International IP Telephony[1]

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CONTENTS

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1. INTRODUCTION

This chapter discusses international Internet (IP) telephony. It presents an overview of the types of providers, the technology and technological challenges, the regulatory issues and the market potential. The chapter first presents an overall schema for the technical architecture for the implementation of the network and provision of international Internet telephony services. The chapter then describes some of the current providers of such services as examples of the alternative approaches to the business, the market and the technological implementations of Internet telephony and other advanced Internet services. The chapter then discusses the domestic and international regulatory issues arising from the advent of Internet telephony. These regulatory questions will dictate the short term future of international Internet telephony. Longer term, network interconnection issues and the resultant positive and negative network externalities stemming from the convergence of voice and data networks and the emergence of differentiated services will be critical for the growth of advanced forms of Internet telephony and other advanced Internet services. Finally, the chapter concludes with a discussion of international interconnection facilities for combining Internet and Intranet type networks and the advantages and disadvantages of both approaches to international Internet service provision.

2. INTERNATIONAL INTERNET ARCHITECTURES

The architectures for intemational Internet or Internet like telecommunications depend upon several dimensions. These dimensions are the users, the uses, the world view and the underlying enabling technology.

The concept of a telecommunications architecture has been a cornerstone in the development of new telecommunications systems. However, the structural elements of these architectures have not played a role in the development of policies. In this section we will develop the concept of an architecture as a means to understand the network as both a market and regulatory entity, and will provide a new set of perspectives for viewing the network in terms of a new paradigms and world views. The more recent actions of AT&T and the BT joint venture clearly depict the world view approach having sustainability. As we shall show latter in this Chapter, the view that the telecommunications world is centrally and hierarchically controllable by a single or limited number of players is still alive an well in the mind of AT&T.

An architecture, first, requires that the underlying system be treated in terms of a set of commonly understood elements and that these elements have a clearly demarcated set of functions and interfaces that allow for the combining of the basic set of elements. The way the elements then can be combined, reflected against the ultimate types of services provided, determine the architecture.

An architecture, secondly, is driven by two factors; technology and world view. Technology places bounds on what is achievable, however those bounds are typically well beyond the limits that are self-imposed by the designer or architect in their view of the user in their world. This concept of architecture and the use of design elements is critical in understanding the paradigms used in the structure of information systems. World view is the more powerful driver in architecture. We argue in this Chapter that it is essential to develop a philosophical perspective and understanding of how to view networks.

The concept of a paradigm is in essence the collection of current technologies that we have at hand for the network and the ways we put these elements together. New paradigms result from new technologies. New technologies allow for the placing of the elements together in new ways.

The concept of a world view is an overlying concept that goes to the heart of the arguments made in this Chapter. If we view our world as hierarchical, then the network may very well reflect that view. If we further add to that view a bias towards voice communications, these two element will be reflected in all that we do. The very observations that we make about our environment and the needs of the users will be reflected against that view.

Architecture is the combination of three elements; the common elements, the underlying technology and the world view. Architecture can be defined as the conceptual embodiment of a world view, using the commonly understood set of constructural elements, based upon the available set of technologies.

The architectural elements are control, transport, interconnect and interface. In Figure 6, we depict the overall architecture of the element interrelationship and the elements of the functions of the separate elements. The details on each are described below:

1. Control: Control elements in an architecture provide for such functions as management, error detection, restoral, billing, inventory management, and diagnostics. Currently, the voice network provides these functions on a centralized basis, although in the last five years there have evolved network management and control schemas and products that allow for the custom control and management of their own network. What is important, however, is that network control providing the above functions is an essential element for either a public or private network. Thus as we consider network evolution, this element or set of function must be included. Control has now been made to be flexible and movable. The control function is probably the most critical in the changes that have been viewed in the context of an architecture.

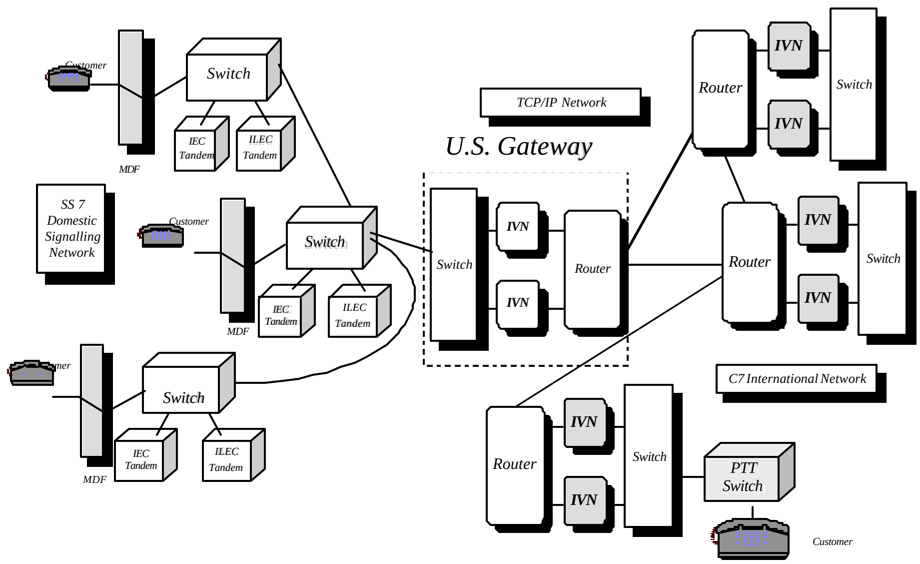
2. Transport: The transport element is provided by the underling transport fabric, whether that be twisted pair of copper, fiber optic cable, radio or other means. Transport should not be mixed or confused with other elements of the network. Transport is merely the provision of physical means to move information, in some form such as digital, from one point to another. At most it is expressed in bits per second and at best it is expressed in bandwidth only. Bandwidth as a transport construct is the most enabling. Transport does not encompass the need to change the information or to do any other enhancement to the information.

3. Interconnect: The interconnect element of the architecture describes how the different users are connected to one another or to any of the resources connected to the network and is synonymous with switching. Interconnection assumes that there is an addressing scheme, a management scheme for the addresses, and a scheme to allow one user to address, locate and connect to any other user. Interconnection has in the past been provided by the Central Office switches. As we shall discuss latter, this implementation of an architectural element was based on certain limitations of the transport element. With the change in the transport element of structures allowing greater bandwidth, the switching needs have changed. Specifically, distributed systems and scale economies of the distributed architectures allow for interconnectivity controlled by the CPE and not the Central Office. There are three general views of interconnection that are valid today; the Telecom, the Computer Scientist, and the User. The Telecom view is based on the assumption of voice based transport with universal service and the assumption of the inseparability of interconnect and control. The Computer Scientist view is based upon the assumption that the network, as transport, is totally unreliable, and that computer hardware and software must be used in extremis to handle each data packet. Furthermore the Computer Scientist's view of the network is one where timeliness is secondary to control. The Computer Scientists view has been epitomized in the quote, "Every Packet is an Adventure". This is said with glee, in that each data packet is set out across the network and it is through the best of hacking that the Computer Scientist saves the packet from the perils of Scylla and Charybdis. The third view is that of the user, who is interested in developing an interconnect capability that meets the needs and minimizes cost. This is minimization of both obsolescence and cost strategy.

4. Interface: The interfaces are the end users connection to the transport element. The interface element provides for the conversion from the end user information stream and the information streams that are used in the transport form of the network. For example, the telephone interface for voice is the analog conversion device.

We have divided the network elements into these four categories to demonstrate that there are clearly four distinct and separable areas for growth and policy formation. Issues of regulation, due to potential monopolist control are always a concern, but it will be demonstrated that in all four there are economies in market disaggregation.

The following depicts the full scope of the international network. The network must support any form of end user telecommunications and must also handle the adjuvant signalling that supports the network operations. Thus signalling includes at a minimum SS 7 in the United States and C 7 in most international domains. This is out of band signalling that must be interfaced via a gateway type switch. In the following we also show the use of TCP/IP as the backbone international transport network. The figure shows a domestic US network using SS7 signalling and then uses a gateway switch that allows for international transport using devices called IP Voice Nodes, IVNs, that converts between circuit switched voice to packet switched voice.

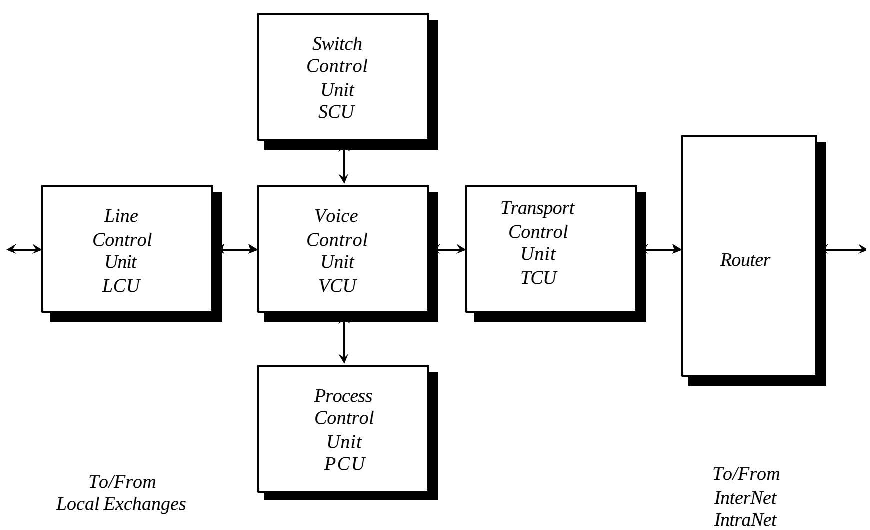


What is important to understand in this general architecture is that this approach blends the telecommunications world of standards such as SS7 and C7 into the TCP/IP world of the Internet.

2.1 Network Elements

The network elements that we generically introduced above can be further described as follows; switches, transport, interface and control. We describe the options and architectural alternatives to these in the following.

We assume that there is a device called the IVN, or IP voice node. The basic system building block is the IP Voice Node (IVN), shown below:



LCU: The Line Control Unit, LCU, is the interface between the telephone network and the IVN. The LCU provides for call initiation and termination. The initial LCU provides for signaling to and from the local telephone network. This unit must provide for SS7 and C7 interfacing or PRI or similar interfacing. One approach may be to front end the LCU with a PBX or switch which may perform these functions.

PCU: Process Control Unit, PCU, provides the capability of controlling the processes of a general nature such as network management, billing, and the IVN provisioning capability. The PCU has an SNMP agent for network management and a billing control unit, BCU, for the management of calling cards and other similar elements.

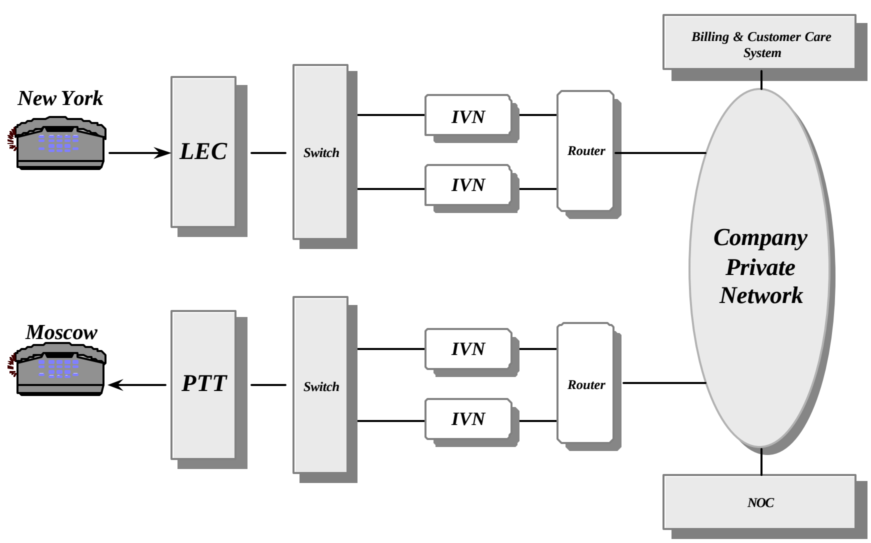
SCU: The SCU, or switch control unit, provides for the conversion between the telephone number for dialing and the TCP/IP address for Intranet connectivity. On initiation, the IVN sends the SCU the telephone number to be called. The SCU converts the telephone number into an IP address and the SCU inserts this in the transmitted packet. On receive or termination the SCU converts the IP address and other header information into the terminating called number. The SCU sends this to the LCU, which then connects this to the local exchange.

VCU: This is the Voice Processor or the voice card. It compresses or decompresses the speech, turns it into a packet, and sequences, schedules, and protocol converts it for Intranet access. It also converts between a local telephone number and an Intranet address. The VCU compresses the analog voice signal into a digital signal. The current system converts the voice in an 8 Kbps signal. The authors believe that it can achieve 4 Kbps compression in a year and 2.4 Kbps compression in three years. This means that more subscribers can be supported on the same IntraNet backbone network.

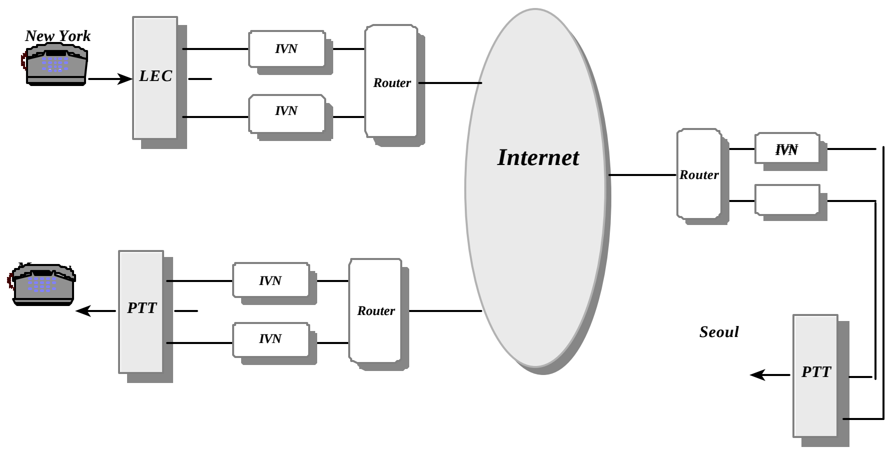
TCU: The Transport Control Unit, TCU, provides for the packet synchronization between transmit and receive. It is the scheduler of the packets on transmit and the synchronizer of the packets on receive. It also provides for the sorting out of the packets on transmit and receive. The TCU interfaces with the Router via an Ethernet interface.

Router: This is a standard router such as provided by Cisco or equivalent.

The IVN is then placed in one of two generic configurations as shown below. The firs configuration is a dedicated network or channel configuration which uses a private network. This is shown below:



The second configuration is the pure Internet approach taken on by many of the early IP telephony start up companies.



It is important to note that in the second architecture that there is the same IVN but now there is no switch, there is no billing system, there is no Network Operations Center, NOC, and there is a shared network over the Internet replacing any dedicated IP links. The result is a different architecture and a differing world view.

The difference in the architecture is quite evident. The difference in the world view however is no. To deconstruct the world view from the architecture may be possible. The Intranet player wants to work within the context of the global telephone network, they believe that the change will be slower than anticipated and they believe that quality of voice will be set at a nominal threshold and that there will be no bifurcation on the voice quality. Namely the end user will demand a voice quality that is at a minimal level and will not pay a differential for poor quality versus good quality. The Internet world view is one that says that the growth will be significant, that there will be a separate network and that at best the meet point will remain the cumbersome multiple dial network that is in the Internet approach, dial once for access to the Internet then dial the ultimate number. The Internet approach also states that there will be a "ham radio" voice acceptability at a lower costs. This we believe fly in the face of all experience. We demonstrate these in the following Table.

Element	Shared Channel Internet	Dedicated Channel
Security	Highly vulnerable access and control.	Very secure from external attack.
Latency	Long and unpredictable latency.	Traffic Engineered for low latency, ultimate latency derived from codec.
Availability	Low availability since there are multiple and un-predictable elements that cause outages, lost packets, and other failure mechanisms.	High availability due to the controlled environment.
Accessibility	Easily accessible from any location with a telephone line.	Needs points of connection or "meet" points for dedicated

Element	Shared Channel Internet	Dedicated Channel
		circuits.
Costs	Low costs since thy depend on fixed costs per port per month and may actually be usage independent. Some pricing may have a usage factor.	Low costs depending on amount of traffic. Example is an E1 from New York to Russia, at $32,500 per month that can carry 2.5 million minutes per month of traffic is $0.0150 per minute.
Control	Total lack of control. May have SNMP access via TCP/IP at end points.	Total control via embedded NOC facilities.
Management	Management at best at end points. Otherwise unmanageable.	Totally controllable at NOC level.
Provisioning	Readily provisioned. Can be implemented in "days" time.	Complex provisioning of international circuits and at meet points. May take weeks to months.
Speed/data rate	Can use whatever speed the Internet allows at the time controlled by speed of end circuit.	Totally under control of bandwidth obtained in the transmission path.
Flexibility	Flexible in the context of an internet connection.	Flexible in the context of a telephone network connection.
Interconnectivity	Limited interconnectivity due to the E/M or wink type line or Feature Group B terminations.	Full interconnectivity to all telecommunication networks.
Speech Quality	Very poor due to latency and transmission reliability problems.	Excellent toll grade quality. Allows for implementation of national as well as international networks.
Signalling Compatibility	Has no ability to cross transfer traffic from IP to SS7/C7	Fully network compatible, allows transfer from C7/SS7 and any IP network.
Standards	Meets at best Internet "standards".	Meets all integrated standards.

2.1.1 Switches

Switches perform the function of allowing multiple users access to each other. The switch may be a stand alone device separate from the end user or it may be integral to the end users equipment. We shall consider both. However, it must be remembered that we are looking towards a network wherein the communications will be between any and all viable other networks, including the existing telephony network. That telephony network has evolved over 125 years into one wherein there are many standards, protocols, agreements, and other elements that make interconnections generally straight forward but also generally less responsive to changes in technology. Thus, despite whatever better improvements may occur in a TCP/IP network, or Internet configuration, one must align ones expectations with what the massive investment and structure exists in the global telephone network.

2.1.2 Transport

The transport elements is that part of the telecommunications package that allows for the interconnection via electronic means between multiple switches and end user devices. We generally focus on two types; dedicated and shared. In the dedicated form we focus on clear channel circuits that most likely will be using TCP/IP protocol. On the shared type we generally focus on the Internet per se type connections. The differences between the two are significant. It is critical to understand that these differences have been used by some to state that there is a difference between the IP voice and standard voice. The difference may and we believe will disappear. The clear channel approach is best for secure channels of know capacity and wherein control and management. The Internet approach is best viewed an the ubiquitous expedient. It allows the implementers to get something up and running is short order, it does not allow much control over the quality of any of the network elements and places control in the hands of multiple and generally unknown third parties.

2.1.3 Network Control

The backbone network will be managed and controlled in a real time fashion. Operating entities, at all levels of operation, will have the capability of being monitored as to operational effectiveness, network performance, and impact on their interconnecting network elements. The network operations center, NOC, or Manager will be able to determine the locations of any and all outages or system degradation points in the network, or in any other network that a customer may have access to.

The NOC combines the interfaces from several subsystems. The LSOs vendor equipment provides its own stand alone network manager. The overall functions of the NOC are as follows;

Fault Management: This allows for the detection, isolation, identification, and repair of any system faults. This set of functions will be presented in detail in this Specification. Fault Management assumes that there are sub-network managers which can generate fault recognition and transmit them in a common format to the NOC. The NOC then takes these fault reports and combines them from all of the subnetwork managers. The following Figure generically depicts how this process functions. Fault Management must integrate all of the elements and their sub-network managers. The IVN system provider may provide a robust manager for the IVN equipment. The backbone service provider may not provide those elements. The NOC must take all of those elements and integrate then into a single network function.

Accounting Management: Accounting functions allow for the provision and complete sourcing of any and all elements necessary for an audit trail on the faults in the system. The accounting function provides for the necessary process of managing the capital asses base. The accounting function may be integrated into the overall NOC functionality and it is essential if it is to support the configuration database. Generally the NOC does not provide any Accounting Management functions.

Configuration Management: This is the capability to assure that all elements in the system are properly configured and identified in this process. The configuration management process allows for the full and complete knowledge and updating of any and all parts in the system. This is a mapping of the overall accounting function for actively deployed parts and system elements. Configuration management is an essential element in the process of repair dispatching as well as the process of inventory management. Configuration Management requires the critical control of installation as well as operations and maintenance. Any time a unit or object is installed, replaced, modifies, or in any other way changed, the configurations system must track it.

Performance Management: This function allows for the optimization of the system. In the current specification we address the inclusion of both “hard” and “soft” trouble tickets for the tracking of faults and for measuring of performance. The current NOC does not perform overall performance optimization but does provide reports on performance analysis and trend analysis. It is capable of isolating performance factors and can, combined with the Fault Tree system, help isolate overall system Performance factors.

Security Management: The management of the security and integrity of the system is assured by means of a fully integrated and protected system design. There are three levels of security that the system will support; physical, software and database, and system access.

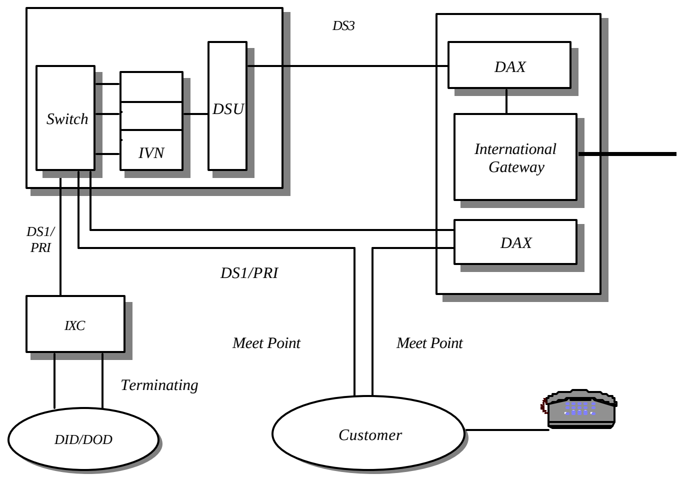
Physical security management is performed by the communications of any and all alarms on IVNs, buildings and other secure locations into the NOC and the connection of the NOC to the appropriate security support systems required by the LSO. The software and database security are the security management measures taken by the NOC and other operators to prevent “internal” compromising of the system.

This is generally by key work control and the NOC can, but is not initially, configured to manages the overall "internal" access management role. The third area is "external" access to the system resources. There is a great concern that with access via TCP/IP or Internet connections. This will require Firewall protection of the system.

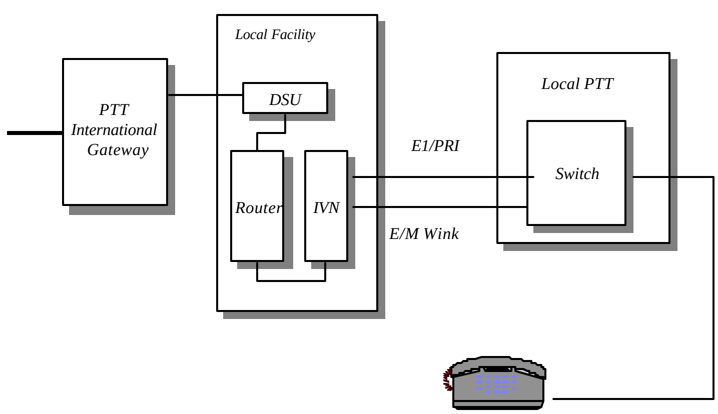
The Network Management function will provide interfaces to all other network system elements. The overall philosophy to the service functions on the network infrastructure side is one of complete integrability and integrity of the data elements. Thus the Network Management functions, as with all others will, ensure such data integrity. The other interface factors are linked to meeting the overall performance goals of the system.

2.2 Network Interconnection or Gateways

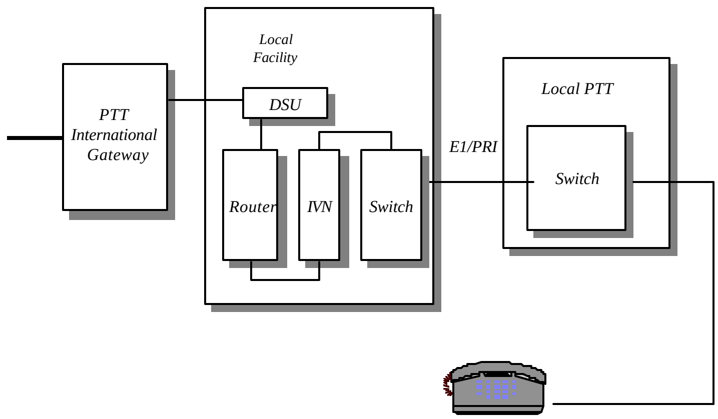
The details of the typical system and service are shown below.



On the international side, the connection is via the local PTT and its switch and the IVN and on the router and DSU side via the international gateway. Note that in the configuration shown below the IVN connects directly to the local PTT. In this case the LCU is required to perform a multiple set of functions and the PCU must also perform some billing functions. This may or may not be the case.



Another approach is to employ a switch adjacent to the IVN for E1 PRI compatibility. This is shown below. It now allows the switch to perform the signalling and effectively via the IVN a gateway function. Also the switch becomes a billing platform as well as a PTT meet point. The latter fact is generally a critical one in the implementation of these networks.



The node, IVN, in each country must have access to an IntraNet backbone or even the Intranet via an Intranet Service Provider, ISP. The Intranet backbone is a compilation of links between countries. The links are high-speed dedicated links between the countries.

A proposed network connectivity diagram is shown below. The network hubs, the IVNs are shown in the listed cities. They are connected via a backbone IntraNet using 1.5 Mbps, 512 Kbps, or 128 Kbps links.

2.2.1 Capacity and Sizing

The above description presents the IVN and its overall evolution. The sizing of the network is also a key factor in its overall operational competitiveness. The IVN has three significant financial factors as an operational element; first, its has low capital per subscriber, second, it has an ability to reach full scale economies with a small amount of loading of traffic (namely, average capital per subscriber equals marginal capital per subscriber), and third, it is highly scaleable, that is it can grow to any arbitrary size.

The sizing is first performed by looking at the capital plant. The Capital Plant may be determined as follows:

- *Consider a single user who talks 100 min per month.*
- *Let us assume that there are 5 days per week, or 22 days per month.*
- *Let us assume that there are 8 hours per day or 176 hours per month or 10,568 minutes per month.*
- *Then the average load is 100/10,568 or 1%*
- *If we assume a 2:1 peak to average this increases this about 25%.*
- *A 1% Erlang Load generates 100 minutes per month per user.*

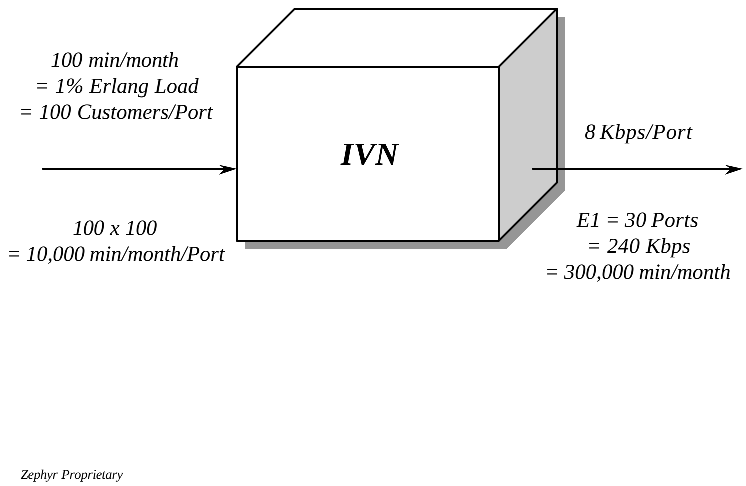
Then the calculated IVN numbers and the interconnection facilities may be determined as follows:

- *Assume that an IVN uses 8 Kbps compression.*[4]
- *For each port on an IVN we can support 100 users at 1% Erlang Load.*
- *This means that a Port can handle 100 users X 100 minutes or 10,000 minutes per Port per month.*

[4] This also depends upon the IP and TCP header which can add up to 50% overhead.

- *An E1 or 30 Port system can handle 300,000 minutes per month.*
- *An E1 or 30 Port system generates 30 X 8 Kbps or 240,000 bps, or it fills a 256 Kbps channel.*
- *If a 256 Kbps channel is, for example, $4,000 for US half circuit plus $12,000 for Country half circuit, that is $16,000 per month, then the per minute rate is $0.0533 per minute for connection.*
- *The Company's strategy is to get links in bulk, get IRUs for lower costs, and own key facilities.*

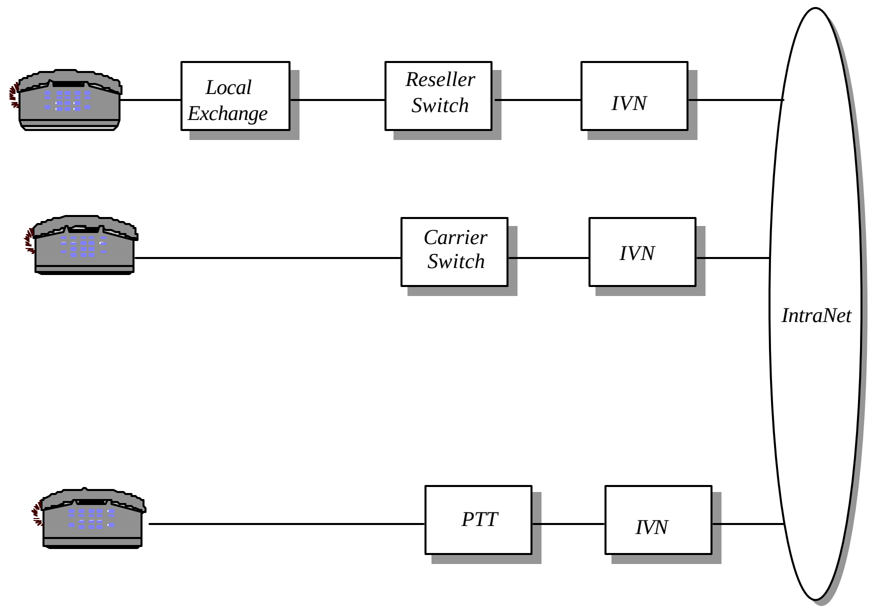
Specifically this leads to the following graphical representation:



Specifically two E1 IVNs are needed for every link with 300,000 minutes which cost fully loaded about $50,000 each. Also a 256 Kbps circuit is need for each 300,000 minutes per month between links or a pro rated portion thereof.

2.2.2 Interfaces With Customers and Resellers

The carrier must have the ability to interface with the customer either directly or via a third party reseller. The reseller may obtain the customer and deliver the traffic to the Carrier. The following Figure depicts the possible interfaces. The Reseller may be a facilities based reseller with a switch. That switch performs the billing function and interfaces with the Resellers Customer Care system. In this case the Carrier is a Wholesale provider to the customer via the reseller. The second case is where the Carrier goes directly to the customer and in that case the Carrier may require its own switch to provider certain nominal telephone functions. The following Figure depicts the possible interfaces with customers. The first shows a dial in via a reseller's switch. In this case the Carrier sells the service wholesale to the reseller who then buys the time in bulk from the Carrier. In the second case the customer is the Carrier's customer and dials in directly to the Carrier switch. This switch may then support a pre-paid card system or may even prepare a bill. The third case shows a PTT configuration wherein the customer may call from a foreign country on a call back basis.



The operator may take two roles on this business; the originator and the terminator of calls. The following Table depicts the relationship between these elements.

Factor	***Originator***	***Terminator***
Sales Costs	This is the customer of the originator and thus sales costs are attributable.	No costs as terminator.
ISP Interconnect Costs	Must pay for ISP costs on a per customer basis. Any originating customer must be a "customer" of the business.	Must pay for ISP costs on a per customer basis. Must remember that any originating customer may not terminate on a "customer" of the business. In fact it is most likely that they will not.
IVN Costs of Capital Equipment	At both nodes.	At both nodes.
IVN Operations	At both nodes.	At both nodes.
Interconnect Costs to PTT/LEC	None. Customer effectively pays at originator end.	Must pay for terminating interconnection.

3. IP TELECOMMUNICATIONS ARCHITECTURES

The domestic Public Switched Network is the result of an evolutionary process that had given rise to the Bell System and has resulted in the current structures under the Modified Final Judgment (MFJ) strictures. The network is based upon a set of technologies that require massive investment in capital assets to allow for the interconnection of many users to each other. The system requires massive switching infrastructures since the underlying transport facilities, the classic copper cables called "twisted pairs", have very limited information carrying capacity.

3.1 Structure

The public switched telecommunications network is built around a hierarchical architecture that makes several assumptions of its environment and the customer base. These assumptions are:

1. Bandwidth is a costly commodity so that it is necessary to provide for concentration of circuits on trunks and tandem lines. This concentration leads to the need for multi layered switching centers, a Class 5 Central Office being the lowest level.

2. Voice is the primary means of communications and all circuits are to be considered multiples of voice circuits. In addition the voice is to be sampled at a rate of 8,000 samples per second and the number of bits per sample may be from 7 to 8.

3. Universal service is necessary in order to meet the needs of the state regulatory bodies, This means that telephone service must be structured to cover the gamut of the rural home to the large corporation.

4. Quality of service is to be as high as possible with overall system availability to exceed 99.95%. This implies redundancy, disaster recovery systems, and a trained workforce that will permit as near as real time restoral as possible. New York telephone has in twenty years responded to crises that would have sent other US corporations reeling in chaos. Their response allowed restoral of services in extreme conditions of distress (See the recent Chapter by Bell discussing the fragmentation of the telephone network).

5. The focus is on operations, namely keeping the network service up to the performance standards set, and this implies that the work force must have the capability to deal with complex operations requirements in multiple positions. All people should be cross-trained to meet the level of service expected by the consumer of the service.

These assumptions make the local telephone company an infrastructure entity. The telephone company as the local operating company has a highly redundant, high quality of service, with a highly integrated work force.

If we look at this network in terms of our architectural elements we see the following:

1. Control: The control is highly centralized. The control emanates from a set of methods and procedures, flows through the overall control mechanism for the network and is integrated to the maintenance and restoral efforts.

2. Interconnect: This is a truly hierarchical interconnect. It is based upon the Central Office Switch, which is designed to conserve bandwidth at the trunk side. It provides a level of common access based on a single voice channel.

3. Transport: The basic transport is the twisted pair to the end user. There is fiber in the loop and some fiber to the user, specifically those users in the higher data rate category.

4. Interface: Generally the interface if the telephone handset. More recently, the interface has been expanded to include data sets.

In contrast to the ongoing performance levels of the Regional Bell Company, the interexchange carriers (IECs) do not have to meet the same levels of service. The recent AT&T service outage in New York with their Class 4 and Class 3 switch outages showed how the level of service has dropped for the IEC level. Specifically, the IECs have recognized that a level of service may be priced on a differential basis. This is in contrast to the pricing structures for the local operating companies whose service levels are more closely controlled by the state Public Service commission. It is of question if there is to be a divergence in service levels over time, between these two types of carriers.

However and in contrast, the essence of Internet facilitation and accessibility is the set of protocols available to the community to allow access by a wide variety of hosts in a complex and fully distributed fashion. The protocols are at the heart of Internet success. They are the "software and system agreements" that allow disparate machines and software to talk across equally disparate networks. The current protocols focus on data transactions, with some innovation allowing images and limited multimedia; namely voice and video. The future challenge will be the development of new and innovative protocols to allow both low end user access to grow while at the same time enriching the capability of the information transferred.

The key underlying protocol structure that makes the Internet function is the Transport Control Protocol/Internet Protocol, TCP/IP protocol suite. This protocol allows for the easy and ready flow of data from one user to another by agreements at various levels of the network to handle, process, manage, and control the underlying data packets. Protocols such as TCP/IP will be the heart of the evolution of the Internet. We shall focus latter on such protocols as applied to multimedia and new access methods. One can best understand the protocol evolution by looking more closely at TCP/IP. To quote Cerf:

"IP (the Internet Protocol) provides for the carriage of datagrams from a source hosts to destination hosts, possibly passing through one or more routers and networks in the process. A datagram is a finite length packet of bits containing a header and a payload. ... Both hosts and routers in an Internet are involved in processing the IP headers. The hosts must create them ... and the routers must examine them for the purpose of making routing decisions, and modify them as the IP packets make their way from the source to the destination."[5]

"TCP is a protocol designed ... to provide its clients at a higher layers of protocol a reliable, sequenced, flow controlled end to end octet stream...."

The development of new protocols can best be determined from studying the twenty year evolution of the TCP/IP protocol. The rationale for many of the TCP mechanisms can be understood through the following observations:

1. TCP operates above IP and IP provides only best efforts datagram transmission service.

2. End to end recovery... leads to sequencing..

3. Flow control requires that both ends uniquely agree...

4. In a concatenation... it is possible for a packet to circulate...

5. Termination ... should be graceful..

6. Every process should be able to engage in multiple conversations

7. ... the arrival of information should contain no semantic differences...[6]

These types of architectural and system requirements must be articulated as clearly and carefully for each of the new dimensions of expansion of the Internet. TCP/IP protocols have emerged as the standard network interface to the Internet that allows users to send messages from one point to another in a reliable form and also the users to embody in those messages certain characteristics that make them more then just a collection of bits. IP gets the packet across the network, and TCP brings the underlying nature of the packet stream into context as a reconstituted entity.

The current Internet Architecture thus has two main elements. The first is the semi hierarchical structure of Backbone, Regional, Campus and Host, and the second is the agreement on a single protocol to talk across the Internet in the TCP/IP suite. These elements reflect a great deal about how the Internet is managed, and what its growth potential truly is. Several observations can be made about the Internet in its current embodiment and how this relates to IP telephony:

i. **Host Orientation:** The Internet is host oriented. It is focused around the host as the terminal entity. This will imply that the concept of a host may have to be expanded to include a new and wider variety of electronic entities, some physical and other actually virtual devices. The Internet is NOT telephone oriented, it does not understand telephone signalling, protocols, and the internalization of intelligence. The Internet is the embodiment of the externalization of intelligence.

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[5]See Cerf, pp. 84-85 in Lynch and Rose.

[6]Cerf, pp. 117-118, in Lynch and Rose.

ii. **High disaggregation of data:** The Internet or IP network assumes a high degree of disaggregation of the data from one location to another. The current assumptions are that data from one location are independent of data from other locations. In a multimedia environment, this will no longer be the case. Data will be virtually aggregated into a compound multimedia object, thus creating a virtual aggregation on a disparate spatial disjoint set of data elements. Specifically, my mouse movement at one location will be related to my voice at another, and a third parties video at a third. The concatenation and orchestration of these disparate entities will be viewed as a single totality. In the world of IP telephony, the telephony parts wants to see structure data as may appear in SS7 or C7 databases, such is inherently not the case in the IP world.

iii. **Poor Transmission Link Performance:** The underlying structure of IP was built to deal with a poor quality transmission path, not those found in fiber optic networks. The new fiber optic networks are almost error free In fact, with the processing at higher protocol layers, one may now assume error free transmission. This means that latency prevalent from the old analog telephone lines may be totally eliminated. This is a critical factor for multimedia transactions. On the other hand, the new wireless communications services may have higher data rates until one better understands how to deal with multipath and other radio propagation factors. Thus the network must handle error free fiber, combined with error prone wireless. The IP telephony world works around that problem of lower transmission quality. The telephony world views it as an anathema and there the issue of quality if paramount.

iv. **Low Intra Network Intelligence:** Limitations of processing in the network are due to the simplicity of the routers and the "intelligence" of the host. New network elements are highly intelligent, and even the PDAs and the wireless devices contain dramatically greater intelligence to perform processing. The ability of the network to drive more processing to the periphery and to the new fully distributed host environment will enable the Internet to added new degrees of both access and services flexibility. As we already stated the standard telephony is the sine qua non of internalized intelligence.

v. **Moderate Speed Transport:** The layered structure of the protocol suite allows for flexibility in low to moderate speed networks. At higher speeds the protocol suites begin to breakdown. Fiber networks will rapidly allow Gigabit per second transmission, and high resolution images and video will be integrated in complex multimedia objects. This will require a significant rethinking of what the object control must look like and the development of new and innovative protocols.

vi. **Single Media Messaging:** The TCP layer focuses on getting a single stream of data through. Modifications can be made for voice or even video streaming but a full multimedia network is not achievable. An enhanced multimedia TCP/IP type system will be constructed that allows the entire suite of users access to multimedia sessioning with high data rates and accessible via fully distributed high end processing devices, albeit at dramatically lower cost. The telephony world has out of band signalling thus imposing multiple paths for communications, again all driven by the voice paradigm.

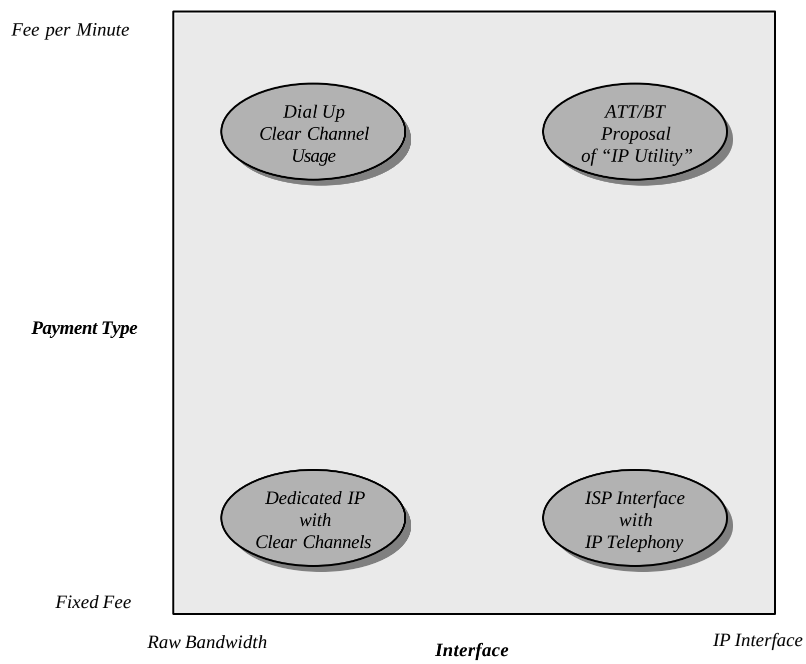
The Internet was initially intended as at data communications tool across the academic community. No intelligence was built in to the network to guarantee arrival of messages, nor to mitigate congestion. Issues of security and virus protection are management options left to the discretion of the host configuration.

3.2 IP Telephony Strategic Alternatives

This section discusses several of the alternative from an operation perspective of the IP telecommunications architectures. There are three that are now currently understood and being offered; the clear channel network approach wherein a dedicated circuit is used, the Internet backbone approach using the current Internet transport mechanism, and, for example, the proposed ATT/BT merger of the international IP which is an IP “service bureau” for other “carriers” to access their IP backbone which will provide a Quality of Service type of IP transport.

The provision of a global IP network that guarantees a quality of service, QOS, at a price point that is matched to the amount of service, its QOS, and possibly its actual usage. The IP service network approach allows the provider to become the network backbone at the IP level and that anyone interested in connecting to them must do so at IP level and not at the raw bandwidth level as is currently done today. In the current world of Internet providers, such an IP service offering is directed to the local IP Service provider and not to the carrier level. It is almost a “reseller” approach wherein the costs of service is above the EBIDTA line and not below it as a capital asset.

This section analyzes the various architectures that may be made available to the IP telecommunications community. There are four possible extremes. The following describes these extremes. There are four extremes depending on what the interface is, clear channel or IP backbone, and what the fee structure is, fixed fee per unit access or fee per transaction (bps, packet, minute, etc.). The four extremes shown that the standard IP telephony using the Internet use an IP interface but use a fixed feed per Internet access to an ISP, say $9.95 per month to a PSI backbone network per IP line. The ATT/BT approach is one which uses an IP interface but charge on a per transaction basis. The approach taken by companies such as Level 3, Qwest, Zephyr and others is an approach which use dedicated clear channel circuits. The interface is at the clear channel basis, namely bit per second, and they do the IP processing on their own network equipment. A fourth approach is a clear channel dial up wherein the IP is done independently. No carrier seems to use this approach at this time.

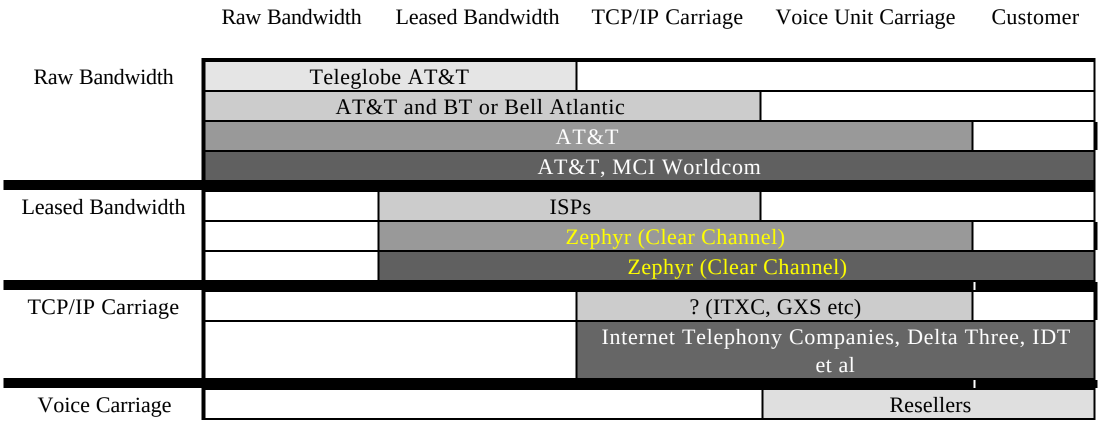


The most important point in the IP service approach is who is the responsible agent for the definition of interfaces and standards as compared to the open Internet environment of today. The offering of a fully open IP network will take a great deal of time to implement and will face significant regulatory as well as political hurdles. The first, as indicated, among them is the issue of who defines the IP interfaces and services. Currently the IP community is highly diversified and entrepreneurial and the last thing they want is an some third party telling them how to build the network.

The risks are this is the typical IBM strategy of pre-release to stall the development of any competitor networks. However, the strategy may backfire since the key here is the IP network combined with the globalization and open markets for bandwidth and the bandwidth lowering of costs on a global scale. Also the opening of most markets following the WTO agreements also opens the Pandora’s Box of competition making this approach highly problematic.

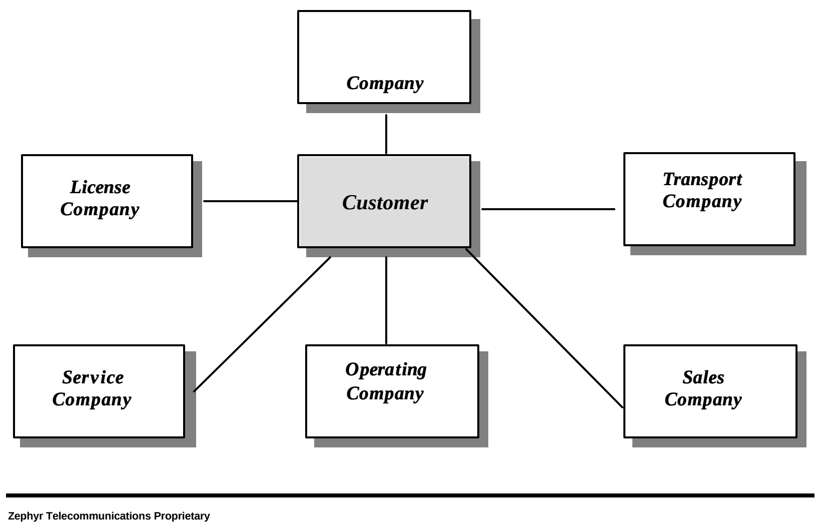
3.3 The IP Food Chain

The provision of telecommunications services via IP consists of the utilization of several elements. At one end is raw bandwidth that is installed in the ground, under the water, or in the skies above. The next step leased bandwidth, such as an E1 circuit. Then there is the access to TCP/IP backbone as may be obtained by accessing the Internet. The next step is the provision of voice carriage. Finally is the customer or end user. The following Table presents the multiple players and where the play within this segmented space, also know as the IP food chain.



The above chart depicts the essence of the theory of disaggregation. 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. The example below what the elements of any telephone company and how they may be Disaggregated.

The Disaggregated Telco



The telephone company is comprised of the following disaggregatable elements:

1. Switch: This includes the ability to switch traffic as well as provide for the interface between the customer's lines and the backbone network. It is not merely the physical switch but also includes any and all software needed for the deployment of the services to be provided.

2. License: This is the license to operate. This may not be just one license but may be a collection or it may be the position to operate without a license in certain circumstances.

3. Services: These are the advanced services such as call forwarding, automatic number identification, voice mail, and other similar services which are generally software based but require access to a switch and a network.

4. Operating Support Systems: These are the billing, customer care, provisioning, and network management services, separately or integrated together.

5. Sales: This is the sales channels.

6. Transport: This is the local transport, the backbone transport, and may include the necessary interfacing with any protocols as may be necessary to provide that transport.

It is important to note that this segmentation into disaggregated elements is not unique and that further each of the elements may be further divided. In today's “telecommunications” market there are separate vendors for each of these services. One can create a “telephone company in a box” approach by adding and aggregating vendors in all areas. The Corollary, however, is that to be a telephone company one needs all of these elements, albeit disaggregated into separate elements and provided by various vendors. An IP telecommunications carrier cannot be a telecommunications services provider and not have all of these elements provided in some fashion.

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. [7]

The existence of the disaggregated business is a challenge to the antitrust laws and especially to the implementation of the 1996 Act. What this implies is that as a disaggregated company any new entrant can achieve the same of better efficiencies of operation of its business as any incumbent, right from the start. This then states that competition is then based solely upon the actions of the monopolistic incumbent and that these actions relate to only one area, interconnection and unbundling.[8]

Disaggregation falls into three dimensions; technical, operational, and relational. We define each as follows:[9]

Technical: Technical disaggregation the ability to overlay applications and platforms a disparate backbone of transport facilities and create a whole. An example of technical disaggregation is the client server architectures and the LAN networks in common use. This type of disaggregation is a result of the many technological advantages that have occurred in telecommunications as a direct result of the 1984 MFJ agreement.[10]Another example of technical disaggregation is the ability to use a distributed system, such as PCS, Personal Communications Services, and have the actual "switching" occur at the end users handsets rather than at the old fashioned hierarchical central office. By distributing the technology and the intelligence we marginalizes the capital deployment requirement and thus achieve technical disaggregation. One example that we discuss in this Chapter is the concept of providing airtime. Namely the ability of a competitor to not only unbundle local loop, namely copper wire, but to unbundle frequency spectrum, namely airtime from an existing carrier.[11]

Operational: Operational desegregation is the breaking apart of re-assembling in any fashion the operational or business elements to effect the successful provision of service. Namely we can separate billing, transport, sales, service, and network control into different pots and create a virtual corporate entity. We no longer have to do all. We only have to do that part that we do well. An example of operational disaggregation is the outsourcing business whereby a company, such as a Bell Operating Company, would use an outsourced customer service center to provide this function, or in another context of a bank who outsources all of its telecommunications network.

Relational: This will be the issue of who does what to whom in such entities as electronic marketing and distribution channels in a telecommunications cybernetwork. This is the most recent example of building cyber-network via relationships. Unfortunately many of the current examples are examples of failure; Prodigy with IBM, CBS and Sears, or MCI and News Corp. on the Internet side. In this Chapter we attempt to focus on the latter two elements. The first has been treated elsewhere.

This Disaggregator entity is a key differentiation in the market. The Disaggregator is one who may use the existing license holders access facilities as one of several means to provide service to a fixed customer base. It is argued that

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[7]See the Chapter by the author at the Columbia University presentation, March, 1996. McGarty, T.P. , "Disaggregation of Telecommunications", Presented at Columbia University CITI Conference on The Impact of Cybercommunications on Telecommunications, March 8, 1996. McGarty, T.P., The Economic Viability of Wireless Local Loop and its Impact on Universal Service, Presented at Columbia University CITI Conference on Universal Service, October, 1996.

[8]See Coll: William McGowan, one of the founders of MCI recognized this in the IEC business. He used a two prong approach to effecting his competitive position, first through the FCC and second via the antitrust laws. Coll, S. The Deal of the Century, Atheneum (New York), 1986.

[9]McGarty, March, 1996, Chapter presented at Columbia University.

[10] The first is the attempt to open the data monopoly of the AT&T was by Bob Kahn, the father of the Internet, to obtain a 300 bps modem from AT&T. AT&T refused to support ARPA and Kahn and his team thus were forced to create a modem apart form AT&T. This then led to the proliferation of PC modems and the ability now with the introduction by Intel of a 56 Kbps dial up modem that supplants ISDN.

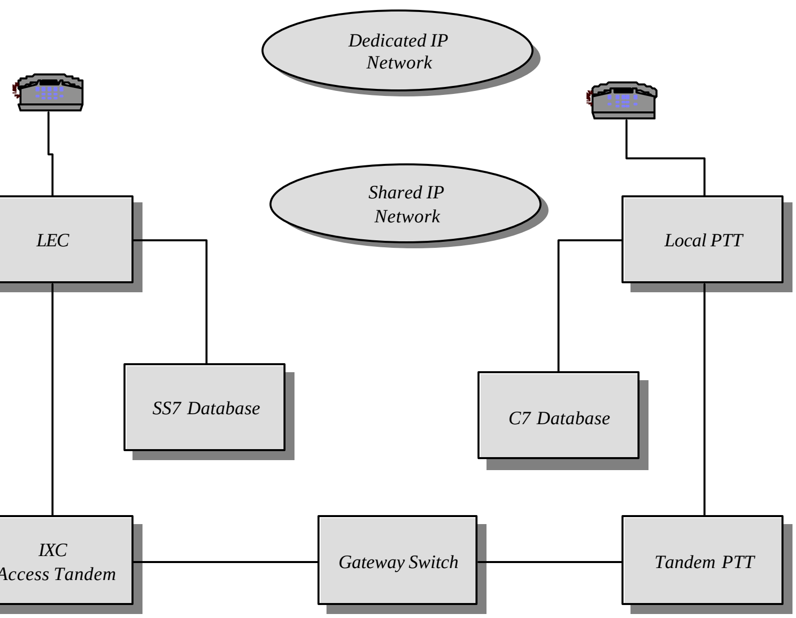
[11]It should be noted that the FCC expressly stated that the carrier was not a LEC and thus was not required to unbundle. In addition, in the FCC First R&O on Interconnection, August 8, 1996, it stated that an RBOCs LEC was not a subsidiary even though the author argued against that based upon the theory of agency.

the Disaggregator is a different entity altogether and more importantly it is argued that the disaggregator is the most likely evolutionary entity to change as full competition is presented in the wireless market.

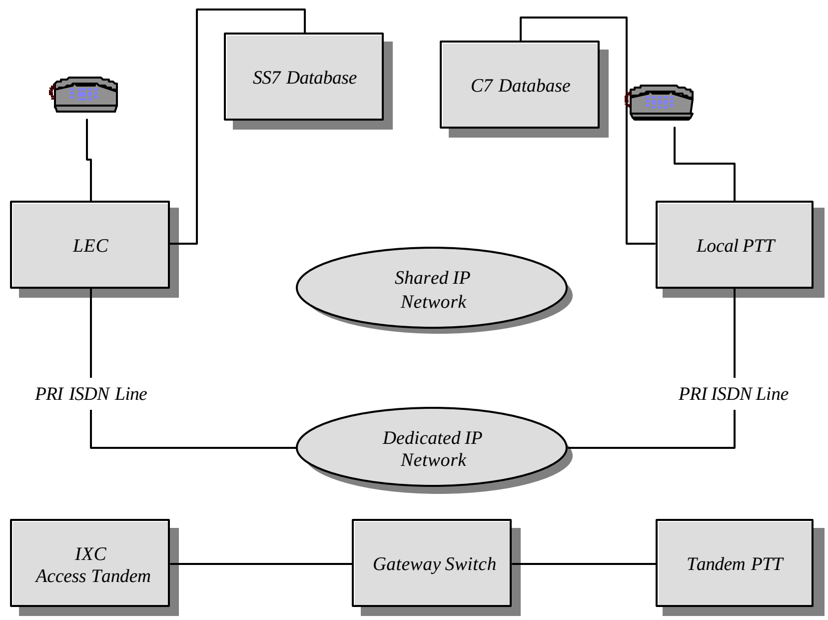
The author believes that by acting as a "Disaggregator" it can effect this competitive position. The Disaggregator works on the following principles. The provision of wireless services is based upon the integration of the service elements. This integration may be performed as an aggregation or as a desegregation approach. The Aggregation is the way most of the carrier entities now work, having control over all of the elements of "production". The Disaggregator may have control of certain strategic elements but will "outsource" others.

3.4 Integration With The Telco Networks

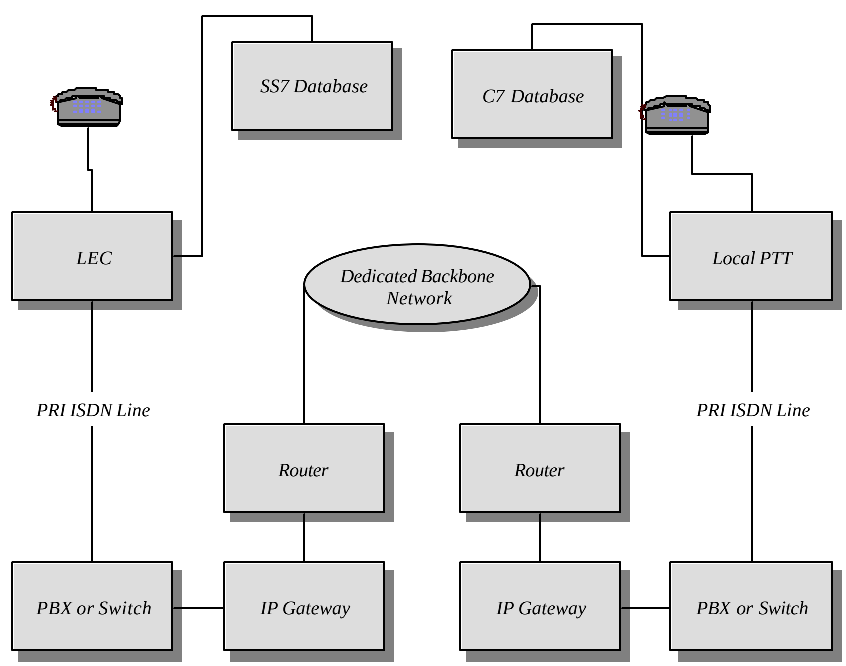
The standard international telephone connection is shown in the figure below. In this case the local LEC customer goes through their local switch, which in turn has access to the SS7 data base and system. This then connects to the IXC access tandem and then via an international set of circuits possibly to an international gateway switch(s) and then to the PTT access tandem and finally to the local PTT switch which has a C7, or SS7 variant, which must via the gateway convert from one to the other.



The next variant is with the use of an IP carrier. We have depicted two different types. The first is a decocted backbone IP network and the second is a shared IP backbone network. The shared is what we typically call the open Internet whereas the dedicated is the closed user Internet, sometimes called an Intranet, although this is generally reserved for a completely closed user group.

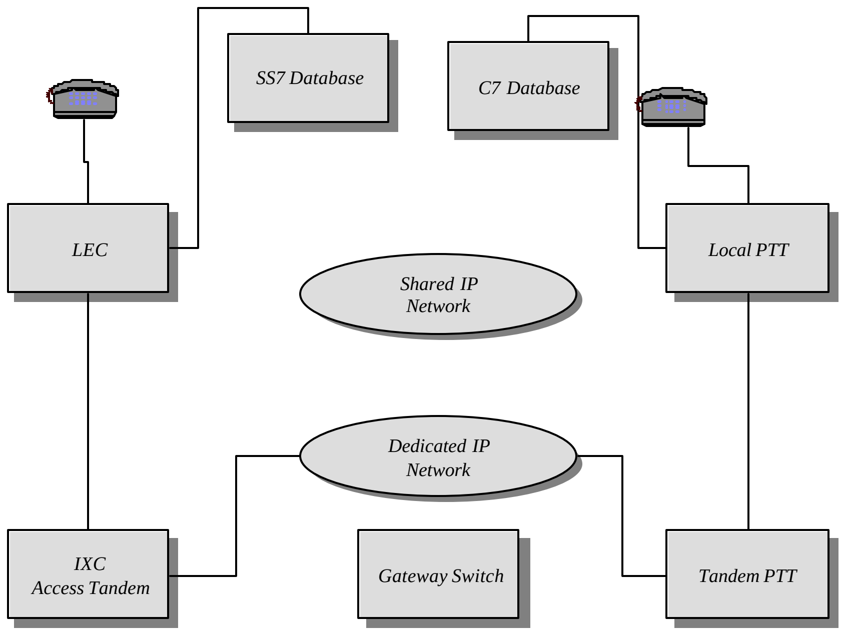


The IP carrier however is further characterized by certain elements as shown below:



In this Figure we depict the Routers, the clear channel backbone network as well as any IP gateways. However we also depict a PBX or switch for interconnect to the LEC or PTT. This may or may not be necessary.

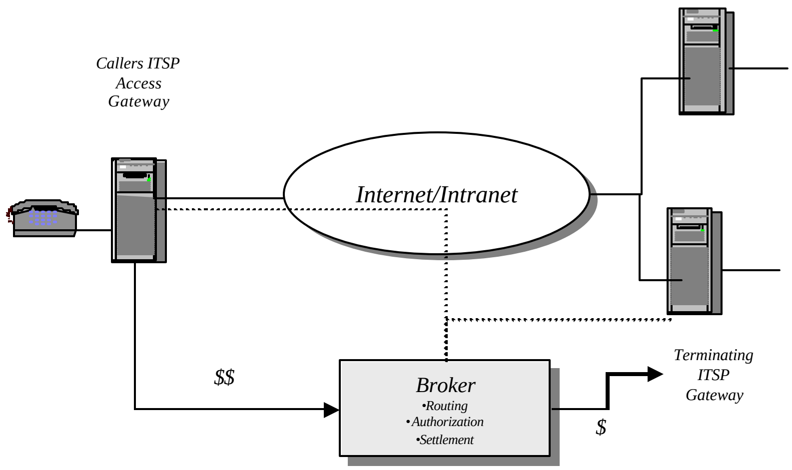
The following depicts a third view wherein the IP carriage is from tandem to tandem. This comes into importance when one connects via access tandems in country as one may do if one were an international record carrier.



Another alternative approach is the intermediary services broker. This is shown below. Companies such as ITXC and GXC have taken this approach assuming the following:

- There are many “naive” and unconnected ISPs that need a clearing house or middleman to effect their transactions.
- That currency transactions and settlements can be done by a multiplicity of third parties.
- That third party billing, network management, and infrastructure provisioning can and must be established.
- That there will be no entry by the more typical telephone carriers into the IP telephony market.

These assumptions are critical to such an approach but they are highly problematic given the needs of this market to have telephony and telecommunications expertise.



4. REAL TIME TELECOMMUNICATIONS MARKETS AND EXCHANGES

There are markets for various commodities in the world today and these market have various forms of derivatives, namely various combinations of puts and calls. We can consider the same being the case for the development of a world wide market for telecommunications services. Consider two types of services that exist today; bandwidth and minutes. Bandwidth is in E1s or fractional E1s, or multiple E1s. This is the bandwidth market. The minute market is in minutes of traffic to a particular place. In each case we can construct a price per unit, namely a price per E1 between two places or the price per minute between tow places.

4.1 The Commodity Concept

As with any market we can call the commodity C and the price P(C). Thus we may pay $50,000 per month for an E1 between New Yo rk and Moscow of $0.1855 per minute between New York and Warsaw.

More complexly, however, we construct the commodity C as follows:

C = {Location_1, Location_2, Duration, Capacity, Start Date, Volume, Other}

For example;

C = {New York, Warsaw, 2 Years, E1, October 15, 1999, 2.5 million min/month, PRI/C7}

That is we want to buy an E1 for two years from New York to Warsaw that can carry at least 2.5 million minutes per month and has a C7 PRI interface.

Then we have a price P(C) on that commodity as of today. We can further create derivatives, namely puts and calls, or rights to buy and sell that commodity or derivatives thereof at some time in the future as we do with stocks and agricultural and mineral commodities.

One would further assume that we can see a declining curve for such commodities, namely:

C_1 = {NY, Warsaw, E1, 1 year, now}

C_k = {NY, Warsaw, E1, k years, now}

Thus we would assume come form of declining costs:

$C_1 > C_k$ for all k.

Likewise, we could assume that if such a market existed for bandwidth that calls and puts could be constructed and the Black Scholes approach for option pricing would most likely apply.

The flow in our model can then be perceived to be from IRUs, to bandwidth, to IP interfaces, to minutes of use. By using some form of technological transformation, such as IP telephony, we can then look at all four markets, namely let:

C^{IRU} = an IRU commodity unit

C^{BW} = a bandwidth commodity unit

C^{IP} = an IP commodity unit

C^{MOU} = a voice minute of use commodity unit.

Let us assume that we have the following transformations:

An IRU is an ST3 or 155 Mbps of bandwidth, or 77 E1s

An E1 can handle 2.5 MOU as an IP circuit.

There is as yet no clear IP unit so we shall avoid this at this time. Thus we would logically have;

$C^{IRU} < 77\ C^{BW} < 77\ (2{,}500{,}000)\ C^{MOU}$

Failure of this would allow arbitrage in the market.

Now there must be clearing houses for these commodities. Two exist today, BandX and RateExchange, both operating on the Internet and both in their early stages of development. One would assume that there could be some real time exchange mechanism for such trades, however, the infrastructure is not there yet.

The essence of an efficient telecommunications commodity market is the ability to "buy long and sell short" or to take advantage of the inherent price arbitrages that will exists. Another advantage of such a market, if efficient, will be to value the "value added" to each step in the change from raw bandwidth to MOUs. Namely if one knows the conversion rate from an E1 to a MOU then if the market values this at some multiple of the conversion rate then this is the valued added by the technological conversion. The same is true in say the oats market where a bushel of oats has a price but an oat bran muffin is significantly higher on a per pound basis!

4.2 Requirements for an Efficient Real-Time Telecommunications Market

There are several simple requirements for a real time telecommunications market. They are:

- A fungible product unit such as bandwidth or MOUs. These exist.

- A readily accessible means to get access to the product units. This does not exist. There must be some way that one who holds E1s must be able to give access to one who desires to buy them on a real time basis. Namely there must be an exchange mechanism. In the commodity markets there is however never an exchange of the actual train care load of commodities, there is only a market on the derivative. In this case however, there may be a “contract” but there also must be a deliver mechanism. This can be done on a futures basis but for real time efforts there must be a real time interconnect facility.

- A readily efficient and trustworthy broker of services and prices. So far this has been the BandX and Rate Exchange players. This may not be the case for a long period of time. Generally the “exchange” is some controlled and independent third party.

Thus there are two elements missing, the exchange mechanism on a real time basis and the actual exchange broker. There are ways to create contracts to void the deficiency of the mechanism but there still needs to be a workable broker.

4.3 Least Cost Routing

The success of any IP telephony model that relies on dedicated networks will depend upon least cost routing. This section presents an analysis and methodology to determine and implement least cost routing for the company in a dynamic fashion so as to ensure a minimal net present value cost to the network portion of the intranet network. The approach builds upon the work in the mid-1970s by the author in the deployment of least cost routing for dynamically variable satellite circuits with a traffic matrix constraint using integer programming techniques.

The cost of a link, L, is defined as P, and P depends upon the vendor, the from and to locations, the data rate and the duration of the contract. Thus P may be parameterized as follows:

$$P = P(M_i, M_j : D_k, T_m : V_n)$$

where M is the city or location, D the data rate, T the duration of the contract and V the vendor. The capacity of the link, C, defined by the above is given in the following:

$$C_{i,j} = D_k / E_k$$

where E is the efficiency of the IVN at that link.

The following chart depicts the prices per link for a specific vendor and for a specific set of locations parameterized on data rates and duration of contracts.

Vendor and Location by Data Rate and by Duration
(New York to Moscow)

Data Rate/Duration	***128 Kbps***	***256 Kbps***	***512 Kpbs***	***E1***
12 mos.	$14,000	$27,000	$36,000	$39,500
24 mos.	$13,000	$25,000	$34,000	$35,500
36 mos.	$12,000	$23,000	$32,000	$32,500

The following Table depicts the prices for a specific vendor and for a 6 month contract between several locations and at various data rates.

Vendor and Duration Rate by Location and Data Rate
(One Year Agreement)

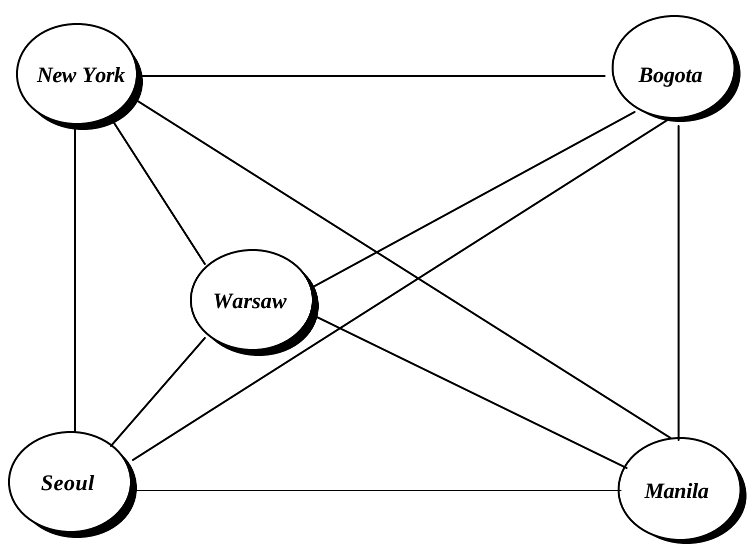
Data Rate/Location	***128 Kbps***	***256 Kbps***	***512 Kpbs***	***E1***
London	$4,000	$8,000	$12,000	$12,000
Frankfurt	$6,000	$12,000	$18,000	$22,000
Warsaw	$9,000	$18,000	$24,000	$36,000
Moscow	$14,000	$27,000	$34,000	$39,500

Consider the following illustration. The company selects nodes for operation in New York, Warsaw, Seoul, Manila, and Bogota. This is five cities. The traffic matrix in minutes per month are shown below:

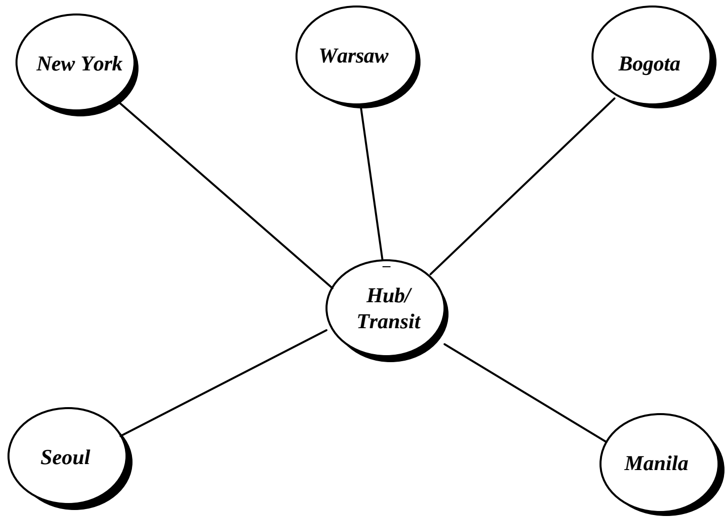
From/To	*New York*	*Warsaw*	*Seoul*	*Moscow*	*London*
New York		*500,000*	*700,000*	*400,000*	*400,000*
Warsaw	*300,000*		*100,000*	*100,000*	*100,000*
Seoul	*700,000*	*200,000*		*100,000*	*200,000*
Moscow	*300,000*	*200,000*	*100,000*		*500,000*
London	*500,000*	*100,000*	*100,000*	*100,000*	

It is possible to do a direct connect mesh network or to select a hub network using a transit switch approach as is done in the airline business. Also a sub-hubbing approach is possible. All depends upon the pricing matrix between countries. Note that pricing may include a differentiator between transit only and termination only.

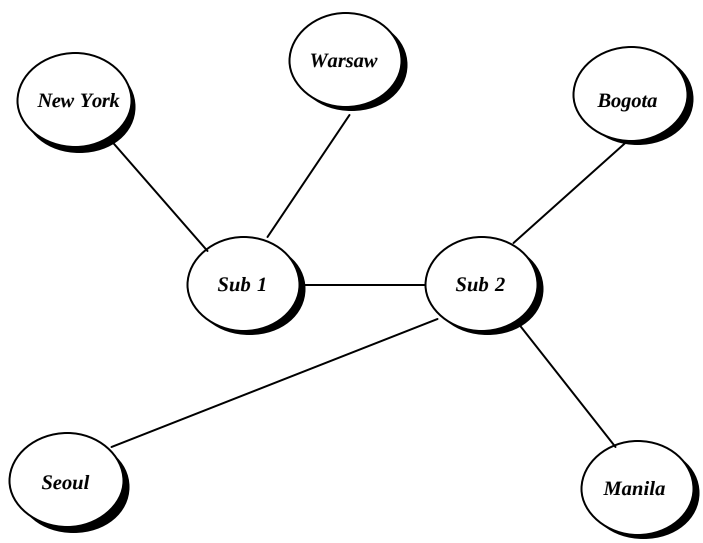
Point to Point: In this network the design is to procure the links on a fully interconnected basis and each link matches the traffic requirement for the network traffic matrix. This is generally the most inefficient use of network resources.



Hubbing: This configuration as shown below uses a hub or transit switch to connect the locations. The location of the transit switch is such that the overall costs of the network is minimized. The circuits from the country to the transit switch is generally sized on total traffic emanating from a country. This is the airline analogy and generally is the least cost approach.



Sub-Hubbing: This is an alternative that uses sub-hubs that may or may not be termination points on the network.

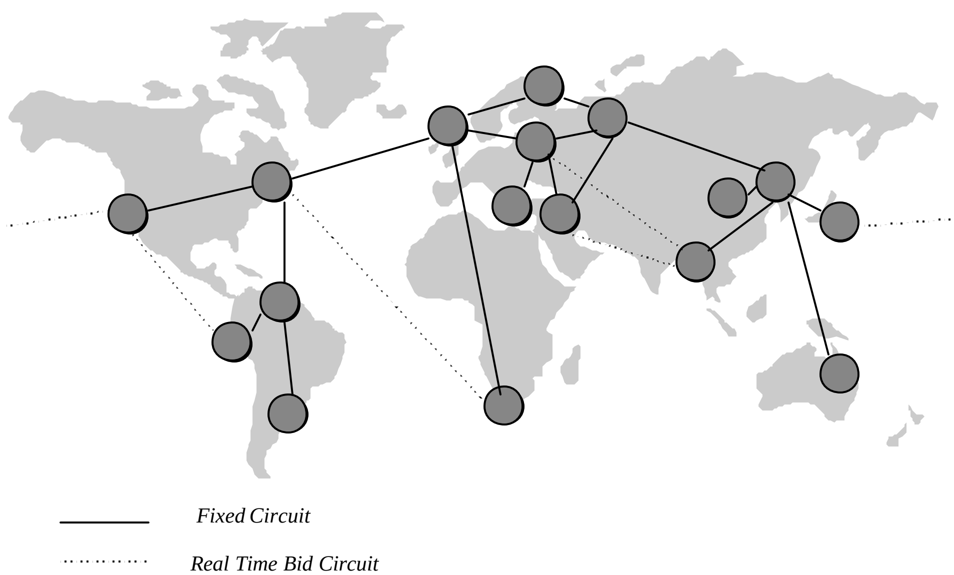


4.3.1 Dynamic Least Cost Routing

Bandwidth can be obtained on a long-term basis, built, or now it can be purchased on what can be called a spot market. The intelligent use of bandwidth will allow significantly lower costs to all parties, especially emerging nations. The issue of real time lease cost routing is a complex issue that means that costs are available, that routing tables can be dynamically changed, and that there may also be a bidding mechanism for bandwidth that can be sent down ultimately to the end user. This becomes a resource utilization issue as well as and end user and market pricing mechanism. The issue is one of implementing, controlling, informing, and communicating pricing information and decisions in a fully distributed fashion and using this at the IP layer as well as the TCP layer. Where should this be accomplished, what protocols in terms of bandwidth bidding should be used and what are optimal schemes.

The following depicts an example of dynamic LCR. It functions as follows:

- *There exists a market mechanism to price bandwidth on demand. For example one of the carriers clearing houses such as Band-X, RateExchange, and Arbinet.*
- *There exists a mechanism to real time interface with such a carrier.*
- *There exists a capability in the Router to determine the lease cost rout and to adjust the router table to provide for that approach.*
- *The routers can communicate with the central facility and the market clearing mechanism to permit real time adaptation and least costs routing.*



5. QUALITY, LEVEL, GRADE OF SERVICE

Recent announcements from established international carriers highlight the standard set of telecommunications offerings and their migration over time using IP technology. The ATT/BT announcement, for example, states clearly that IP is at the heart of the offering. It also states that the offering is a re-composition of Concert which has been a failure on a global scale. Concert was first attempted by BT and MCI. Upon the MCI failure then BT sought another player and ATT with its new Chairman saw this as a play for attention for AT&T which was under stress.

The new IP offerings will provide the following benefits:

i. *Offer customers the widest range of seamless advanced global products and services to meet their end-to-end communications needs;*
ii. *Give customers unequalled levels of integrated service and support;*
iii. *Carry trans-border traffic on a greater scale and more efficiently than ever before.*

This is a standard set of combined offerings which already exist. The IP services to be offered by several new entrants are:

i. highly secure, global virtual Intranets and associated IP-based applications;
ii. multimedia networks with point-to-point and multicast data, video and audio capabilities;
iii. a new system of global call centers providing 24-hour, multi-language customer support;
iv. new communications services to support the traveling executive and allow virtual meetings to take place with anyone, anywhere.
v. toll grade voice quality.

The above four elements need some clarification. Security is the number one. Clearly, many carriers recognize this in order of priority and this must be incorporated into any such system design. Multimedia communications and customer support are also critical. The last item is a "follow me anywhere" concept which ahs been discussed elsewhere and which we will describe in some detail.

5.1 Telecommunications Voice Quality

Telecommunications networks generally have levels of performance that are tested in the normal acceptance of a circuit. The set of typical criteria for acceptance are shown below.

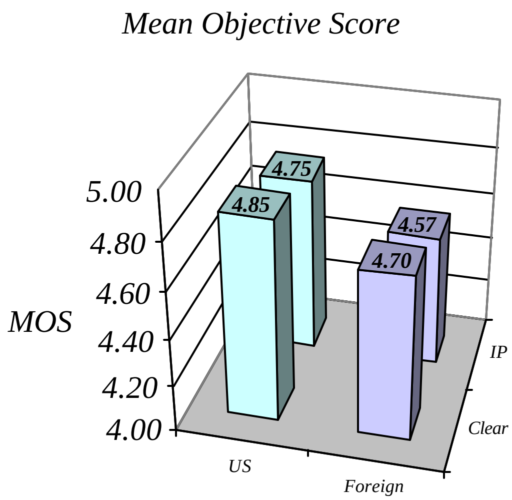
Performance Factor	***Value***
Call Blocking Rate Busy Hour	<5%
Call Set up Time	< 12 sec, 95% of the time
Call Set Up Failure Rate	<5%
Dropped call Rate	<3%
No Answer Rate	<5%
Echo Suppression	>20 dB
MOS Speech Quality	>3.8

These acceptances are determined by means of a set of detailed tests. The following Table depicts several of these tests, the objective of the tests that are generally performed, the procedures used, the desired results and the level of performance sought.

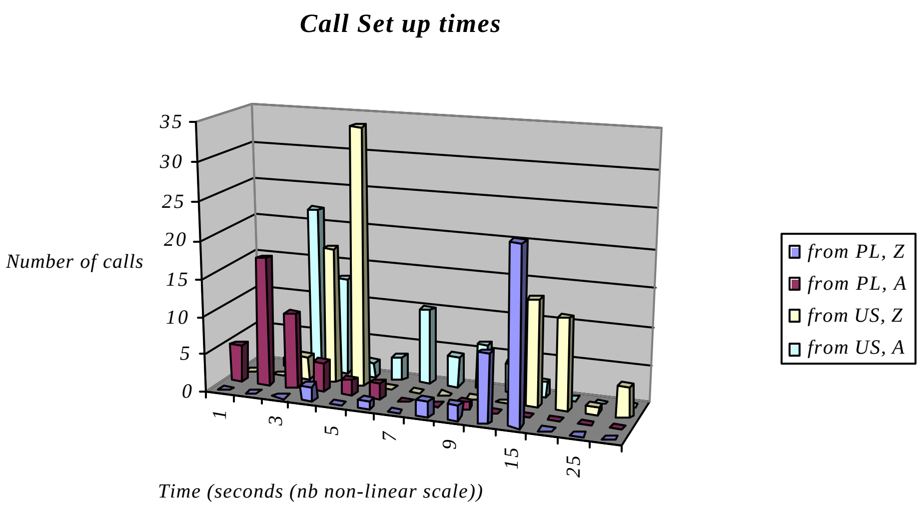
Test	*Objective*	*Procedure*	*Level of Performance*
Call Set Up Time	To test the time to set up a call measured from the time the last digit is entered until time end party ringing is commenced.	This will be an A/B test procedure using the circuit and a standard reference on a time of day basis. The Standard Reference shall be a US generated AT&T clear channel circuit. The test shall include the measurement of the time between the last digit dialed and the time of the commencement of end number ringing. The test shall include measurements for 50 calls of Type A and B.	<25% difference
Link Loading	To determine the maximum loading on each circuit to meet the Blocking Probability requirement.	This will include the loading of the circuit to its maximum handling capability by placing calls onto the circuit and determining the maximum number of simultaneous calls before blocking exceed the 5% level.	Maximum loading with blocking probability < 5%
Call Completion	To determine the fraction of calls that are terminated without problem.	This test shall consist of the placing of 100 calls in a row and determining the number which are terminated successfully. This shall be done on both ends of the circuit.	> 95% call completion
Call Blocking	To determine the call blocking probability on the circuit.	Calls shall be made at three levels of loading, 50%, 100% and 125% of maximum peak busy hour capacity and call completion shall be	< 5% call blocking at load

Test	*Objective*	*Procedure*	*Level of Performance*
		recorded.	
Voice Call Quality	To determine the voice quality of the circuit.	This will be an A/B test procedure using the circuit and a standard reference on a time of day basis. The Standard Reference shall be a US generated AT&T clear channel circuit. The procedure will be to place twenty calls on each end of the circuit in a double blind fashion. There will be a 50:50 mix of the Standard Reference and the company circuit. The caller will be asked to determine whether the quality was acceptable or not. Then the two will be compared for statistical significance of difference using a Student t Test.	<15% determining difference in average
Bit Error Rate	To determine the end to end bit error rate, BER, of the circuit.	Use a BER tester on the loop back circuit.	BER $< 10^{-6}$
Fax Quality	To determine if the fax transmissions are acceptable.	Transmit fax ten times.	Readable fax
Modem Test	To determine if the modem transmissions are acceptable.	Try data modems up through 56 Kbps	Modem connection via synch.
Failure Reporting Tests	To determine if the failure reporting procedure is followed.	Failures will be generated at each end of the circuit. Calls will be placed to the NOC and the time to determine and report the trouble will be measured.	Time to Rep[ort < 15 min Failure to report rate < 5%
Trouble Tickets	To determine if Trouble Tickets are prepared properly and if the clearing process is commenced.	Trouble Tickets shall be prepared and circulated.	Time to issue shall be < 15 min.
Trouble Clearing	To determine if trouble clearing process is working.	This will entail the end to end clearing of the created trouble.	Time to clear shall be < 75 min.
Billing	To determine if billing system integrity is in operation.	Traffic shall be loaded for 48 hours from both ends of the circuit. Bills and CDRs shall be prepared.	< 1% billing errors.
Customer Care Test	To determine if customer care system integrity is working.	Calls shall be placed at random to customer care.	Time to answer shall be < 45 sec

Results on voice quality are shown below for a link on a clear channel IP telephony system as measured by both ends. Note that on this link we compare IP to the clear channel AT&T links. There is no noticeable difference in voice MOS, mean objective score, QOS. Several carriers have achieved this QOS at this time and we further believe that few IP carrier has even begun to test for this factor no less achieve it.

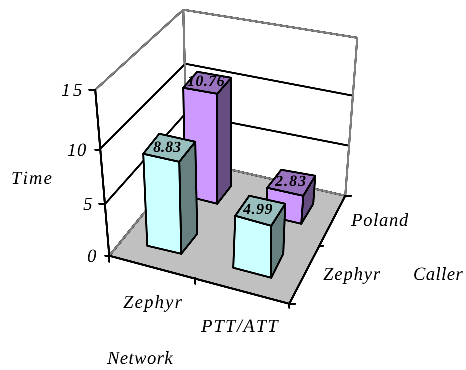


This above test shows that MOS scores for IP telephony clearly match those of the clear channel telephony whether they originate from the US or from a foreign country. There is at most a 10% difference which given the size of the sample makes its statistically insignificant. The following show results from call set up time measurements on an IP versus standard call set up procedure. Note the bi-modal characteristics.



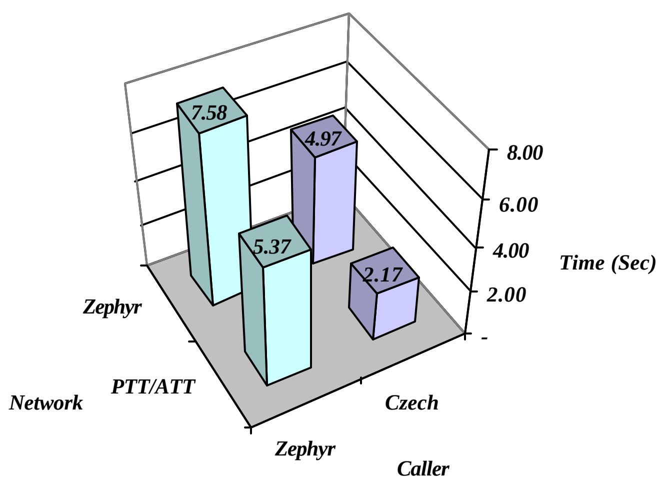
The following is the summary of these call set up tests. Namely that an IP network may have longer call set-up times. In actuality this was due to the process of having a non-PRI interface and in establishing a call by a second dial tone basis.

Call Set up times

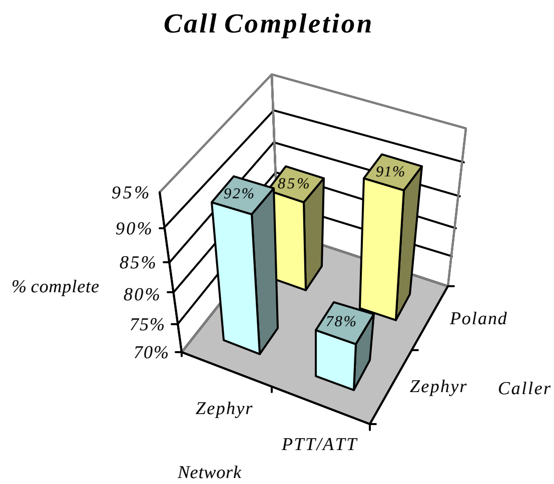


Calls, however, terminating via a C7 interface are shown below. Note the dramatic difference in call set up time. There are still some differences since the interface is a local switch, albeit with C7 and not an international tandem switch with C7.

Call Set up times



The last measurement that can be shown is the call completion rates. The following Table depicts some of these rates. Note that they comparable but generally reflect the network configuration.



5.2 Security

Clearly the need is for security. Security is a key element in the deployment of any IP telecommunications service. Security falls into three categories:

Physical Security: This is also part of network management. It is the securing of the physical network to compromise, penetration, misappropriation, or similar compromise.

End to End Security: This is the security associated with the end user access. This is voice, data, or information security.

Logical Security: This is the security to penetration by an adversary who can cause errors or faults or otherwise compromise the system, end user, or information via access to the logical elements of the network.

There are may typical security functions that can be considered. These common functions are listed below.

Function	***Details***
Unauthorized Access Control	The system shall be designed so that there shall be no unauthorized access of any IVN, router, switch, or IntraNet backbone element. The IVN shall provide for total and complete firewall capabilities to insure secure access and shall not permit any unauthorized packet flow through any IVN connected router.
Billing Control	The IVN shall provide for a complete secure billing collection system with complete and full real time redundancy. It must also provide alarms for any attempt to penetrate the system in an unauthorized fashion and shall provide for a complete and secure keyed access system for company access.
Wiretapping Implementation	The system shall allow for any and all legally authorized wiretaps to be implemented on the system. The taps must be in a standard format and must be able to be obtained in a secure and compartmentalized format.
Remote Instantaneous Cutoff	The system must have the capability of remotely and instantaneously being cutoff to prevent any unauthorized breach of security.

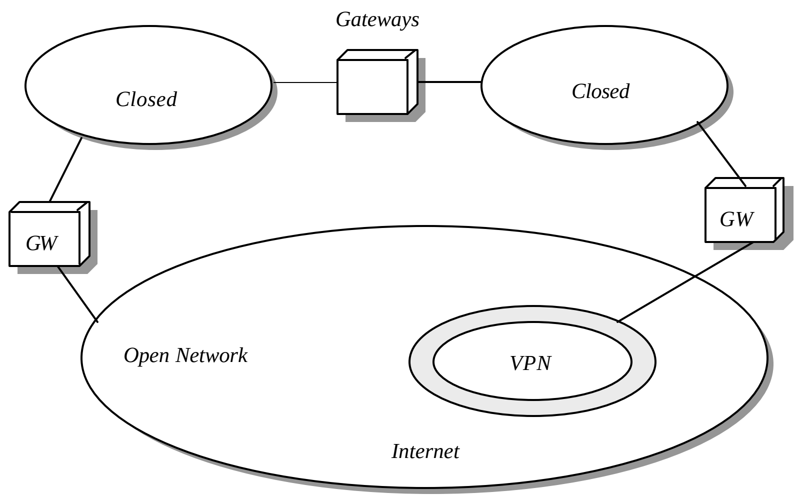
Function	***Details***
Packet Streaming Control	The system must prevent packet streaming. Namely the system must prevent the unauthorized use of the routers, whether they are connected via an IntraNet or Internet, by others for the purpose of sending packets over the network or through the routers. The IVN must have the capability to authorize each and every packet before transmission.
Network Management Compartmentalization	The network management system must be fully compartmentalized from the system. Any access to any voice channel must be monitored and must have a key control access capability. No user of the system may access any voice circuit in any fashion without having that access monitored.
Code Key Control	The system must use a secure code key access technique for any access to, modification of, reconfiguration of, or any material change to the system, its configuration, connections, or any other operational function.

Security commences with the analysis and determination of threats, compromise protocols, and similar security risks and what can architecturally be done to ensure a secure environment.

The overall issues of network security are at our levels; physical attach of resources, transport compromise between resources, logical attack at software in it broadest sense, and end user compromise. One can view the issues in an open and a closed network environment. The following Table presents an overview of these extremes.

Level	*Open Network*	*Closed Network*
Physical	Physical Breach	Uncontrolled Access
Transport	Intercept v Destruction	Intercept v Destruction
Logical	IP/TCP header swaps Delay/Intercept/Intrusion	Intrusion via compromise
User	Encryption & Authentication	Encryption & Authentication

The network alternatives are shown below. There are two Closed networks, the open Internet, and a Virtual Private Network, VPN, which is encapsulated by some form of security form the Internet. The VPN is constructed by and within the Internet construct. The Gateways are interfaces between the networks and it is at these points that protocols and techniques must focus on the security issues discussed above.



The security elements discussed in this section must use all three dimensions, Internet, Closed, and VPN, as a means to specify and evaluate the issues of network security. Security is also at the heart of any defense against information warfare.

5.3 Multimedia Communications

Multimedia communications is simply displaced conversationality. From the New User perspective it represents a truly transparent medium of talking, of sharing ideas and conversations with others in a simple fashion, blending seamlessly all elements of communications that typically are in any normal human conversation. Multimedia communications is not merely the devices and displays, it is not merely advanced CD players with enhanced sound. It is a conversation with others, using all of the available senses, combining meaning and content between a group of individuals, displaced in time and space. The key architectural and technical question is whether Internet can and will support the types of multimedia communications that is envisioned. It is the opinion of the authors that the elements to do so are available and that further, the New User community is anticipating that such service will be available.[12]

When we introduce the multimedia communications concepts, we do so in the context of having multiple users share in the use of the multimedia objects. Thus multimedia communications requires that multiple human users have sensory interfaces to multiple versions of complex objects stored on multiple storage media. In contrast to data communications in the computer domain, where humans are a secondary after thought, and optimization is made in accordance with the machine to machine connection, multimedia communications is a human to many other human communications process that must fully integrate the end user into the environment. Multimedia communications thus generates a sense of conversationality, it is sustainable over longer periods, and has an extreme fluidity of interaction. The current Internet affords a sense of conversationality. It is the expanding of that conversationality to a wider array of multimedia objects that is the challenge.

[12] The details of what it will take to achieve true multimedia functionality in the INTERNET are significant. Such issues as what is needed, what barriers are there in the current INTERNET design that must be overcome, who will do the changes, and what are the risks would need an lengthy exposition. Suffice it to say that there are no fundamental barriers to introducing multimedia into the INTERNET environment. In fact, there are small efforts already underway that show how to do this. The INTERNET Users Society will be one vehicle, but more importantly, it will be the innovativeness and creativity of the end users, as usual, that will make it a reality.

We concentrate on three issues in the area of multimedia communications; the data objects, the conversationality of the interaction and the overall communications architecture. It is this concept of conversationality, of displaced sharing of information and creating transactions of the mind that make this definition of multimedia communications more expansive, and represents a challenge for integration into the Internet fabric. It is this concept of displaced conversationality that demands interaction and such transparent interaction is the inherent capability and functionality of the Internet, especially as it addresses the New User

The major observation that can be made is that the standard approach to communications system design, from the physical layer and up is the wrong way to proceed for multimedia. Specifically, in a multimedia environment, one must, perforce of user acceptance, design the system from the top layers and down.

6. INTERNATIONAL REGULATION

The foreign PTTs, through their countries, generally have entered into the WTO agreements that generally place voice in the settlement arena and data in the non-settlement elements. The World Trade Organization (WTO) is the principal international body concerned with solving trade problems between countries and with negotiating trade-liberalizing agreements. WTO replaces of General Agreement on Tariffs and Trade (GATT) and is the embodiment of the results of the 1986-1994 Uruguay Round of trade negotiations conducted under the GATT.

6.1 WTO Overview and Status

WTO has a cooperative relationship with the United Nations but is not a UN specialized agency. It was established on January 1, 1995 as a result of the implementation of the Uruguay Round results. The WTO encompasses previous GATT legal instruments as they existed when the Uruguay Round was completed (known as GATT 1994), but also extends new disciplines to economic and trade sectors not covered in the past. Whereas the GATT's scope was limited to trade in goods, the WTO also covers trade in services, including such sectors as banking, insurance, transport, tourism, and telecommunications sectors as well as the provision of labor. In addition, the WTO covers all aspects of trade-related intellectual property rights (copyrights, patents, trademarks, etc.). Furthermore, while the GATT had a relatively ambiguous status as a multilateral agreement without any institutional provisions, the WTO is an international organization with a stature commensurate with that of the World Bank or International Monetary Fund (IMF).

The GATS, General Agreement for Trade in Services, which is a part of the current WTO structure, has developed a set of rules and regulations an a schedule of timetable to open up the member markets to trade in telecommunications services. There are three dimensions for such trade in services. The first two are basically for the intra country markets and represent the local and long distance telephony market. The third is the international telecommunications market. In all three cases we can further break this up into voice, data, video, valued added services, and other types and classes of services. The breakout is shown as follows:

	International	*Long Distance*	*Local*
Switched Voice	Generally tightly controlled	Generally controlled by internal ownership.	Generally controlled by internal ownership.
Switched Data (Off Net to Off Net)	Generally tightly controlled	Generally controlled by internal ownership.	Generally controlled by internal ownership.
Non Switched Data (On Net to On Net)	Generally there is limited control.	Limited to little control.	Limited to little control.
Video (CATV)	Issue is ownership and content.	Not Applicable in General	The control is limited to any entity having a franchise or similar license
Internet	Generally open and limited by Government controls on content.	Generally open and limited by Government controls on content.	Generally open and limited by Government controls on content.
Value Added Services	Generally controlled as an On Net Service	Generally controlled as an On Net Service	Generally controlled as an On Net Service

The main concern is two fold; first, if there is a significant amount of trade differential flowing to these countries perforce of the accounting irregularities and second there is a need to expend the market for US services in international traffic that the accounting rules are a barrier to entry to.

6.2 Settlements as Part of Trade

The current International Record Carriers, IRCs, enter into bilateral agreements with other IRCs, namely the PTTs of the foreign entities to agree to settlement or accounting rates between each other. Generally these are bilateral agreements performed one at a time. The following is the FCC's current estimate of the size of the settlement process.[13]

> *"The United States paid roughly $5 billion in settlements to the rest of the world in 1995, up from $2.8 billion in 1990. The U.S. out-payment results in part from the fact that U.S. consumers make more telephone calls to foreign countries than foreign consumers make to the United States. In fact, the size of the imbalance between U.S.-outbound and inbound minutes has accelerated in recent years, as the chart in Appendix C demonstrates. To the extent that these settlement payments exceed the actual costs foreign carriers incur in terminating U.S.-originated calls, they represent a significant subsidy to foreign carriers. Based on our estimate of the costs of international termination services, we estimate that at least three-quarters of the $5 billion in out-payments is such a subsidy from U.S. consumers, carriers and their shareholders to foreign carriers."*

The system works in the following fashion. One carrier negotiates with another for the right to terminate traffic. For example Canada negotiates with the Ivory Coast. They agree on a settlement rate of say $0.40 per minute. This applies only to voice traffic. Say it is Teleglobe Canada and the Ivory Coast PTT. Now any traffic between he two is a $0.40 per minute. At the end of the year they add the traffic up and if there is more traffic from Canada to the Ivory Coast then the difference must be paid by Canada to the Ivory Coast at $0.40 per minute.

Now let us assume that Teleglobe Canada wants to place a call to Uganda. It places the call in transit through the Ivory Coats which charges a transit fee of say $0.020 per minute and the Ivory Coats has an agreement with Uganda for terminating at say $0.15 per minute. The Teleglobe gets charged the sum.

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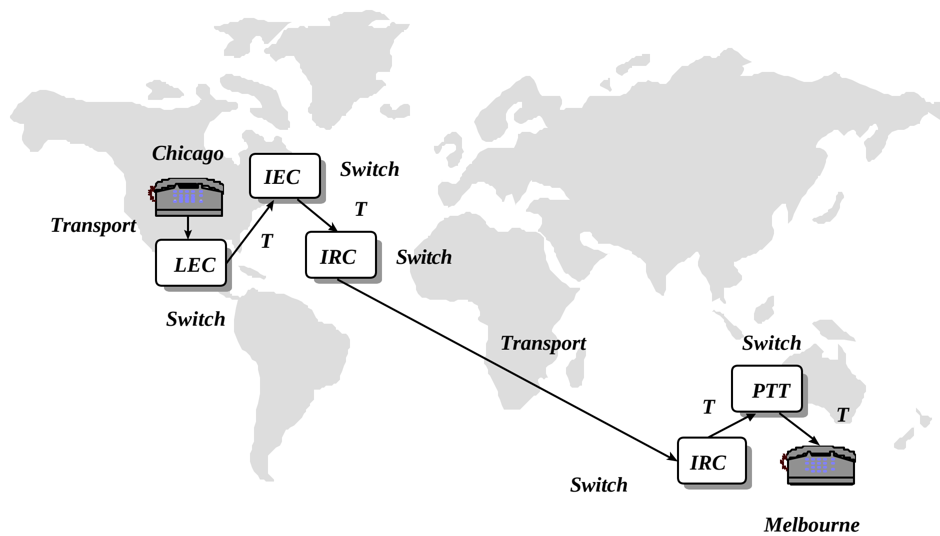
[13]Federal Communications Commission, FCC 96-484, Washington, D.C. 20554 In the Matter of International Settlement Rates , IB Docket No. 96-261, Adopted: December 19, 1996, ¶ 17.

The key issue however is that a carrier that has an agreement that any traffic that it terminates is voice and that it will pay the Ivory Coast at the agreed to rate. It cannot generally go back and say, this is Internet voice and I do not want to pay the Ivory Coast. A new entrant can start that way but an existing entrant places their existing agreements in jeopardy. Thus there is a general agreement that if there is an existing settlement agreement between two parties that the Parties shall honor the terms of the agreement and that any termination or transit of traffic shall be via the agreement and thus will require the payment of the pre-agreed settlement fees. This therefor places and existing carrier at jeopardy in view of attempting to get Internet terminations.

6.3 Accounting Rates and Settlements[14]

To understand the principles of accounting rates and settlement costs it is necessary to understand how a call is made in an international call. The accounting rules are to international traffic what the access fees are to domestic. The following Figure depicts that process.



A customer in Chicago desires to place a call to Melbourne, Australia. The customer first uses the transport and switch of Ameritech, who then connects to MCI. MCI provides transport and switching. The international record carrier chosen by the customer is AT&T. MCI then hands the call off to AT&T and AT&T has an agreement with the Australian IRC, International Record Carrier, namely an accounting agreement, to handle all traffic at the net rate of say $0.55 per minute. For that, the Australian PTT then handles the call and places it to the terminating point in Melbourne. The customer is billed $1.55 per minute. The IRC in the US charges the customer for their switching and transport and then adds on the costs of MCI and that of Ameritech, generally visa the access fee applied as a LEC.

The accounting rate is the rate agreed to by and between and amongst international record carriers for the provision of a unit, say a minute, of telecommunications, generally voice, between two locations or terminations. For example the United States carrier AT&T may agree to a number, say $0.45 per minute, with France Telecom, for all traffic between the United States and France, no matter what the direction of the traffic. This fee is the full and complete fee for the delivery of that minute from the midway point of the cable to the end destination point in the called location.

[14] See FCC IB Docket No. 96-261 which describes the process of accounting rates and see R. Frieden, "International Toll Revenue Division", 17 Telecommunications Policy, No 3 pp. 221-233, April, 1993.

The accounting rates is supposed to represent the total cost of carrying the traffic from point of origin to point of destination.

The settlement rate is the mechanism that any pair of carriers select to divide up the number of minutes from and to each other based upon the accounting rate already agreed to. Namely, if AT&T provides France Telecom with 500 million minutes, and France Telecom provide AT&T with only 400 million minutes, and the agreed accounting rates if $0.045, then at then end of a period, AT&T owes France Telecom, 500 million less 400 million, namely 100 million times $0.45, or $45 million dollars.

There is the third factor of why a call is $0.55 from the US to Israel but is $1.90 from Israel to the US. The answer is quite simple. The US and Israeli carriers have agreed to a settlement fee of say $0.35 per minute. The US market is competitive for barriers thus there cannot be an excessive distortion in price. Thus the $0.55 represents a fail demand based price subject to the $0.35 "subsidy" paid in the accounting rate. However, in Israel there is a pure monopoly and thus there is no clearing of the market and the PTT charges a rate based upon a social and fiscal policy that states that this is a means to subsidize those who cannot afford to call internationally. It is social policy and not economic policy that dictates the actual price.

The FCC states that the accounting rate system has the following characteristics:[15]

> *The current accounting rate system was developed as part of a regulatory tradition that international telecommunications services were supplied through a bilateral correspondent relationship between national monopoly carriers.[16] An accounting rate is the price a U.S. facility-based carrier negotiates with a foreign carrier for handling one minute of international telephone service. It was originally intended to allow each carrier to recover its costs for terminating an international call.[17] Each carrier's portion of the accounting rate is referred to as the settlement rate. In almost all cases, the settlement rate is equal to one-half of the negotiated accounting rate. At settlement, each carrier nets the minutes of service it originated against the minutes the other carrier originated. The carrier that originated more minutes of service pays the other carrier a net settlement payment calculated by multiplying the settlement rate by the number of imbalanced traffic minutes.[18]*

Thus under the existing settlement agreement, bilateral and multilateral, the existing carriers have generally affirmed and agreed to pay settlements on their voice circuits and that any change by them directly or otherwise would put their agreements in breach and could result in the immediate termination of their traffic from their home locations to the countries with whom they have agreements. The existing agreements are generally and in most cases expressly for the provision of voice traffic and have followed the generally accepted terms in existence for the past one hundred and thirty years.

6.4 WTO Agreement Details

The following Tables summarize the WTO agreements that exist for countries in question. The Table is for Korea and is typical for all.

Korea	Sector or Sub-sector	Limitations on Market Access
	C. Telecommunications services	None except that the provision of all services is subject

[15] Federal Communications Commission, FCC 96-484, Washington, D.C. 20554 In the Matter of International Settlement Rates , IB Docket No. 96-261, Adopted: December 19, 1996, ¶ 6

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[16] *We note that this tradition is not compelled by the international legal regime.* See *Article 9, International Telecommunication Regulation (Melbourne, 1988) and Article 31, Constitution of the International Telecommunication Union (Nice, 1989).*

[17] *See, e.g., Regulation of International Accounting Rates, CC Docket No. 90-337 (Phase II), Second Report & Order and Second Further Notice of Proposed Rulemaking, 7 FCC Rcd 8040, n.3 (1992).*

[18] *Every carrier is required to file a copy of its settlement agreements with the Commission. 47 C.F.R. § 43.51.*

Korea	Sector or Sub-sector	Limitations on Market Access
	Facilities-based: 1. Voice telephone services 2. Packet-switched data transmission services 3. Circuit-switched data transmission services 4. Private leased circuit services	to commercial arrangements with licensed Korean service suppliers None except that: (i) Each service supplier must be a licensed Korean juridical person. (ii) Until 31 December 1998, a licence, including radio station licence, may not be granted to a juridical person whose largest shareholder is: (a) Foreign government, (b) Foreign person, or (c) Juridical person 50 per cent (15 per cent, if the largest shareholder of the juridical person is a foreign government or a foreign person) or more of whose voting shares are owned by foreign governments or foreign persons. (iii) Until 31 December 2000, a license, including radio station licence, may be granted to a juridical person in whom no more than 33% of the aggregate voting shares are owned by entities identified in (a) through (c). From 1 January 2001, a license, including radio station licence, may be granted to a juridical person in whom no more than 49 % of the aggregate voting shares are owned by entities identified in (a) through (c). (iv) A licence, including radio station licence, may not be granted to a juridical person more than 33 per cent (10 per cent, in the case of wireline-based voice telephone services) of whose voting share is owned by a person[19] (v) The largest shareholder of KT must be Korean government or a Korean person. While KT's share owned by a person[20] must be no more than 3 per cent, the aggregate foreign shareholding in KT must be no more than 20 per cent until 31 December 2000, and no more than 33 per cent from 1 January 2001. (4) Unbound except as indicated in horizontal commitments
	Resale-based: 1. Voice telephone services 2. Packet-switched data transmission services 3. Circuit-switched data transmission services 4. Private leased circuit services	None except that: Provision of all services is subject to commercial arrangements with licensed Korean service suppliers. Until 31 December 2000 resale of voice telephone services interconnected to the public telecommunications network can only be supplied by companies established in Korea. None except that: Each service supplier must be a licensed Korean juridical person. Foreign shareholding in suppliers of resale voice telephone services, interconnected to the public telecommunications network, will be permitted only after 1 January 1999. From 1 January 1999, foreign shareholding will be permitted up to 49 per cent. As of 1 January 2001, 100 percent foreign shareholding will be permitted.

7. US POLICY IMPLICATIONS

[19] The definition of "a person" is in accordance with the relevant provision of the Presidential Decree of the Korea's Telecommunications Business Law.

[20]The definition of "a person" is in accordance with the relevant provision of the Presidential Decree of the Korea's Telecommunications Business Law.

The FCC in its Docket IB Docket No. 96-261, adopted December 19, 1997, stated the major policy issue in a clear and precise fashion. Specifically it stated,

> *"U.S. consumers pay on average 16¢ a minute for a domestic long distance call, but they pay 99¢ a minute for an international call. Yet, the difference in cost between providing domestic long distance and international service is no more than a few cents. As a result of recent technological advances, the underlying costs of providing telephony are becoming virtually distance insensitive. For example, because of new fiber optic technology, the cost of undersea cables on a per circuit basis is only one eighth of what it was seven years ago. We anticipate that increased competition in international satellite services will bring similar potential benefits to countries that are not now served by undersea cables and comparable land facilities. Differences in underlying costs therefore do not explain why international services are so much more expensive than domestic long distance services. The difference is attributable in part to limited competition in the IMTS market and in part to the inflated settlement rates paid by U.S. carriers to terminate traffic in foreign markets."*

We address two policy areas in some detail; first is the issue of what should the accounting rate be and how should it relate to a cost based system, and second, what is the policy future of Internet like telecommunications which is currently free from any settlement process.

7.1 Cost Based Settlement

The FCC has argued in its recent NPRM on Settlements that costs should be the key factor in establishing settlement rates. The FCC proposes that the costs be based upon three elements; international transmission, local switching, and national extension.[21] The Commission then predicates all of its costs analyses on these numbers. While the author agrees with this approach for the current means and methods for switched based voice telecommunications, the author argues that such an approach fails when applied to alternative telecommunications approaches.

The specific model as proposed by the Commission for costing contained the elements mentioned above. The Commission applied a specific methodology to those elements to come up with certain costs. [22] The three elements are: international transmission, local switching, and national extension. The author argues that rather than using tariffs as the sole arbiter of setting settlement rates that there is also a method for setting those rates on a costs based basis that reflects the actual costs incurred by the in-country provider. This additional approach shows that there can be an argument made for costs based upon forward looking technology as well as obtaining returns on past investments, if such be the case.

The cost elements for each relate to the following elements:

Capital Equipment Costs: It can be argued that the capital plant and equipment is generally the same for any country exclusive of tariffs and other tax like costs that the country must pay on the procurement of the equipment. The country may also have a costs of capital, so then when the capital and plant and equipment is equated to an

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[21] See ¶ 35 of IB Docket No 96-261, FCC 96-484, December 19, 1996.

[22] See ¶ 37, wherein the components are defines as: " ***International facility component:*** *The international facility component consists of international transmission facilities, both cable and satellite, including the link to international switching facilities. This component includes only the half-circuit on the terminating end because originating carriers have traditionally been responsible for the half circuit on the originating end of a call. High capacity circuits, normally 1.544 Mbps or 2.048 Mbps circuits, are used for IMTS and most telephone administrations offer these circuits to customers on a dedicated basis. The cost element for this component, therefore, is based on foreign carriers' private line rates for dedicated circuits. Multiple 64 Kbps circuits are derived from the high capacity channels and multiplexed into voice grade circuits based on standard U.S. operating practices. This information, along with average monthly traffic volume per circuit, is used to convert the private line rates to a charge per minute for each country.* ***International gateway component****: The international gateway component consists of international switching centers and associated transmission and signaling equipment. Foreign carriers do not generally offer a separate tariff rate for the international gateway component, so the study relies on information published by the ITU. The cost of this component varies with the level of digital facilities.* ***National extension component:*** *The national extension component consists of national exchanges, national transmission, and the local loop facilities used to distribute international service within a country. Foreign carriers' domestic rates and the distribution of U.S. billed service within a country[22] are used to compute an average charge per minute for cost of this component."*

annualized leased rate the lease rate must reflect that changing costs of capital. For example, in Poland, the respondent sees a 25% excise tariff on any imported telecommunications equipment that increase the capital costs base by that amount. In addition there is a risk premiums on capital financing of 2% to 2.2% that raises the annualized effective lease rates. The following Table presents a typical example using Poland as a case. If we assume an effective life, a tariff or excise tax rate, an interest rate and a risk market premium, then for every dollar the costs of switching per month is as shown below.

Effective Life (Years)	*Tariff Rate*	*Interest Rate*	*Market Premium*	*Monthly Fee*
5	*25%*	*8.00%*	*1.50%*	*$0.0263*
5	*25%*	*10.00%*	*1.50%*	*$0.0275*
5	*25%*	*12.00%*	*1.50%*	*$0.0288*
5	*25%*	*14.00%*	*1.50%*	*$0.0301*
10	*25%*	*8.00%*	*1.50%*	*$0.0162*
10	*25%*	*10.00%*	*1.50%*	*$0.0176*
10	*25%*	*12.00%*	*1.50%*	*$0.0190*
10	*25%*	*14.00%*	*1.50%*	*$0.0206*
15	*25%*	*8.00%*	*1.50%*	*$0.0131*
15	*25%*	*10.00%*	*1.50%*	*$0.0146*
15	*25%*	*12.00%*	*1.50%*	*$0.0162*
15	*25%*	*14.00%*	*1.50%*	*$0.0179*

Now let us assume that each trunk associated with switching is approximately $200.00 US. This is a reasonable costs for switching in large numbers. Then we further assume a usage of 100 minute per month per use or equivalently a 1% Erlang load, a trunk can then support 100 subscribers. Thus we find that the capital per subscriber per month, and corresponding per minute is:

Per Month Per Subscriber: Assume a ten year, 8% rate, and we have $2.60 per trunk per month or $0.0260 per subscriber per month.

Per Minute Per Subscriber: On a per minute basis this is $0.00026 per minute for switching.

The general conclusion is that switching is de minimis as a cost element.

Transport Costs: The transport costs are the costs for the fiber or other telecommunications facilities. They are generally distance sensitive but with fiber being more prevalent this distance sensitivity is no longer a significant factor. We assume a similar capital costs for transport but we double it, thus it is $0.00052 per minute as with the above argument.

Direct Operations Costs: These costs include the provisioning of network management, customer services, billing, provisioning, inventory management, and repair and dispatching. These costs are generally personnel driven and thus are produced at local market rates. Frequently these costs dominate the overall costs element of the system. In US costs the total cost for these elements is between $4.00 and $8.00 per month per subscriber. This is allocated across all of the subscribers usage, local, long distance and international. If we assume that a typical international call represents 10% of the total usage, a high number, we have an average of $0.60 per subscriber per month. This is $0.006 per minute.

Overhead Operations Costs: Generally this represents a 40% to 70% overhead. We shall use 50% based upon the most likely costs as an overhead on the operations costs. This then is $0.003 per minute.

Sales and Marketing Costs: These should relate solely to local in-country operations.

The summary of cost basis is as follows:

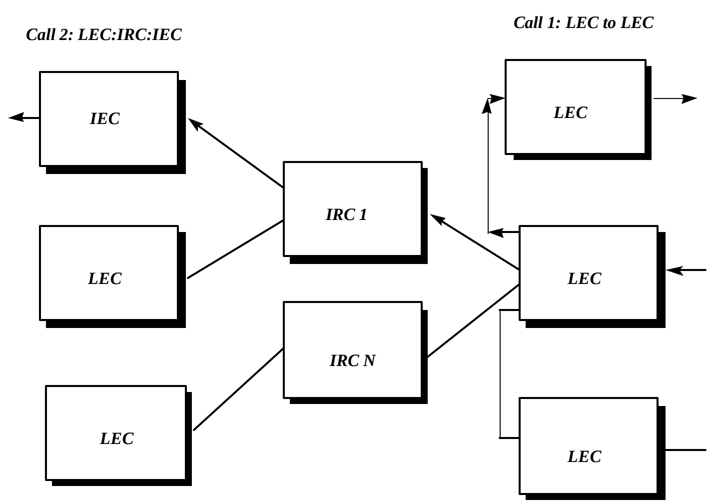
Cost Element	Unit Cost	Number Units	Total Costs
Capital Plant	*$0.00026*	*3*	*$0.00078*
Transport	*$0.00052*	*2*	*$0.00104*
Operations Costs	*$0.00600*	*3*	*$0.01800*
Operations Overhead	*$0.00030*	*3*	*$0.00090*
Sales Costs	*$0.00000*	*1*	*$0.00000*
Total			*$0.02072*

In the above we have assumed that there are multiple Units of each element involved in any transmission. This is consistent with the model shown previously. If we further assume that the system is at best loaded at only 25% then the change to above model occur only in the Capital Plant and transport elements. We then quintuple those numbers, increasing the costs about $0.0050 per minute, or at most 25 % increase. This is because the dominant costs are operations. We have kept the operations costs at US rates, and we know if we factor in local economy costs the rates drop a factor of four in most markets, thus reducing the costs to well less than $0.0100 per minute. It should be noted that these costs are dramatically lower than AT&T costs. These costs do not include the sales costs, a significant factor, nor do they include any R&D, product development, marketing, legal or other similar costs. These elements may easily, along with profit, raise the rate to a number comparable to AT&T.

The point we seek to make is that a "bottoms up" analysis of costing is essential by a market by market basis. The Commission has taken the approach of doing a "top down" approach using the "answer" of the tariffs. We argue that a "bottom up" approach using the actual costs is the better approach.

7.2 Principle of Cost Based Pricing

We conclude this with the Principle of Cost based Pricing. The principle can be explained via the following example. Consider the interconnection shown in the following Figure. Here we have a CMRS, an I-LEC, a C-LEC, several IRCs, and their interconnection. The CMRS will be the focal point. The CMRS connects to the IECs and to the I-LEC and C-LEC as well as to other similar players on the other side of the IECs.



Consider two calls. Call 1 goes from the CMRS to the local I-LEC. Call 2 goes from the CMRS, over an IEC to a customer at a distant I-LEC. Both calls are originated by a CMRS customer and terminate on an I-LEC customer.

Today, any IEC call must pay an interconnection access fee to the I-LEC to terminate on their network. As we indicated this is a wealth transfer policy and does not reflect any true cost. The CMRS before the Act paid the I-LEC a termination or origination fee and there was no compensation from the I-LEC to the CMRS. As we have demonstrated that is no longer the case.

The Principle of Cost Based Pricing states the following: The consumer should pay for each link separately and they should pay only for those links for which they are customers of that link provider. The payment the customer makes should reflect a price that is in turn based on the costs of that link.[23]

The basis for the Principle is the same basis for the Baumol Willig theorem, namely maximizing consumer welfare. The argument is based upon the theory of Ramsey pricing. The classic approach taken by Baumol and Willig is as follows:

$$\text{maximize}^{\{P1, \ldots, Pm\}} \; [\, CS + PS \,];\ \text{subject to } PS = F$$

where CS is the consumer welfare and PS is the production surplus or the profit of the monopolist provider.[24] If however, we eliminate the monopolist totally, that is maximize it on the basis of consumer welfare alone, and if we assume a fully displaceable and commodicizable service, and if we further assume the change in technology that eliminate scale in toto, then the resultant position is the Principle of Cost Based Pricing. Namely, each separate provider sells their service on the basis on their own costs and the interconnection is free and reflects not costs to the consumer.

7.3 Interconnection Agreements

The Commission has raised concerns about individual settlement agreements and the possibility of various large international carriers taking undue advantage of arbitrage opportunities within their own field of operations.[25] The author recognizes that the opportunities not only exists but lead to clear anticompetitive practices. The smaller nondominant carrier has no recourse to this procedure and no remedy under international law if the settlement agreement are allowed to be set on a company by company basis. The author argues that the rates must be set as if they were standard tariffs, and in fact similar to the benchmark rates for interconnect suggested by the Common Carrier Bureau in the Section 251 proceedings. The author argues that the Commission should itself or through an appropriate government agency establish and set those rates. In the case of interconnection, the Commission had established a process and procedure that has a default to the local PUCs. The respondent believe that this process is a common process. Without recourse or remedy however, the FCC should, if they are the entity of choice, set standard rate based upon the TSLIRC or similar pricing models.

7.4 Internet Telecommunications

Data is generally free from settlements. This is the accepted result of the WTO negotiations and has been opined on by various entities. The FCC states its position in the following in the following:

> *"There are other technological developments that accentuate the market distortions caused by above-cost settlement rates. For example, the routing of bilateral traffic through third countries has become increasingly prevalent as a means to arbitrage settlement rate differences. Such re-routing can be helpful in undercutting the settlement rate system, but it can also lead to inefficient traffic routing patterns that are not aligned with underlying economic network costs. Use of the Internet also has emerged as an alternative to higher priced IMTS. Though internet traffic and switched voice traffic are carried over virtually identical facilities, the price for internet service is far cheaper because switched*

[23]The issue here is a quid pro quo issue of parity in providing interconnection in a commodicizable market. For example, if two or more LEC or LEC like carriers enter a market, then there should be not interconnection fee and each carrier should price their services at the price based upon their costs and have no third party intervenor establish a de facto subsidization. If however, one carrier provides a service such ad aggregation to more efficiently interconnect, then this added non pari passu facility should be compensated at an equal, comparable, and costs based level, shared amongst all players. The Baumol-Willig approach can apply here if we merely eliminate the artifact of ensuring a profit to the monopolist as Baumol has consistently done. By maximizing consumer welfare at the expense of the suppliers, namely by creating a competitive market, one arrives at the principle of cost based pricing.

[24] See Brown and Sibley, The Theory of Utility Pricing, Cambridge University Press, 1986, p. 39.

[25] See ¶ 75, ID-96-261.

traffic is subject to international settlement rates, while internet traffic is exchanged outside of the traditional accounting rate system."[26]

The Organization for economic Co-Operation and Development, part of the European Common Union, ECU, in its recent report further opines on the introduction of Internet type telephony and its advantages in its ability to have zero settlements. The OECD Study states the following:[27]

"In the previous section, the call-back services which were examined provided service within the framework of the accounting rate and collection charge system. In this section, services which by-pass the international telecommunications charging system are examined. These services include international simple resale, which is already being offered in some countries. Other services, such as telephony using packet switched networks, including the Internet, would also be included in this group of services.

An overview of the different charging and settlement for a number of technologies is shown in Table 9. The services where there is no settlement are to a large extent used mostly by large business customers, but they are becoming increasingly available to the smaller customers given developments in technology, and regulation.

In general, the pricing structure for telecommunication services other than telephony does not depend on time and distance, and does not normally incur a settlement between the operators 12 . Telephone collection charges have also shown a trend toward being less time and distance related reflecting the digitalization of networks. There is, therefore, precedence for using systems other than accounting rates. Despite different charging frameworks many of these other services based on technologies other than the PSTN are profitable.

Table 9. Collection Charges and Settlement for Different Services[28]

Service	***Technology***	***Collection Charge Type***	***Settlement***
		Subscriber Line/ Trunk Line	
Telephone	*Switched Line*	*Time/Flat/ Time/Distance*	*Accounting rate system*
Packet	*Packet*	*Time/Volume/ Volume*	*Settlement by traffic volume*
X 400	*Store-and-Fwd*	*- /Volume*	*No settlement*
Leased line	*Leased Line*	*Flat*	*Half split (No settlement)*
Frame Relay	*Frame Relay, ATM*	*Flat*	*Half split (No settlement)*
Internet	*Packet / Others*	*PSTN, ISDN, L. lines, etc. / Flat*	*No settlement*

The above table depicts the WTO agreements as reflected in the Uruguay round of GATT talks. Namely that Internet, namely TCP/IP, is free from settlements and is the only one free on a full circuit basis.

The OECD report goes on to state:[29]

"Internet Telephony

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[26] *See: Federal Communications Commission, FCC 96-484, Washington, D.C. 20554 In the Matter of International Settlement Rates , IB Docket No. 96-261, Adopted: December 19, 1996, ¶ 17.*

[27] Organization for Economic Co-Operation and Development, Paris, 1997, "New Technologies and Their Impact on the Accounting Rate System", p. 35.

[28] *FR stands for Frame Relay Service. Source: OECD*

[29] OECD p. 39-40.

The ability to provide voice services based on packet switched network technology is increasingly providing a competitive threat to traditional public switched telecommunication networks. Although the use of this technology for voice is only emerging, there is considerable interest in its potential. This interest is being fuelled by the fact that time-based usage charges are not traditionally used for packet switched networks. The Internet is providing the underlying infrastructure to begin experiments with providing international voice communications over networks based on packet switched network technology. Although initially voice communications tended to be computer to computer communications, developments are now emphasizing computer to telephone communications. The advantage of packet switched networks also includes, as well, the ability to handle integrated voice, data, and video services which many customers are increasingly requiring for day-to-day business. The fact that there are no international usage charges and only the price of local calls is paid is evidently providing an impetus to Internet telephony. Although arguments have been made that existing Internet capacity will not be able to handle an explosion of voice communication on these networks, it is not evident that the required capacity will not be forthcoming if the demand for services is there.

The development of Internet telephony (see Information Infrastructure and Pricing: The Internet, OECD/GD(96)73 for a comprehensive overview of pricing on the Internet) threatens the viability of the existing accounting rate system. The fact that telecommunication operators, and many governments, seem to continue to support high collection charges (and accounting rates) is in fact accelerating the development of new technologies which help by-pass the existing payments system. Long-term strategy by operators, if they wish to maintain their viability, would argue for lower, more competitive prices which would serve as well to slow down the development and diffusion of alternate calling procedures.

Governments, given the increasing liberalisation of data networks and in PSTN markets, will have difficulty in regulating the entry of many new services which use packet switched network technology, including voice communications. First, there is the problem in differentiating one type of digital message from another. Second, there is the difficulty in disrupting communications with any one 40 relation in that re-routing of traffic is a simple procedure. Third, there is the policy emphasis that many governments have placed on the diffusion of broadband infrastructures to create the information infrastructures of the future. To have an economic impact, usage prices on these infrastructures need to be low otherwise new services and on-line applications will be slow to develop. ***Many of these new services will gravitate to packet switched networks because of price advantages***"

Thus under the WTO and under the generally agreed to terms of the WTO agreements on services, especially in telecommunications, data is free from both transit fees and settlement fees, and TCP/IP is defined as a form of data and is thus free from such fees. If a country who is a signatory to the Uruguay rounds decides to unilaterally violate that terms then it subjects itself to the severest penalties under the WTO.

8. CONCLUSIONS

This Chapter discussed many of the issue of architecture, interconnectivity, standards and regulation as regards to the deployment of global IP telephony. There are several overall conclusions that can be reached at this time.

Architecture: There are several differing architecture available. There is no clear cut path to which of these will survive. The issues of survival and dominance are economic, institutional, regulatory, and market acceptance. Specifically, we believe that there is a common level of service for voice that will dictate a single standard and not a bifurcation of voice quality into high costs and low costs voice. We may be wrong in that assumption and thus there may be other surviving architectures.

Bandwidth versus Minutes: The architectures will dictate what will be sold; bandwidth or minutes. Also is the "bandwidth" IP bandwidth or clear channel bandwidth. The ATT/BT merger discussions on the IP issue reflect the clear challenge as to what is going to be sold and in which architecture it will be sold. The ultimate resolution of this will be some time in coming.

Regulatory: The FCC has commenced its efforts in attempting to address the settlement and accounting rate issue. The growth in international telecommunications traffic and the pursuant growth in the internal economies will be strongly reliant upon free and open trade. An element of that trade is telecommunications. The telecommunications market is internal and external. We have argued herein that the internal portion is generally under the control of the local country and as best we might try we can at best influence that in the normal course of trade and tariff discussions. The traffic in international voice, data, and other service however is a new development within WTO, being part of GATS, and thus demands closer attention. The trade barriers of telecommunications must be realigned to meet the changes in these markets.

Markets: ATT/BT has focused on the Multinational Company market. Delta Three, Zephyr, and others have focused on the carriers carrier market. Some have tried to retail market of the end user. Where are the real markets? This will be an evolving question. The Carriers Carrier market is a simple entry point. The retail market is large, high revenue, but expensive as a cost of entry. We see the carrier's carrier market being the entry point but also being the growth point at this stage.

Services: The services that we have seen are dominantly voice but we have discussed multimedia, data, fax, and other services. This means that we can envision a wide set of IP based services. The question with multimedia is again what standards do they apply in the standard telephony context, is there a set if ITU compatible IP to SS7 to C7 interfaces. Is ISDN like service portable to IP?

Competition: There will be clear competition on may fronts. The barriers to entry to this market are operational and regulatory and not just economic. The Internet players can provide the degrade quality at low entry costs. We have argued that such quality may be unacceptable however with advances in Internet Quality of Service parameters this may be less of a problem. Thus there would be ubiquity, low entry costs, and any player can enter and the game becomes a marketing and sales gam and not one of operations. We counter ague however that there will always be the need for interconnection to the global telecommunications network so that despite the simplistic Internet approach a switch or switch like device, the LCU in our parlance, will be required. Thus there will be a barrier to entry based on technical and operational competence as well as marketing. We further argue that having operations in foreign countries is key to the success after having achieved the sales and operational levels. This mans partners, affiliates, or other experienced players. This we argue is the ultimate barrier to entry. We then argue that competition will be seen as these three forces are brought to bear.

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