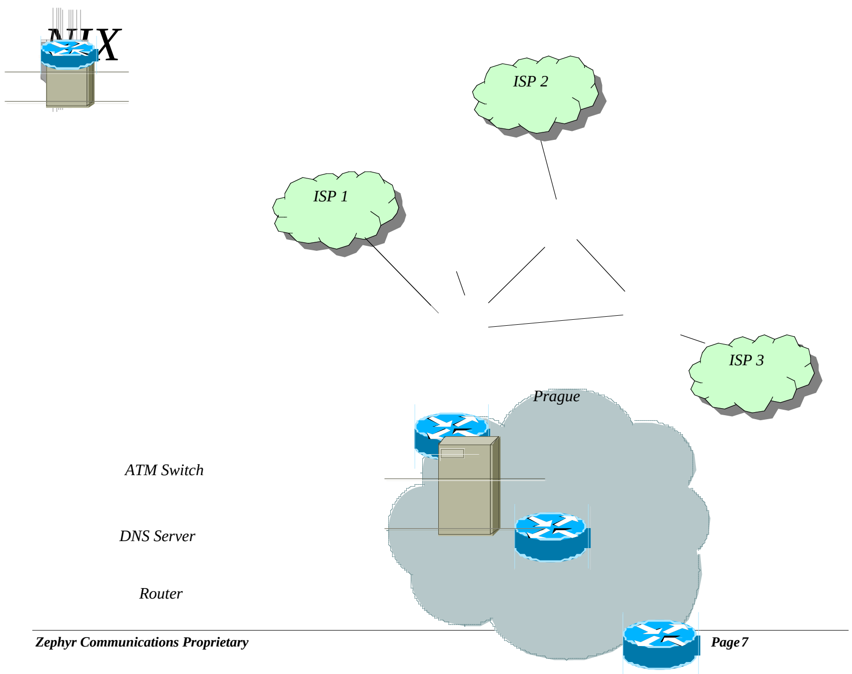
5.4 MAEs

MAE, the Merit Access Exchange, is a peering point of ISPs who then interconnect into the vBNS, the broadband Internet backbone. The MAE in many ways look like a NAP.

ISPs maintain IP networks, connected to the Internet through network access points (NAPs), at key locations currently California, Chicago, Washington, D.C., and New York, or by connecting to other ISPs. NAPs are the entry points to the Internet, where ISPs share information. There are other means of sharing such data between networks, such as the Commercial Interexchange (CIX). Netcom's star-shaped points of presence and telecommunications backbone are centered on the NAPs' hookups. Note that the ISP network is a 45 mbps backbone of T-3s that connect the major points, as well as to the Texas area, where there is no NAP (also see UUNET's backbone network topology in Figure 6.2). Typically, larger ISP networks are cell-switched and framerelay- based. For reliability, ISPs usually depend on more than one interexchange carrier (IXC) to provide time division multiplexing (TDM) point-to-point (or permanent leased line) T-1 and T-3 circuits, which interconnect the POPs. ISPs provide two types of service: leased line and dial-up. We have seen the emergence of another class of ISP, those which interconnect POPs by leasing frame-relay service directly from IXCs, which reduces somewhat the capital an ISP must make to its own network

5.5 NIXs

The NIX, the National Internet Exchanges, is simply a local intra country DNS type facility allowing local ISPs to have interconnectivity. It is shown below in simple form. The NIXs are quite prevalent in Central Europe. They evolved from the academic institutions and generally provide intra-country peering. It is possible to use a Polish ISP and be able to access only Polish web sites and send mail only to Polish subscribers. The ISP has no external connection. The NIX has no connection to the outside world and the ISPs who connect do so only with each other and block any attempts by others to transit.



6. CONCLUSIONS

Interconnection and access is either a complex economic analytical problem if viewed from the perspective of the incumbent and the retention of the incumbents control over the market or a fairly simple matter if viewed from the perspective of the consumer.

The author has struggled extensively over the past ten years in working the simpler interpretation of interconnection and access.[13] What has been shown in the development of telecommunications access is

[13] McGarty, in March of 1993 presented a paper at a forum at MIT recommending the elimination of access fees between peers. McGarty meets with Robert Pepper head of OPP at FCC and files on February 17, 1993 an ex parte report since his company is seeking Pioneer Preference license. In the case discussed he suggested that a new wireless contended was the equivalent of the existing wire based carrier and that since traffic was generally equal in and out that the most efficient pricing scheme for interconnection was zero, or what is now called "bill and keep". Bill and Keep refers to the artifact that the party collecting the money for the call keeps it. Namely that the party initiating the call has received payment from its customer for service which includes calling and receiving. McGarty stated that from the consumers perspective they are "buying" service up to a connect point whether they initiate or receive a call. That long distance is a separate service from a separate vendor, and that interconnection between essential peers, that is facility based entities providing the same service should be at bill and keep.

that regulation has been totally ineffective. It has allowed for regulatory delay and this delay has been a contributing factor the many of the CLEC failures. The regulation of the Internet, what little there is, seems to be well out of the hands of the FCC but clearly focuses on issues of similar concern. There are dominant carriers but they do not seem to be as healthy as the ILECs. For example, currently Genuity makes $300 million or more per quarter in revenue, has zero percent gross margin and has OPEX of $300 million, thus loosing $300 million per Quarter! Clearly there is something wrong somewhere. The details on UUNet are not as clear.

It is essential that common and readily achievable conditions for peering be specified. It is clear that growing markets such as Central Europe and South East Asia need to have par passu positions with American ISPs and that the peering element is a key element in this process. It is clear that peering is the embodiment of bill and keep and that fortunately the carriers have taken the step without regulation in that direction. There is no Baumol Willig theorem for the Internet, despite the attempts to do so.

Extensions to local broadband networks is also essential. For example, although not discussed at length herein, the same issue would apply to CATV except for the lack of per user disaggregation capacity.

The following Table compiles a set of attributes of Telephony and Internet Services and compares and contrasts them. The recent paper by Frieden on the change of the Internet and its control, also its architecture in may ways, is prescient in terms of what is presented in the following and the changes that are occurring in the Internet.[14] This following Table can represent a starting point for the comparison of these two markets and can be used to see that there are great similarities and inherent market dominances and inefficiencies.

	Telephony	*Internet*
End User	The end user is frequently a person who makes all the choices, phone, local carrier, long distance carrier and international carrier. Also the end user chooses the collection of added services.	The end user is the same in almost all cases to the telephone world.
End User Control or Choices	End User has significant span of choice in selecting the elements to create the services.	The end user has limited control or visibility of the service elements or providers. Generally there is a local purveyor who bundles all elements together.

On May 24, 1993, J. Hausman files a response to the McGarty ex parte filing. William Adler, head of Federal Regulatory for Pacific Telesis actually files a report by Jerry Hausman, date May 15, 1993, responding to the McGarty paper, to the FCC. Hausman states in his rebuttal to the McGarty paper:

"The … paper's preferred solution of co-carrier status … based on equal access fees for all common carriers is bad economic policy…it takes no account of the costs of providing access. Cost based prices are the correct basis to ensure economic efficiency."

Based upon the new law, COMAV files a complaint with the Justice Department on March 30, 1996 against Bell Atlantic (COMAV, LLC v. Bell Atlantic NYNEX Mobile, March 30, 1996, Complaint filed with Department of Justice, Antitrust Division.). COMAV is a Massachusetts based CLEC and using the theory of bill and keep it seeks to establish interconnection between wireless companies as well as wireline companies. COMAV argues that the new law can be interpreted to make a CMRS, Commercial Mobile Radio Service also a Telecommunications Service. Bell Atlantics refusal to establish interconnect was considered anti-competitive.

Based upon delays in the Justice Department and based upon the FCC establishing the Admistrative law, COMAV withdraws its complain and files with the FCC, May 15, 1996, COMAV Petition to FCC Common Carrier for Interconnection to Bell Atlantic. The FCC still has not established the interpretation of the new law. That will take a year.

The Complaint from 1996 sat silent for four years, no hearings, no documentation. Three weeks prior to the FCC OPP bill and keep report, November 2000, FCC Rejects the COMAV Complaint, the Common Carrier Bureau suddenly reacts and rejects the complaint. In three weeks it would be moot.

[14] See also the paper by Mindel and Sirbu, regarding regulatory treatment if IP.

	Telephony	*Internet*
		This is due to the newness of the services as well as the current structure of the industry.
Pricing	The End User has general visibility to service element pricing. There is separate billing, disaggregatable service providers and pricing. Namely, the end user can see the prices for each segment of his selected purchase.	Generally these are bundled prices. The end user sees a fixed bill per month, in the US, and a fixed plus variable bill elsewhere. In non-US locations the carriers charge per minute fees. These are split with ISPs. However, with a cable modem or DSL device there is variable pricing, and the pricing is more media related than service related.
End User Interconnection Device	This is the simple telephone.	This is a PC or similar device plus a dial modem, a cable modem, a DSL device, or some other device.
Local Interconnection Carrier	This is the ILEC in almost all cases but it may be a CLEC. In some rare cases it may be a wireless or CATV entity. We have kept wireless/mobile networks as separate entities, albeit they appear very much the same as telephony that is wire based.	This may be an ISP which is dial up, a CATV carrier, or a DSL provider. In some cases it may even be wireless. However the local carrier bundles everything into one service. The local carrier typically gets you to the backbone provider. Thus Verizon ISP gets you to Genuity.
Backhaul Interconnection Carrier	This is the Interexchange carrier. The IXC frequently still pays an access fee and is now generally considered sub-ordinate to the LEC.	This is typically one of the large Tier 1 carriers who provide meet points that are public or private in many locations. They bill on a transit basis. The local carrier pays the backhaul a fee and the backhaul is inferior to the local carrier. The change in power seems to be less due to the control of the customer than control of the DNS or peering points.
International Carrier	There generally are international carriers who range from PTTs to Internet Telephony carriers. Some are licensed and some are not. Arbitrage has been swept out of this market and price reflects cost	Generally this is the extension of the US Tier 1 ISPs and their meet points. The presence of UUNet is almost universal. Generally the cost of entry was network access.[15] With the glut of fiber

[15] McGarty (1990) stated the following:

	Telephony	*Internet*
	in most carriers. This economic clearing of the market occurred in less than five years.	however in western markets transport costs are virtually zero.
Switching	Switching is hierarchical but with some distributed elements with SS-7.	Switching is generally or conceptually distributed. In reality however it hierarchical with the Tier 1 carriers establishing meet or transit points and the Tier 1 carriers establishing network architecture.[16]
Architecture	Generally highly hierarchical with the classic five levels of switches. Introduction of some distributed processing with SS-7 type databases and signaling.	Generally very distributed. However, with the control of the backbone, the span of fully distributed may be limited to a country or a region, and may actually be shrinking.
Control	Control is centralized and intercarrier control procedures are well defined.	The progress towards an improved control scheme is being worked. However, Tier 1 carriers are effectively controlling this by their introduction of Service Level Agreements.
Billing	Disaggregatable billing.	Bundled billing. This is amazing especially for what is a distributed network where billing could be quite creative. This may be a carryover from the original intent of a free and open network, namely a total disregard for billing as a concept.
Meet Points	Well defined technically and in a regulatory framework.	They are not supposed to exist due to the distributed network style but clearly exist in the

---

This technological change will undoubtedly change the world view of network providers. If ***bandwidth is relatively free*** *then the use of processing at the CPE becomes a vital ingredient in the network design. The hierarchical network is no longer the only choice, in fact its viability is called into question. The move towards that end, as we have already shown in the LAN area, is already under way. The development of new means of interconnect will result in significant changes to the network. Specifically, we see;*

1. The network will become more organic. The end user will have direct control and access to the interconnect, interface and control functions.
2. There will be less materiality of scale. In the current architectures, there is scale and the performance of interconnect is a result of the scale of the network. Simply stated, we need a big network with a great deal of switches so that we can talk to one another. In the network with user controlled interconnect and "free" bandwidth, the materiality of this scale is no longer a factor. That is, infrastructure is at best irrelevant and at most counterproductive.
3. Multiple overlay networks are connectable, from both within and without the core net. Thus, viable overlays can lead to local short term optimizations that meet end user needs.
4. Intelligence in the CPE is expansive and reduces the capitalization needs for networks. It also reduces the time scale factor for the introduction of new technologies mapped to the technology change curves.

[16] See Frieden

	Telephony	*Internet*
		context of economic control points. In this paper we have tried to establish a set of criteria for them and we believe that they exists and can be used in a manner consistent with the ability to disaggregate all elements.
Transit or Access Peering or Bill and Keep.	Access fees are charged to all but monopolists. Bill and keep has been recently suggested by FCC.	Transit fees are charged by all Tier 1 oligopolists. Peering has been recently recommended by FCC.
Pricing	Pricing seems to being reduced to cost factors, monopoly rents seem to be less of a factor except in LEC markets where there is no competition.	Local pricing now seem to be rising. Unknown what true prices are in backhaul.
Legal Underpinnings	Telephony has developed in a state run monopoly structure in almost all countries except the U.S. In the U.S. it was a non state run monopoly. Currently controlled by the 1996 Act and the Administrative code developed derivative thereto, and as may be interpreted by Administrative precedents.	None
Regulator	In the U.S. it is the FCC or the State PUC.	None.
Regulatory Theory	In the U.S. the theory developed extensively in the 1950s-1960s just prior to de-regulation. The theory was developed to in many ways justify actions that the monopolist wanted to take, and not necessarily from any free market understanding. The attempts to do ad hoc propiter hoc arguments as was done with Baumol and Willig have been maintained but seem to be breaking.	None as of this date has take hold. The attempts to regulate as a telephony network have been attempted. The ability to establish a parity of service and system elements has not been dramatically successful to date.
Place for Remedy	Initially Administrative bodies such as FCC or PUC then courts through Antitrust procedures. May also seek remedies in Tort	Antitrust and tort issues. Establish antitrust issues as tying agreement and the like to litigate.[17]

[17] See Areeda- Turner test in Areeda and Kaplow.

	Telephony	*Internet*
	law issues.	
Security	High physical and network security. Closed system elements, legal protection, regulatory protection.	Highly insecure. The Tier 1 backbone providers quite frankly provide best security.

It is recommended that more detailed comparison between the two markets be developed. The stated dictum that they are dramatically divergent appears to be false. The similarities between the two may act as a means to balance the growth of both in a open and competitive fashion.

7. REFERENCES

1. Areeda, P., L. Kaplow, Antitrust Analysis, Little Brown and Co (Boston), 1988.

2. Baumol, W.J., J. G. Sidak, Toward Competition in Local Telephony, MIT Press, Cambridge, MA, 1994.

3. Brown, S.J., D.S. Sibley, The Theory of Public Utility Pricing, Cambridge University Press, Cambridge, England, 1986.

4. Coll, S. The Deal of the Century, Atheneum (New York), 1986.

5. DeGraba, Patrick, Bill and Keep at the Central Office As the Efficient Interconnection Regime, FCC OPP Working Paper, December, 2000.

6. de Sola Pool, I., The Social Impact of the Telephone, MIT Press (Cambridge, MA), 1977.

7. Frieden, R., Revenge of the Bellheads: How the Netheads Lost Control of the Internet, TPRC, 2001.

8. Henderson, J.M., R.E. Quandt, Microeconomic Theory, McGraw Hill, New York, 1980.

9. ITU, ITU Internet Reports: IP Telephony, December 2000, ITU, Geneva.

10. Laffont, J.J., J. Tirole, Competition in Telecommunications, MIT Press, Cambridge, MA, 2000.

11. McGarty, T.P., Alternative Networking Architectures; Pricing, Policy, and Competition, Information Infrastructures for the 1990s, John F. Kennedy School of Government, Harvard University, November, 1990.

12. McGarty, T.P., Communications Networks; A Morphological and Taxonomical Approach, Private Networks and Public Policy Conference, Columbia University, New York, October, 1991.

13. McGarty, T.P., Alternative Networking Architectures, B. Kahin Editor, McGraw-Hill (New York), October, 1991.

14. McGarty, T.P., Architectures et Structures de L'Information, Reseaux, No 56, pp. 119-156, December, 1992, Paris.

15. McGarty, T.P., Wireless Access to the Local Loop, MIT Universal Personal Communications Symposium, March, 1993.

16. McGarty, T.P. , Spectrum Allocation Alternatives; Industrial; Policy versus Fiscal Policy, MIT Universal Personal Communications Symposium, March, 1993.

17. McGarty, T.P., Access Policy and the Changing Telecommunications Environment, Telecommunications Policy Research Conference, Solomon's Island, MD, September, 1993.

18. McGarty, T.P., Internet Architectural and Policy Implications, Kennedy School of Government, Harvard University, Public Access to the Internet, May 26, 1993.

19. McGarty, T.P., Wireless Architectural Alternatives: Current Economic Valuations versus Broadband Options, The Gilder Conjectures; TPRC Solomon’s Island, MD, September, 1994.

20. McGarty, T.P., PCS Economics, TPRC Solomon’s Island, MD, September, 1994.

21. McGarty, T.P., From High End User to New User: A New Internet Paradigm, McGraw Hill (New York), 1995.

22. McGarty, T.P., Disaggregation of Telecommunications, Presented at Columbia University CITI Conference on The Impact of Cybercommunications on Telecommunications, March 8, 1996.

23. McGarty, T.P., The Economic Viability of Wireless Local Loop, and its Impact on Universal Service, Columbia University CITI seminar on "The Role of Wireless Communications in Delivering Universal Service", October 30, 1996.

24. McGarty, T.P., Communications Networks; A Morphological and Taxonomical Approach, Private Networks and Public Objectives (Noam, Editor),Elsevier (London), 1996.

25. McGarty, T.P., The Economic Viability of Wireless Local Loop, and its Impact on Universal Service, Telecommunications Policy, Elsevier (London), 1997.

26. McGarty, T.P., Comparative Deregulation of Far Eastern Telecommunications Markets, Telecommunications Policy Research Conference, Washington, DC, September 28-30, 1997.

27. McGarty, T.P., The Application of IP Telephony to Local Exchange Carriers, MIT, Internet Telephony Consortium, March, 1999.

28. J.L. Mindel, M.A. Sirbu, "Regulatory Treatment of IP Transport and Services", TPRC, 2000.

29. Shinman, D.R., J. Rosenworcel, Assessing the Effectiveness of Section 271 Five Years After the Telecommunications Act of 1996, TPRC, 2001.

30. Willig, R.D., Consumer Equity and Local Measured Service, in Perspectives on Local Measured Service, J.A. Baude Eds, Telecommunications Workshop Kansas City 1979.

8. UUNET POLICY

WorldCom Policy for Settlement-Free Interconnection with Internet Networks
January 2001

Background and Introduction

This document sets forth WorldCom's Policy for Settlement-Free Interconnection with Internet Networks ("Policy"), also referred to as "peering." The Policy extends WorldCom's existing North American Policy to Europe and Asia-Pacific and adjusts the minimum operating requirements to current traffic levels. The Policy is consistent with settlement-free interconnection policies recently announced by other Internet Networks. WorldCom will publish, maintain, and update its Policy on the WorldCom public Web site at www.worldcom.com/peering/.

Part 1 of the Policy details the interconnection requirements that an Internet Network requesting interconnection (the "Requester") must meet in order to qualify for settlement-free interconnection. The Policy establishes separate requirements for each of WorldCom's three regional Internet Networks, AS701 (WorldCom-US), AS702 (WorldCom-Europe), and AS703 (WorldCom-ASPAC), with the requirements scaled for each network. WorldCom also will consider requests for settlement-free interconnection on a national level or in other regions of the world, with the same guiding principles and with appropriately scaled interconnection requirements. Part 2 of the Policy specifies the operational requirements for interconnecting networks, which both the Requester and WorldCom must satisfy. Finally, Part 3 delineates some general notifications regarding the Policy.

This Policy is effective January 5, 2001, and applies to all requests for settlement-free interconnection with a WorldCom Internet Network, either via dedicated connections ("direct peering") or via traffic exchange at a multi-party network access point ("public peering"). WorldCom will not apply the Policy with respect to existing agreements for settlement-free interconnection via dedicated connections until January 5, 2002. At this time, due in part to inadequate measurement capabilities and WorldCom's traffic levels at public peering points, WorldCom has no plans to apply the Policy with respect to existing agreements for settlement-free interconnection at multi-party network access points, and WorldCom will provide at least 12 months notice to existing public peers before doing so.

1. Interconnection Requirements

1.1 Geographic Scope. The Requester shall operate facilities capable of terminating customer leased line IP connections onto a router in at least 50% of the geographic region in which the WorldCom Internet Network with which it desires to interconnect operates such facilities. This currently equates to 15 states in the United States, 8 countries in Europe, or 2 countries in the Asia-Pacific region. The Requester also must have a geographically-dispersed network. In the United States, at a minimum, the Requester must have the ability to meet WorldCom's Internet Network at an East Coast location, a West Coast location, and at least two Midwest locations.

1.2 Traffic Exchange Ratio. The ratio of the aggregate amount of traffic exchanged between the Requester and the WorldCom Internet Network with which it seeks to interconnect shall be roughly balanced and shall not exceed 1.5:1.

1.3 Backbone Capacity. The Requester shall have a fully redundant backbone network, in which the majority of its inter-hub trunking links shall have a capacity of at least 622 Mbps (OC-12) for interconnection with WorldCom-US, 45 Mbps (DS-3) for interconnection with WorldCom-Europe, and 12 Mbps for interconnection with WorldCom-ASPAC.

1.4 Traffic Volume. The aggregate amount of traffic exchanged in each direction over all interconnection links between the Requester and the WorldCom Internet Network with which it desires to interconnect shall equal or exceed 150 Mbps of traffic for WorldCom-US, 30 Mbps of traffic for WorldCom-Europe, and 5 Mbps of traffic for WorldCom-ASPAC.

2. Operational Requirements

The following operational requirements apply both to the Requester and to the WorldCom Internet Network with which it desires to enter into a settlement-free interconnection arrangement:

2.1 Each Internet Network must establish and maintain traffic exchange links of a sufficient robustness, aggregate capacity, and geographic dispersion to facilitate mutually acceptable performance across the interconnect links.

2.2 Each Internet Network must operate a fully functional 24x7 Network Operations Center.

2.3 Each Internet Network must set next hop to be itself, the advertising router of the network. Each Internet Network will propagate such routes to its transit customers with its own router as next hop.

2.4 Each Internet Network shall implement "shortest exit routing" and advertise routes consistent with that policy, unless both Internet Networks mutually agree otherwise based on special circumstances.

2.5 Each Internet Network must operate a fully redundant network, capable of handling a simultaneous single-node outage in each network without significantly affecting the performance of the traffic being exchanged.

2.6 The two Internet Networks must exchange with each other prior to any settlement-free interconnection agreement a free shell or PPP account for testing and auditing purposes related to routing. This will be used for confirmation of traffic flows, troubleshooting of interconnection-related issues, and auditing purposes.

2.7 Each Internet Network must be responsive to unsolicited email and network abuse complaints, as well as routing and security issues, providing a knowledgeable technician within a two-hour period after notice.

2.8 For the purposes of Requirements 1.2 and 1.4 of the Policy, all traffic is to be measured over interconnection links. In the event that such links do not exist, the two Internet Networks may establish temporary test links for the purposes of traffic measurement. In the event that establishing such links is not feasible or desirable, traffic will be measured at peak utilization, based upon a representative sample consistent with industry practice.

2.9 For the purposes of Requirements 1.2 and 1.4 of the Policy, the traffic to be measured will include only what is being exchanged by the two Internet Networks and their respective customers (excluding any transit traffic).

3. General Policy Notifications

3.1 The two Internet Networks must enter into a Mutual Non-Disclosure Agreement and an Interconnection Agreement.

3.2 The requirements in Part 1 must be met at the time the request for settlement-free interconnection with WorldCom is made.

3.3 All requirements of the Policy must continue to be met to continue a settlement-free interconnection relationship. Status under the policy will be evaluated periodically. In the case of a change in ownership or control of an Internet Network with which WorldCom has an interconnection agreement, status under the policy will be evaluated within 30 days of such change.

3.4 WorldCom will continue to monitor the development of the Internet and traffic conditions and make appropriate changes in this Policy as the Internet continues to evolve. WorldCom reserves the right to modify this Policy at any time. Any contractual rights shall arise out of a bilateral interconnection agreement, not this Policy.

3.5 All requests for settlement-free interconnection should be submitted to WorldCom via e-mail at **peering@wcom.com**. An Internet Network may submit a request for interconnection once per calendar quarter.