

The Evolution of International Internet Telephony¹

Terrence P. McGarty²

Abstract

This paper presents a summary of the evolution of the Internet Telecommunications market internationally. It shows the evolution of various strategies that are being deployed as well as the dramatically changing regulatory market that companies are working in. The main change that has been noticed has been that certain companies are becoming IP carriers and services providers whereas certain companies have refrained from any expansion into infrastructure. The strategic question is what strategy brings the best sets of services especially for growing markets.

1. INTRODUCTION

International Internet Telephony has been evolving since its introduction in 1996. In 1996, the typical player was someone like Delta Three, who used the Internet as a backbone network, used agreements with local ISPs to “gray-market” terminate traffic in a country, such as Columbia or Israel, and then used a VocalTec type gateway to interconnect the local call with an E&M or R2 type signaling. Voice quality was bad, call set up time interminable, and call completions were limited at best to 10-15%. The only selling point was price.

Today, four years later, there is a clear segmentation of models. At one extreme is the extension of the Delta Three approach still being provided by delta Three as well as IBasis and ITXC. This is the “be everywhere but be shallow” approach. This approach uses the Internet as a backbone and then deals with local players as did Delta Three at the beginning. The other approach is one which integrates IP services. It is an approach characterized by “be selective but own the IP market” approach. To some degree Net2Phone exemplifies that strategy as does Zephyr, as does many of the would be players such as KPM Qwest, Colt, and Level3.

1.1 Business Models

The business models fall into two dramatically distinct extremes, and anything in between. At one extreme is the model which uses the Internet and has contractual relationships. The other extreme is a model which has its own infrastructure and has an in country business operation under its own control. In both cases however we consider the issue of the business being international in nature.

The articulation of the two extreme strategies can be shown as follows:

Strategy 1: Internet and Land; In this case the Internet is used as the medium to connect to any country and then the landing point is the drop off point in that country. For example, a carrier such as ITXC uses the Internet from a meet point in the united States to get to Russia, for example, and then in Moscow agrees via a local ISP or comparable player to terminate the calls in that country. The Internet costs are low, never free since there is an Internet connection and access cost at both ends, and in addition the ultimate costs of the network operations is the terminating cost per minute, namely terminating the call in Country.

Strategy 2: Backbone Network and Expand; The second strategy is shown below also. It starts from a switch but uses a dedicated and fully controlled network which goes to a country. The in-country network is landed and then expanded to cover all of the country, or say 70% or more. This network is also owned and controlled. This network is an all IP network allowing for IP telecommunications as well as any and all other IP related services. It takes maximal benefit from an integrated and controlled IP backbone network.

1.2 Market and Services Segments

The markets and services are seeing a confluence and convergence. Namely, the provider of IP telephony also provides other types of IP services, The markets are segmented by services provided: IP telecommunications services, broadband Internet access, and web hosting.

¹ Presented at Telecommunications Policy research Conference, September 23-25, 2000, Washington, DC.

² Dr. McGarty is the Chairman and CEO of the Telmarc Group, LLC, a venture capital company and is also on the advisory Board of the MIT ITC Group.

(1) *IP Telecommunications*: IP telecommunications is the provision of standard telephony services. For IP telecommunications services, this includes Country inbound and outbound traffic and Country domestic traffic. Currently, the primary customers are carriers and businesses. IP telecommunications may also include certain enhanced telecommunications services that are uniquely implementable with IP, namely multi party multi country conference calling, integrated multimedia calling, and other similar services. Generally Quality of Service, QoS issues, are critical in this environment.

(2) *Broadband Internet Access*: Broadband Internet access is the provision of high speed Internet connectivity. It can be provided via DSL, wireless, dedicated lines, leased lines or a variety of other means and methods. Broadband is generally characterized as anything above 128 Kbps and typically peaks at 2 Mbps, the E1 standard. However it may go higher. The user for such services is an end user and they want to be able to connect to a LAN or some other common end user device. The end user is also concerned about the ability to get rapid Internet response thus the last mile must be fast but the backbone MUST ALSO be fast.

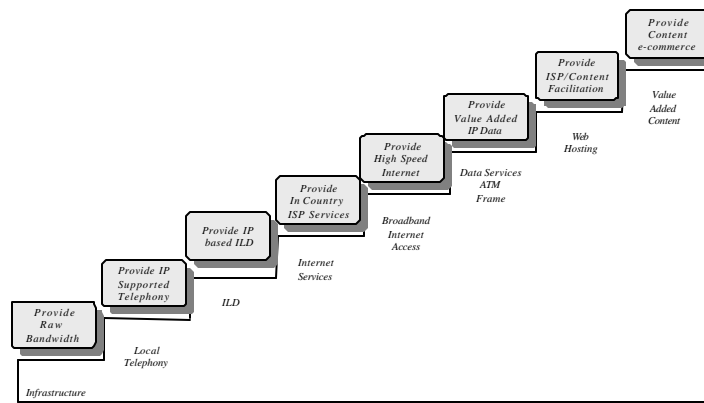
(3) *ISP Interconnectivity*: This is the provision of high quality high speed access to an Internet backbone. The critical issue here is not last mile but backbone. This for a network provider it is essential to have MAE East/West, NAP, NIX, and other comparable connectivity. Only by having a fully connected and peering optimized network can this service be sold. This requirement implies that we have a network that is owned and controlled, and a Strategy 1 type player cannot provide such services.

(3) *Internet Data Services (IDS)*: IDS is the provision of such services as web hosting and other content, e-commerce, and portal related services.

1.3 Strategy Execution

The following shows eight segments of the IP value chain, from raw bandwidth to content/e-commerce provisioning. Each has an increased value element. Each element is IP based in its delivery and support. The positioning of the segments is also highlighted with a typical company and the multiple of Market or Enterprise Value to Forward Looking Revenue values. The higher the multiple the better the investment potential. Pacific Gateway is a pure infrastructure company with the lowest multiple. The content companies have the highest ratios.

IP Value Chain



Company	Pacific Gateway	IDT	GTS	PSI	COVAD	COLT	InterNAP	Amazon
EV/FLR	0.5	1.0	3.3	8.0	16.1	15.3	81.9	90+

The overall strategy of several companies is combine multiple service offerings. It expands to the Local and Inter Exchange market which provides direct access to the local commercial and retail customer and expands upward to the

web hosting and Internet Data Service market segment providing in-country facilitation of Internet services, including hosting, interconnection, and management.

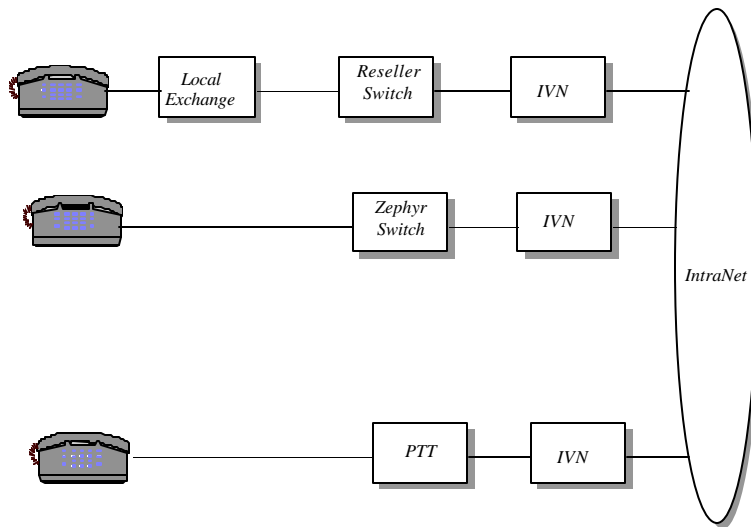
2. SERVICES

This section presents a summary of the services that can be provided.

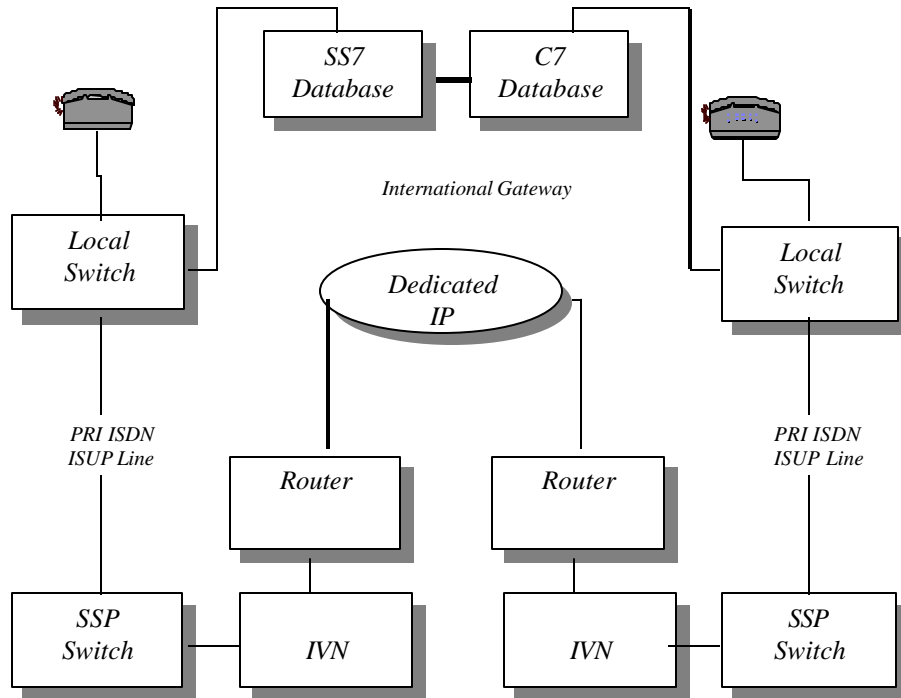
2.1 IP Telecom Plant

The first element of the Company's plan has been the establishment of IP telecommunications services. IP allows for better switching, improved and expanded enhanced services, lower costs, and more versatility in the deployment of systems and services. The ILD segment establishes a Company "beachhead" in each country which becomes the key element in the development and deployment of other services.

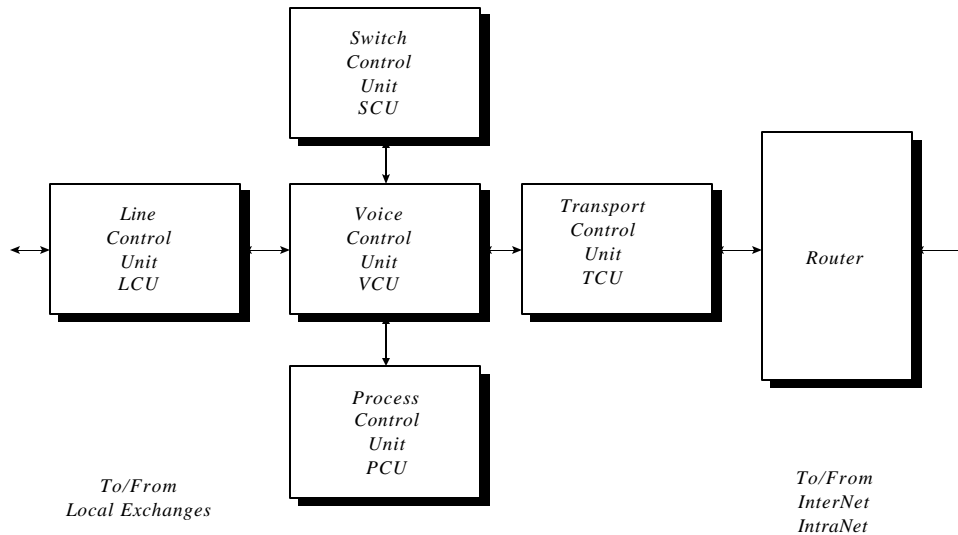
The Company ILD services allows the customer either to call directly or via a third party reseller using a standard telephone. The following figure depicts the possible interfaces currently supported. The reseller may be a facilities based reseller with a switch. The Company sells the service wholesale to the reseller who then buys the time in bulk from the Company. The second case is where the Company goes directly to the customer and in that case the Company may require its own switch to provide certain normal telephone functions. This switch may then support a pre-paid card system or may even prepare a bill. In the second case the customer is the Company's customer and dials in directly to the Company switch. The third case shows a PTT configuration wherein the customer may call from a foreign country on a typical direct dial basis.



The following depicts the full scope of the international network configuration. The network must support any form of end user telecommunications and must also handle the signaling that supports the network operations. This signaling includes SS 7 in the United States and C 7 in most international domains. This is out of band signaling that must be interfaced via a gateway type switch. The following shows the use of TCP/IP as the backbone international transport network. The figure shows a domestic U.S. network using SS7 signaling and then uses a gateway switch that allows for international transport using devices called IP Voice Nodes ("IVNs"), that convert between circuit switched voice to packet switched voice.



The basic system building block for services is the IP Voice Node (IVN), shown below:



It consists of the following elements:

LCU: The Line Control Unit is the interface between the telephone network and the IVN. The LCU provides for call initiation and termination.

PCU: The Process Control Unit provides the capability of controlling the processes of a general nature such as network management, billing, and the IVN provisioning capability.

SCU: The switch control unit provides for the conversion between the telephone number for dialing and the TCP/IP address for Intranet connectivity.

VCU: This is the Intranet Voice Processor or the voice card. The current system converts the voice into an 8 Kbps signal. The Company believes that it can achieve a 4 Kbps compression in a year and a 2.4 Kbps compression in three years. This means that more subscribers can be supported on the same backbone network.

TCU: The Transport Control Unit provides for the packet synchronization between transmit and receive.

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

The IVNs are currently provided by Motorola.

The following is a summary of the technical elements, the unit cost, the average costs and the vendor status.

<i>Element</i>	<i>Vendor</i>	<i>Performance Factor</i>	<i>Cost</i>	<i>Capital Per Minute</i>	<i>Cost per Minute</i>
<i>IVN</i>	<i>Motorola Cisco Lucent Ericsson</i>	<i>500,000 minutes per month per unit</i>	<i>\$15-18,000 each, \$30-36,000 per pair.</i>	<i>\$0.0720</i>	<i>\$0.0013</i>
<i>Router</i>	<i>Cisco</i>	<i>Handles up to an STM1 which is 155 Mbps or 75 E1s.</i>	<i>\$30,000 each</i>	<i>\$0.0001</i>	<i>\$0.0000</i>
<i>Switch</i>	<i>Lucent, Siemens Nortel, Ericsson</i>	<i>Switch has multiple E1s. Each E1 must be paired.</i>	<i>\$1.6-\$2.2 million and supports 800 to 1,000 E1 terminations. However need a pair of E1's, input and output. Typically \$1,800 per E1.</i>	<i>\$0.0090</i>	<i>\$0.0002</i>
<i>E1 Circuit Compressed</i>		<i>5,000,000 min per month</i>	<i>\$90,000 per month</i>		<i>\$0.0180</i>
<i>E1 Circuit Uncompressed</i>		<i>400,000 minutes per month</i>	<i>Local Termination costs</i>		<i>\$0.0290</i>

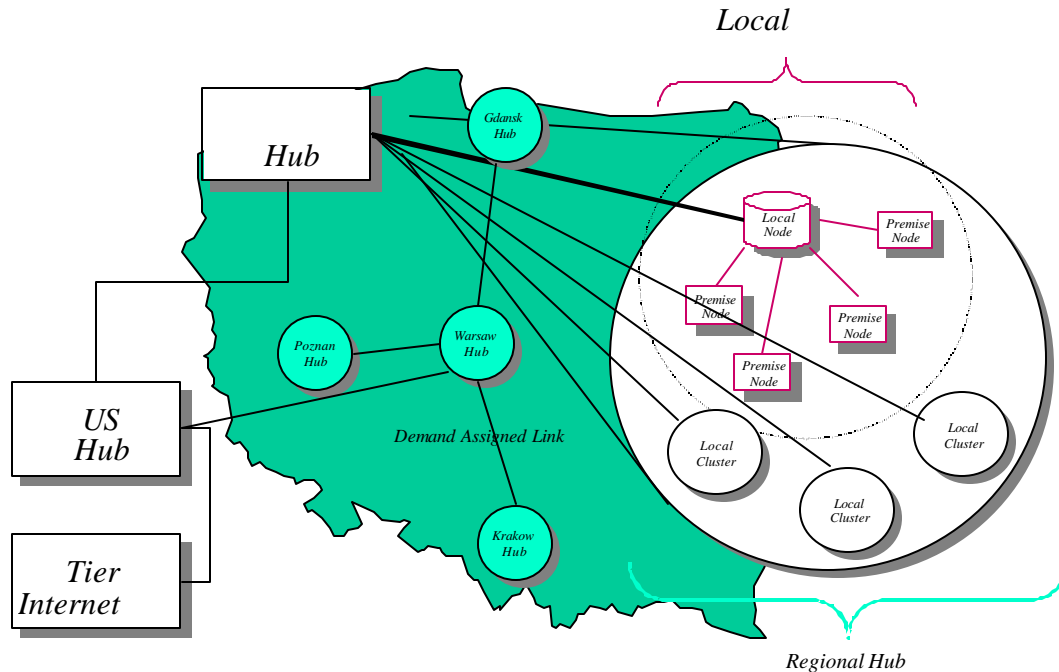
2.2 High Speed Internet Access

There are three modes of High Speed Internet Access; wireless, cable, and DSL or Exchange Carrier Based.

2.2.1 Wireless Based High Speed Internet Access

The following depicts the full scope of the wireless high speed Internet Access network. The wireless approach uses technology over both licensed and unlicensed bands. It is roof top to roof top. This is targeted to commercial or high density residential users. The service uses the backend IP backbone for connection to the high speed Internet backbone.

The network must support any form of end user telecommunications and must also handle the signaling that supports the network operations. This architecture is shown below. The Warsaw Hub allows connectivity to the Internet backbone via the ILD circuits and then using the in-country network connects to local hubs in the locations of operation. Frequently the Local Hub is a building roof location. The local hub then broadcasts out to premise nodes on surrounding buildings and to the end user.



The ISP connects to the network via a Frame Relay or ATM depending on the carrier, which circumvents the modem pools. This is a higher speed, continuous time, and lower cost means of interconnection. The Internet Network allows for any user to have remote high speed access to the Internet at speeds up to 100 Mbps. This system provides for the most cost effective interconnection alternative that is available. There is a hub location that interconnects into the Internet Service Provider, ISP.

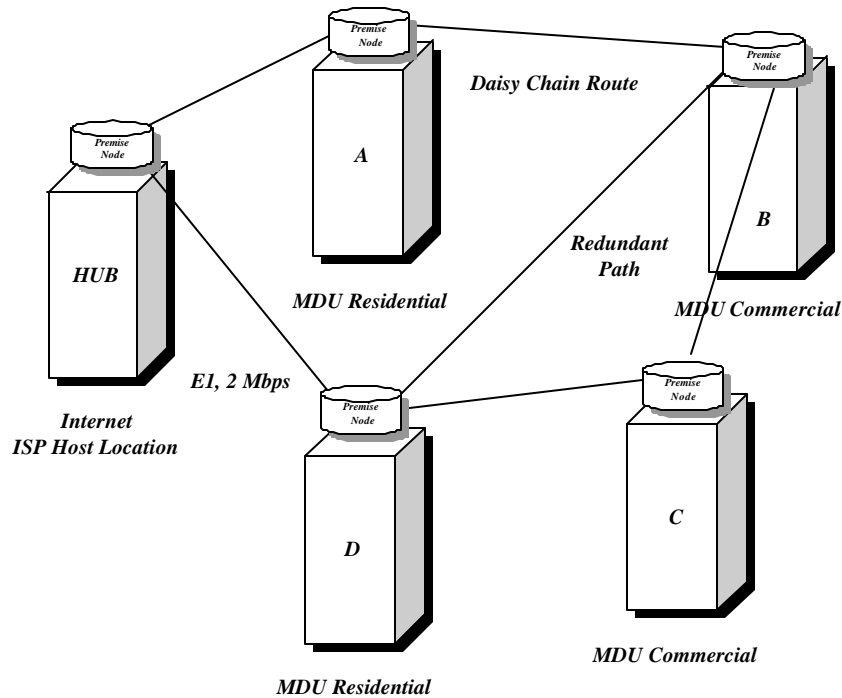
- *The Hub transmits to other nodes.*
- *The nodes on the other locations receive the transmission, convert it to a digital signal, look at the destination, and if for that location, bring the message down, and if for another location, retransmit the message. This is done via a router interface supporting each node location. The backbone is a TCP/IP network.*
- *The node takes those message bound for the users at the node down to a standard data format that can be used to distribute the signals within the facility. This is typically done by an Ethernet type connection or via some proprietary approach.*
- *The return path works in a similar fashion.*

The overall global architecture of the Internet is shown below. The Internet has a high speed backbone that connects down to regional network providers such as UUNet, BB&N, MCI and others. These carriers generally have their own high speed interconnected network. They then sell their services to local Internet Service Providers, the ISPs. The ISPs may or may not have their own facilities. Generally the local Internet provider provides for dial up modem connections at rates up to 56 Kbps or even T1, 1.544 Mbps rates. These higher rates are generally quite expensive.

The overall architecture of the network is shown below. Specifically it functions as follows:

- *The unit has a hub location co-located with the ISP. The interconnection is at the Frame Relay switch level with the master node.*
- *The EBU links are connected either on a hub and spoke basis or on a daisy chain basis.*
- *The hub and spoke design allows for a dedicated access link to the Hub site.*

- *The daisy chain design allows for a single high speed link to be shared amongst several locations as well as allowing the deployment of an effectively endless chain of links to expand the effective coverage area despite the single link range of one mile plus.*
- *There may also be redundant paths as shown below where there is always more than one way to get to a building. In fact building B has three paths available thus dramatically increasing the link availability.*



The in building connectivity is driven by the need for a low costs and low risk approach. The connection to the end users computer can be configured as shown in the following Figure.

- *The external unit connects to a router, which then connects to a server. The server provides for the Ethernet connection.*
- *The modem can be as simple as an FM modulator or demodulator as is used in a TV set to up band and down band the signal.*
- *The advantage of this scheme is that the Ethernet cards are available and can be used as the transport means.*
- *In addition the use of the Ethernet cards allows for the expansion, via the server, of a full end to end network management capability.*

2.2.2 Cable Based High Speed Internet Access

High Speed Internet access provides a significant and growing application for IP transport. High Speed Internet can provide two elements; high speed data and voice telecommunications. The high speed data requires a two way cable plant that can provide a high speed access down stream and a moderate speed upstream. The typical High Speed Internet plant is shown below. It has a Head End and a access capability for the high speed data access. It assumes that the system allows for two way capabilities, over a fiber backbone to the Hubs and from there via coax to the homes or end users. The strategy for High Speed Internet applications is to deploy valued added service via joint ventures with High Speed Internet companies. The services are twofold: high speed data and Internet access and local and inter exchange carriage using IP over the High Speed Internet plant.

The total High Speed Internet architecture is shown in the following chart. Here we have depicted the residential as well as the business user. The High Speed Internet plant via such protocol as IEEE 802.11 can provide for an integrated telephony and high speed data service. This presents a great revenue opportunity. The specific services offered are:

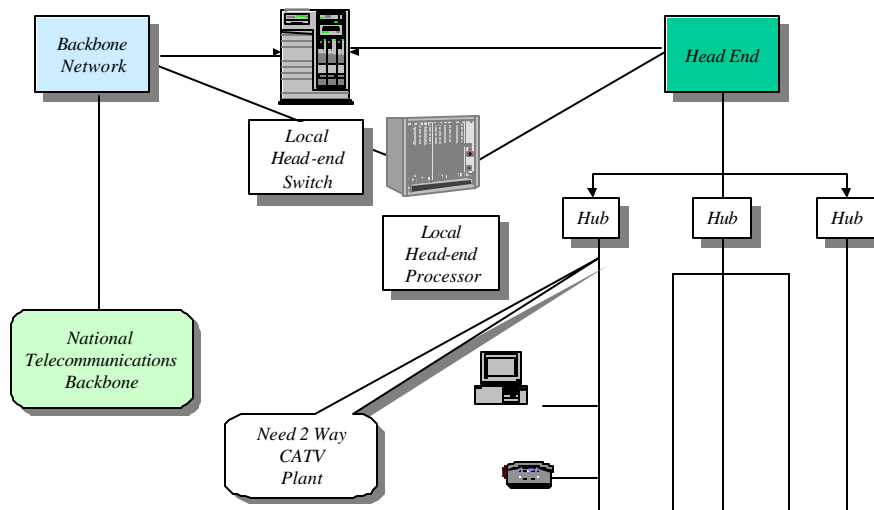
- *Local, National, International Voice*
- *Internet Access: WWW, SMTP, FTP, etc.*
- *Conventional Speeds (64 kbps)*
- *High Speed (3 Mbps)*
- *Enhanced PC Content*
- *Business-to-Business Data (IP VCs)*
- *Digital High Speed Internet*

The High Speed Internet strategy is to work jointly with local High Speed Internet. Specifically the strategy implications are as follows:

- *High Speed Internet plant provides much more bandwidth to consumers.*
- *Provides the substantial interconnectivity necessary to realize value in 2-way High Speed Internet upgrades.*
- *All-IP solution provides advantageous regulatory treatment for telephony.*
- *Polish/local content significantly enhances value of @home/www style services.*

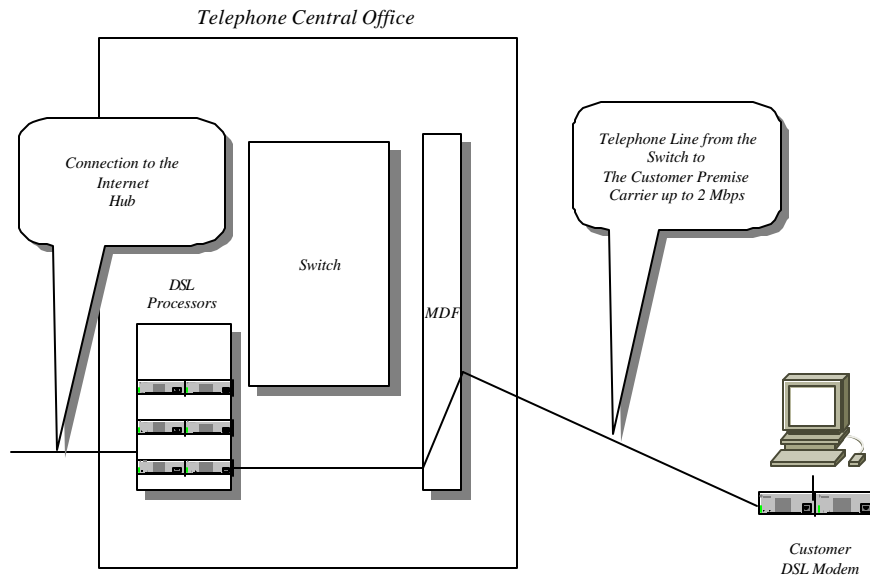
The cable based approach also allows for the integration of Internet and telephony. The network configuration for this service is shown below.

System Architecture - Integrated



2.2.3 DSL Based High Speed Internet Access

DSL, digital subscriber loop, is a high speed Internet Access Technology that uses the existing telephone lines. The operation is quite simple. This is shown below.

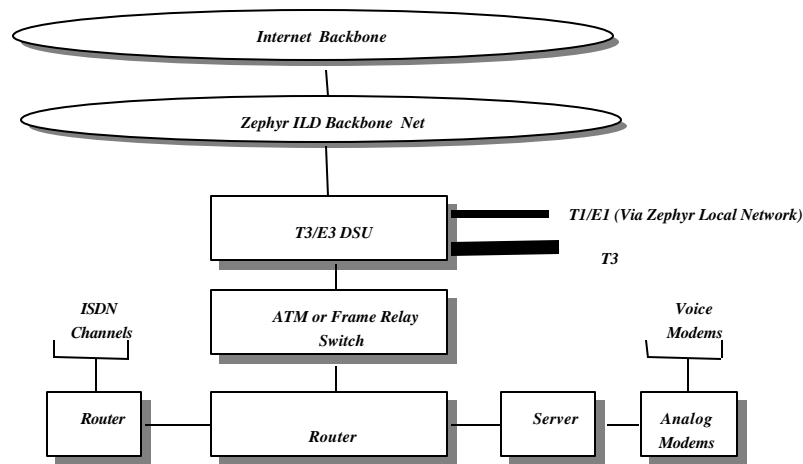


2.3 IP Services

The IP services architecture and elements build on the common network and the common IP infrastructure. The following figure depicts the Web Hosting and IP Service overall architecture showing ISP interconnectivity or BIA access as well as Content provider services and server support. IP Access Services include the following set of service elements:

1. **Web Hosting:** This includes the hosting locally of portals, e-commerce, and other web based service providers in facilities in a Hub or similar location. This will allow a portal such as Yahoo! Or an e-commerce company such as Amazon to have a real presence in a country by having the facilities to locate their content as well as search and commerce engines locally.
2. **Caching:** This is the storage of local data so that it may accessed locally thus dramatically reducing transport and response time for the user.
3. **NAP/MAEAST Interconnection:** This direct connectivity reduce any response delay, lowers end to end costs, and allows for potentially improved Internet based Quality of Service.
4. **Local in-Country Interconnection:** The local in country connection is for the local ISPs who can connect at the Hub. This allows them to have dramatically lower costs. For example, if an ISP wants to get a connection to the Internet, it would go to a UUNet or PSI and pay from \$15,000 to \$30,000 per month for an E1 connection.
5. **Local Presence Support:** The local presence and support provides for the assistance and interconnection of ISPs, portals, content providers and e-commerce players along with an established customer base in any single country and other countries.

The following Figure depicts the overall Internet architecture. Locally the network may be accessed by modems or directly by T1 or E1 circuits. Namely, the ISPs in the country may connect to the network over the in-country Local Network. This gives each ISP a virtual presence in the Hub.

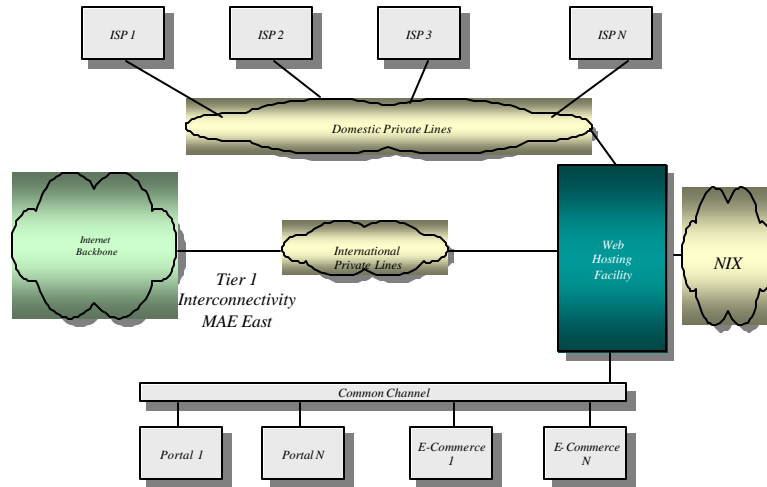


The following Figure shows the overall set of elements and the interconnectivity of each. It complements the prior Figure. Here is shown:

1. *ISPs connect to the Hub via the in-country network.*
2. *Content Providers are connected by a direct presence in the Hub location this permitting better response and local content changes on a real time basis.*
3. *The Hub is composed of telecommunications IP system to interconnect to the ISPs as well as to provide a high quality connection back to the Internet backbone in the U.S.*

The strategic advantage is clearly its combination of international backbone, in country backbone, integrated IP platform, integrated Operations Support Services, access to a high quality customer base, and the ability to initiate in a rapid fashion Internet service access and support in country.

Web Hosting Architecture



3. MARKETS

The following is a list of selected countries based on market analysis and identified opportunities. The following Table is an overview of the demographics of the selected target countries.

Country	Population(000,000)	GDP(\$000)	Phones/100	Phone Lines(000)	Telco Growth(%)	ISP Hosts	ISP Hosts per 10,000	ISP s	ISP Users	Growth(%)	TV Sets per	TV Sets
Argentina	35.67	\$297.50	19.1	6,824	11.50	79,185	22.20	90	170,000	55.0	28.88	10,301,496
Bangladesh	122.10	\$31.10	0.3	316	10.80	-	-	-	-	-	0.71	866,910
Brazil	158.90	\$774.90	10.7	17,038	12.80	221,631	13.95	400	1,310,000	77.0	31.63	50,260,070
Canada	30.30	\$601.60	60.9	18,460	2.30	2,242,954	740.25	na	4,500,000	125.0	70.82	21,458,460
Chile	14.66	\$69.20	16.1	2,360	17.00	25,917	17.68	13	250,000	79.0	23.25	3,408,450
Czech Republic	10.30	\$56.50	31.8	3,280	16.40	68,940	66.93	na	300,000	50.0	44.56	4,589,680
Egypt	62.01	\$67.40	5.6	3,463	14.10	-	-	-	-	-	12.21	7,571,421
Germany	82.21	\$2,352.50	55.0	45,200	2.50	1,662,309	202.20	67	5,000,000	100.0	56.99	46,851,479
Greece	10.52	\$124.10	51.6	5,431	1.90	46,580	44.28	73	200,000	33.0	46.57	4,899,164
India	955.22	\$360.40	1.9	17,802	22.40	60,923	0.64	1	200,000	200.0	6.91	66,005,702
Indonesia	201.89	\$227.40	2.5	4,983	19.00	30,738	1.52	40	250,000	213.0	9.73	19,643,897
Israel	5.91	\$95.20	44.9	2,656	4.60	119,500	202.20	24	300,000	100.0	32.18	1,901,838
Italy	57.52	\$1,213.60	44.7	25,698	1.70	494,455	85.96	320	700,000	20.0	48.33	27,799,416
Korea	46.00	\$484.60	44.4	20,422	4.20	250,758	54.51	23	800,000	33.0	34.23	15,745,800
Malaysia	21.67	\$99.50	19.5	4,223	12.00	55,337	25.54	2	600,000	838.0	16.61	3,599,387
Pakistan	138.15	\$60.20	1.9	2,557	7.60	-	-	-	-	-	2.15	2,970,225
Poland	38.50	\$134.60	19.5	7,510	15.00	101,898	26.47	7	800,000	60.0	41.40	15,939,000
Russia	147.11	\$429.60	18.3	26,875	3.70	137,340	9.34	na	700,000	132.0	38.79	57,063,969
Switzerland	7.09	\$295.10	66.1	4,688	3.10	301,421	425.14	88	500,000	35.0	53.57	3,798,113
Thailand	60.60	\$181.40	8.0	4,827	14.90	44,862	7.40	na	150,000	88.0	23.43	14,198,580
Turkey	62.87	\$176.20	25.0	15,744	10.60	64,571	10.27	78	800,000	150.0	27.57	17,333,259
U.K.	59.03	\$1,157.80	54.0	31,878	3.90	1,784,080	302.23	300	4,300,000	80.0	64.04	37,802,812
U.S.	267.90	\$7,636.00	64.4	172,453	1.10	20,052,222	748.50	4,354	40,000,000	33.0	84.73	226,991,670
Ukraine	50.70	\$44.60	18.6	9,410	1.80	-	-	-	-	-	49.31	25,000,170
Viet Nam	76.55	\$23.30	2.1	1,587	33.80	-	-	-	-	-	17.96	13,748,380
Total	2,723.38	\$16,994.30		455,682		27,845,621		5,880	61,830,000			699,749,348

3.1 Overall Market Demographics

The following is a brief summary of Internet capabilities in several selected markets.

3.2 Greece

We have chosen Greece and certain other central European markets because of their growth potential. We first summarize the status of Greece and the Balkans in general. The following is a summary of these markets.

Country	Growth Rate (%)	DLD to ILD Ratio (%)	ROW to US Ratio for Outbound (%)	Inbound to Outbound Ratio (%)	ILD From	ILD To	Domestic LD	ILD From
Albania	20%	700%	2298%	257%	70,556,082	181,245,085	493,892,574	84,667,298
Bulgaria	20%	800%	2500%	919%	39,600,850	363,917,275	316,806,800	47,521,020
Cyprus	20%	500%	2992%	243%	266,212,523	646,994,111	1,331,062,615	319,455,028
Greece	20%	800%	1674%	272%	1,025,948,160	2,787,375,083	8,207,585,280	1,231,137,792
Romania	20%	800%	2261%	241%	191,462,400	462,339,097	1,531,699,200	229,754,880
Yugoslavia	20%	800%	3423%	250%	374,976,000	937,440,000	2,999,808,000	449,971,200
Total Balkans					1,968,756,015	5,379,310,652	14,880,854,469	2,362,507,218

The following depicts the infrastructure elements and their growth.

Country	Content Provider Growth Rate (%)	ISP Growth Rate (%)	Access Line Growth Rate (%)	ISP Subscriber Growth (%)	Content Providers	ISP	Access Lines (000)
Albania	43%	40%	36%		148	10	218
Bulgaria	348%	100%	3%		137,533	12	2,930
Cyprus	765%	35%	7%		48,562	5	472
Greece	99%	33%	5%		120,792	129	6,287
Romania	229%	30%	5%		86,834	12	3,659
Yugoslavia	381%	35%	5%		37,106	10	2,526
Total Balkans					430,975	178	16,092

The following is the details on the individual users.

Country	ISP Subscriber Growth (%)	Internet Users/ISP	Internet Users	Internet User per Access Line
Albania	55%	2,000	20,000	9.16%
Bulgaria	45%	2,917	35,000	1.19%
Cyprus	40%	9,000	45,000	9.54%
Greece	33%	1,549	200,000	3.18%
Romania	60%	10,417	125,000	3.42%
Yugoslavia	25%	5,500	55,000	2.18%
Total Balkans		31,382	480,000	

Greece was the fastest growing European market for telecommunications in 1999. Year end 1999, the telecommunications sector in Greece alone constituted 4.5% of GDP and is growing at 8.5%. In addition, Internet business has increasing steadily. The following chart represents the demographics for the region:

	<i>GDP Per Capita</i>	<i>Pop.</i>	<i>Phone lines</i>	<i>Teledensity</i>	<i>Int. Hosts</i>
<i>Albania</i>	\$724	3,730,000	86,800	2.3	161
<i>Bulgaria</i>	\$1,181	8,300,000	2,681,000	32.3	14,009
<i>Cyprus</i>	\$13,088	680,000	385,000	56.6	5,611
<i>Greece</i>	\$11,797	10,520,000	5,430,900	51.6	60,736
<i>Romania</i>	\$1,555	22,570,000	3,161,000	14.0	20,356
<i>Yugoslavia</i>	\$991	10,600,000	2,182,000	20.6	7,635
Total	\$3,388	56,400,000	13,926,700	34.3	108,508

An early indicator of the Greek Internet market is the growth of ISPs. The following chart shows the ISP leaders in Greece and their market share:

<i>Rank</i>	<i>Company</i>	<i>IP Addresses</i>	<i>Share</i>
1	<i>Forthnet</i>	18,268	39.7%
2	<i>OTEnet</i>	13,431	29.2%
3	<i>HOL</i>	4,579	10.0%
4	<i>HellasNet</i>	2,893	6.3%
5	<i>IPNG</i>	1,326	2.9%
6	<i>Sparknet</i>	946	2.1%
7	<i>Internet Hellas</i>	935	2.0%
8	<i>AiasNet</i>	931	2.0%
9	<i>Ideal Telecom</i>	624	1.4%
10	<i>Groovy net</i>	377	0.8%
11	<i>Hub</i>	349	0.8%
12	<i>Acropolis</i>	314	0.7%
13	<i>IGN</i>	301	0.7%
14	<i>Compulink</i>	272	0.6%
15	<i>Stargate</i>	139	0.3%
	<i>Other</i>	317	0.7%
	Total	46,002	

Greece may place second to last among the European Union countries in terms of per capita spending on telecommunications, but the revenue increase rate is the highest in Europe, according to the European Information Technology Observatory (EITO).

In 1998, the Greek market grew by 14.5 per cent against the average European rate of 7.2 per cent, while this year it is expected to increase by 12.7 per cent against 6.2 per cent in Europe. In both cases, the Greek telecommunications market has the highest development rate in Europe. Meanwhile there are still numerous development opportunities. According to studies conducted by ICAP and Eurocom Expertise, telecommunications comprise 3.1 per cent of Greece's GNP (2.7 per cent in 1996), whereas the average percentage in other EU countries is about 5-6 per cent. HSBC Securities expects it to rise to 4 per cent by the year 2002.

3.3 Albania

While Albania received its first Internet connection in the early 1990s, the country's backward telecommunications infrastructure, financial problems, lack of policy coordination and, until recently, monopolistic regulatory regime severely hampered Internet development.

On host count surveys, Albania ranks lowest in the region. The actual number of Internet users is unknown, but is certainly quite small.

In the early 1990s, Albania gained access to European academic networks, bringing email connectivity to a number of institutions. At the same time, a number of projects were started on Internet access, and Internet centers were established in a few scientific institutions and non-governmental organizations. large percentage of Internet users were

associated with the Albanian Academy of Sciences, mainly with the Albanian Institute of Informatics and Applied Mathematics (INIMA). At the end of 1995, as a result of cooperation between the UNDP and non-governmental organizations, including the Soros Foundation, an Internet center was established at the United Nations Development Programme (UNDP) office in Tirana. The center provided email service for NGOs as well as a limited connection to the Web and other services. In June 1997, the Soros Foundation founded the Open Internet Center (OIC) and offered connections to academic and scientific institutions, NGOs and some important state institutions. Additionally, a backbone was established for the Albanian academic network, ARDIANET, which connects UNDP with OIC, INIMA and the Electronics Department at the Polytechnic University of Tirana. As of 1998, the country had two ISPs: the Soros Foundation and Albanian Telecom. The latter operated at 622 Mbps on a fiber backbone linking four cities. There were three foreign links: 622 Mbps to Italy (under construction); 64k wireless to Italy; and satellite connectivity to the US.

3.4 Bulgaria

Bulgaria at this point is a study in contrasts. Telephone penetration is among the highest in the region, but the technology of the country's infrastructure remains outdated: party lines still abound and local exchange digitization is very low. In 1998, to lay the groundwork for market liberalization, Bulgaria adopted a new Telecommunications Act, and began planning to privatize its monopoly telephone company. There was concern that regulations under the new law requiring the licensing of ISPs would stifle the development of the Internet, but in November 1999, regulators announced that ISPs would not be subject to licensing.

More than 10 ISPs with international connectivity provide Internet access. The largest providers, which cover most of the country, are as follows:

- GOCIS (<http://www.gocis.bg/en/>), is a joint venture between Global One Communications Ltd. (60%) and the Bulgarian Telecommunication Company (40%), connected to UUNET, Deutsche Telecom and Global One.
- BTC is the largest ISP in Bulgaria. BTC has international connection (terrestrial lines) through Deutsche Telecom (Germany), Teleglobe (Canada) and a satellite channel to MCI (C&W).
- Orbitel (<http://www.orbitel.bg>), connected to UUNET.
- Naturella agency (<http://www.naturella.com/>), connected to UUNET.
- Spectrum Net (<http://www.spnet.net/en/>) has a satellite channel to Loral Orion and terrestrial lines to Deutsche Telecom and Teleglobe.
- Digital Systems (<http://www.digsys.bg>) was the first Internet provider in Bulgaria, founded in 1989. It is connected to EUNET. DigSys started as a company for computer networks and equipment and, since early 1991, offers commercial Internet services. DigSys is the administrator of the .bg domain.

Numerous organizations have high-speed international connectivity and resell their unused capacity; one example is the Bulgarian Industrial Association (<http://www.bia-bg.com>). As of June 1999, the capacity of Bulgaria's international access was about 80Mbps, compared with 2 Mbps in 1997.

In mid-1999, BTC charged about \$80 for ISPs to add a new telephone line. The average dial-up Internet access price ranged from \$10 per month for night-time only access to approximately \$15 per month for unlimited access. While \$15 per month is not high compared with costs in the West, the average wage in Bulgaria is about \$120 per month, so the cost of an Internet account is beyond the average citizen. Still, ISPs cannot come close to meeting demand, making it hard to obtain service.

Since December 1998, Bulgarian Internet users have had access to Internet telephony, allowing users to make international telephone calls over the Internet.

One of the biggest obstacles to a greater Internet penetration in Bulgaria has been the lack of a VSAT Internet provider. There was no legal groundwork for the licensing of VSAT operators, the only one being GOCIS. This situation should change, as the VSAT market was due to be opened to competition after November 1999.

3.5 Romania

Even though there are over a dozen ISPs in Romania, private Internet use is still limited due to the high price of access.

As of 1999, Romania had at least 11 major commercial ISPs, about half with their own backbone networks. The main service providers were Rom Telecom (the former state-owned monopoly), ROMPAC, LOGICnet, Sprint and the Academic data network. PC-NET, present in 3 major cities, had VSAT links and a 2M satellite connection to NetSat (US). DNT had points-of-presence in 4 major cities and has independent satellite links: a 4M link to NetSat (US) and a 2M link to Taide. RDS was present in 6 major cities. Each POP connection had a satellite link. Global One was present in all 15 main cities, with an international fiber optic connection to the Global One network. The non-commercial, academic ISP, RoEduNet, linked 6 major university centers via leased lines and had international connectivity by satellite at 2M. Deployment of the Internet through the cable television delivery system had been launched.

3.6 Poland

The principal provider of telecommunications services in Poland is TP S.A. TP S.A. has the exclusive right to provide international non-IP based public telephony services in Poland until 31 December 2002, subject to compliance with obligations undertaken by the Republic of Poland (WTO) and sovereign decisions of the Government. TP S.A. currently enjoys exclusivity in the provision of domestic long distance public telephony services under the Communications Act; however, the Minister of Communication (MoC) has announced his intention to encourage competition in the provision of domestic long distance public telephony services commencing in 1999. The local fixed line public telephony market in Poland has been partially liberalized over the past few years and as of 30 June 1998 some 45 LTO's had been licensed. As of 30 June 1998 TP S.A. held an approximately 97 % share of the local fixed line telephony market in terms of number of access lines in service. Competition in all segments of the public fixed line telephony market is expected to increase in the future as the market becomes fully liberalized and new competitors, who may have significant financial resources and technical experience, enter the market.

The availability of the Internet in Poland depends, first, on the overall performance of the telephone network, as most access is through modems. The main impediments to Internet use and development are lack of access to basic telephone service and high prices: the cost of access is very high, the second highest in Europe. Users pay an initial set-up fee and a monthly fee to their ISP. The largest cost, however, comes from the fact that Poles, like others in the region, pay for local phone calls. One can expect to pay just under \$3 per hour for the connection to an ISP. The national telephone company, TPSA, has experimented with an "IP dial tone," a single dial-in number offering direct Internet connection.

Despite cost barriers, Internet usage in Poland has grown rapidly, benefiting from the digitization of central office switches and increased ISDN availability in major cities, as well as from the general increase in the number of installed lines. Traffic increased 12 times during 1995 alone. The Public Opinion Research Center estimated that approximately 2.5 million Poles have "access" to the Internet, with about half of those considered "active" users. It is estimated that there are 700,000 users. About 38% of users obtain access through a university or other educational institution, 36% at work, and about 26% at home. Internet usage is concentrated in large metropolitan areas, with less than 9% of Internet users in smaller cities and rural areas.

There are numerous ISPs. The most important non-commercial provider is probably NASK, the Scientific and Academic Computer Network, which has a network of regional, interregional and international leased telephone lines. Beginning in 1990, NASK underwent rapid development. The Government State Committee for Scientific Research (KBN) finances and manages the network, but most of the physical lines are maintained by the TPSA while some are supported by the Banking Telecommunications Enterprise (TELBANK S.A.). The main node of NASK is located at Warsaw University. NASK interconnects several older internal networks, and provides access to the Internet, which now accounts for about 80-90 % of the total NASK traffic. MOST, which is associated with APC, is an Internet provider for environmental NGOs and activists.

Poland has several other ISPs. TPSA is present all over the country and has a fiber backbone at speeds ranging up to 155 Mbps as well as 20 Mbps satellite links to Canada and the U.S. (In 1999, TPSA began a further upgrade of its backbone, connecting directly to the main German and U.S. backbones.) Telbank serves the banking sector as a commercial ISP with a fiber backbone between major cities at 34 Mbps, and other connections to smaller cities at 1-8 Mbps. It also has a satellite connection to MCI. POL34 is an academic network connecting 14 major university centers that buys bandwidth (34 Mbps links) from TelEnergio. It also has a 3 Mbps link to Sweden via satellite. IdS is a non-commercial ISP that acts as an Internet-for-schools network; it receives its Internet connectivity through TPSA. Other ISPs include ATOM, Polska Online, CNT, TOPNETI, MediaNet and Internet Technologies.

Poland also has a few bandwidth and leased line companies that are not necessarily ISPs.

TelEnerg, a network connecting all major cities and built around the power network grid, has a fiber backbone operating at speeds up to 622 Mbps. Kolpak, the Polish Rail Network, connects all rail stations, and is thus present all over the country. It has fiber connections to major cities at speeds up to 155M, as well as copper lines.

Outside of major cities, dial-up or switched service remains a problem due to line quality, which sometimes results in transmission speeds as low as 300/1,200 bps. Within the major cities, ISDN availability is increasing, and standard dial-up intra-city communications are possible at 64 Kbps. International leased line transmission is readily available. Some providers have been offering voice telephony over the Internet.

In May 1998 there were an estimated 1 million active internet users in Poland, and every seventh Pole used the internet at work or at school. The estimate as of May 1999 is in excess of 2 million subscribers. Poland has the most extensive internet network in Central and Eastern Europe, with some 200 private ISP companies, but only a few of them are active and generate more than US \$10,000 in annual revenues. The two biggest providers are still TPSA and NASK, the latter being controlled by the Polish Academy of Sciences. NASK provides internet services to more than 1,000 universities, scientific institutions, government organizations, and private companies, and manages a backbone network serving the major metropolitan centers. At the beginning of 1999 GTS bought equity in two ISP companies, Atom and Internet Technologies. Both these companies last year had joint revenues of \$ 3.5 million, which made the first two leading companies the market, not including TPSA or NASK. The cost of internet access is very high, the second highest in Europe. Internet subscribers in Poland pay approximately 2.5-3 times more per month for full service than subscribers in the U.S., where access prices are lowest.

Super Media is developing very rapidly, has ample domestic financial resources, is looking into VOIP and is not interested in a foreign investor or selling.

PDI is rapidly expanding its business all over Poland and found a foreign equity investor last year. It is not interested in selling its equity.

POLBOX is active mainly on the Warsaw market. Its revenues in 1998 were \$ 500,000 and in the first quarter of 1999 amounted to \$ 400,000. Polbox is working with Motorola's local dealer Twins in Warsaw regarding the carrying of voice over data. The owners are ready to sell all their equity and claim that they are currently negotiating with several foreign potential investors.

TOP NET. TOP NET has a presence in 33 cities of Poland. In 1998 their revenue was \$750,000 and \$200,000 for the first quarter of 1999. Since last year they have been looking into the possibility of adding VOIP as part of their service. The current owners are ready to sell. They underwent due diligence twice and are talking to Delta 3 and another unnamed company.

IDS (Internet Data System). Last year's revenue was \$ 250,000. Revenue for the first quarter of 1999 was \$ 100,000. ISD is focused on Warsaw but is currently expanding to other cities and has a presence in 9 Polish cities. ISD provide high speed internet access for Aster City, one of the two biggest TV cable operators in Poland. IDS is interested in talking to a foreign investor and seeking one.

Under Polish law foreign ownership is limited to 49% of the equity in such companies.

3.7 Czech

The Internet is relatively expensive -- according to an OECD report, the price for residential Internet connection in the Czech Republic using off-peak prices is the most expensive for all OECD countries, based on purchasing power parity. Nonetheless, the Internet is being widely used in the Czech Republic. Estimates of the number of Czechs with regular Internet access range from 270,000-400,000. The number is expected to rise between 34 and 41% per year through 2002.

The first commercial ISPs came online in 1996. Since then, the number of ISPs has increased rapidly. By 1999, over 40 ISPs offered access through dial-up, leased lines, direct links and VSATs. About 16 ISPs operate their own backbones, typically at 8 Mbps. The number of subscribers per ISP varies, but many are quite small. Econnect is the major non-commercial ISP. In April 1998, the SPT Telecom began operating its own ISP, Internet On-Line. Its foreign connectivity included a cable to Amsterdam and a satellite link to Teleglobe at speeds up to 10 Mbps. In Prague, two local networks have also been implemented. PragoNet, owned by the city of Prague, and MetroNet, owned by several private companies, offered LAN network communications, virtual private networks operations, e-mail, interactive services, and Internet access.

CESNET (Czech Educational and Scientific Network) is a commercial network and ISP operated by the a consortium of Czech universities. CESNET has international connections to EBONE at 8 Mbps and to TEN34 at 16 Mbps.

In February 1999, the Czech Republic's Deputy Vice-Chairman for the Economy said that telecommunications monopoly SPT was the biggest obstacle to Internet development in the Czech Republic. He urged adoption of legislation to ensure effective competition in telecommunications after SPT's monopoly rights expire in 2000.

A second major impediment facing the Internet in the Czech Republic is the fact that the modernization of the network has not reached all of the country yet. Dialing in, especially from smaller villages, can be difficult.

Increasing competition among ISPs and the privatization of telecommunications services may eventually bring costs down to a level that most Czechs can afford, but so far cost remains a major barrier to Internet access. There were two components of Internet subscriber fees: 1) fees paid to the Internet provider, which include payments for international and domestic fixed lines used by ISPs, and 2) fees paid to the telephone company for connection time. The latter account for a majority of the cost of Internet usage. In mid-1997, the average price for 20 hours of Internet connection was \$50-60.

In the Fall of 1998, SPT Telecom announced an increase in per minute local rates. Because connection time is such a high percentage of the Internet subscriber fees, many users requested SPT to reassess how it bills data calls. The "Internet Against Monopoly Movement" called on Czech users and service providers to protest. On November 18, 1998, over 90,000 people and 900 IT companies boycotted the Internet for the day to protest the rate increases. ISPs temporarily shut down or featured a protest page. Organizers of the protest asked that special rates be applied to Internet users either through a flat rate fee for weekend and evening access or a two-rate system to distinguish between voice and data connections.

In response to the protests, SPT offered a reduced rate called Internet 99, applicable to data communications with ISPs, decreasing during the evening and late night. On top of this, there is a flat per call charge after the first 119 seconds. The Internet 99 rate was an improvement, but a small one. Considerable controversy remained over whether the new tariff would lower prices or not. Users opposed the one-time connection fee, because they would be charged for the failed connections that are common due to SPT's aging local infrastructure. More fundamentally, the "Internet rate" left intact the basic concept of per-minute tariffing for local calls.

4. ARCHITECTURES

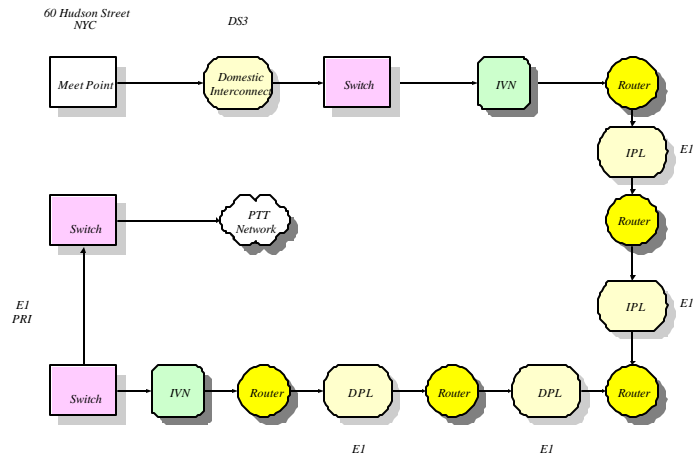
4.1 Network Infrastructure

The network infrastructure contains the following several elements:

- i. **Originating Meet Point:** This is the point at which the communications meets with another carrier be that carrier an international telephone company, an Internet provider, another IP network, or even an ISP or content provider.
- ii. **Originating Local Interconnection:** The local connection is that set of transmission or signaling handling facilities that allow for the transfer of the signals from the meet point to the location of the switching and other equipment which is the first processing point of the network.
- iii. **Originating Local Switch and Equipment:** This equipment is a combination of switches, routers, VOIP equipment, processing equipment, and signal conditioning equipment as may be required for the service. In fact such equipment, such as routers may be distributed from this point throughout the network and include the terminating point.
- iv. **Originating Domestic Private Line:** This is the local domestic circuits as may be required to get to an international circuit.
- v. **International Private Line:** This is the international circuit that connects one country to another.
- vi. **Terminating Domestic Private Line:** This is similar to the originating DPL.
- vii. **Terminating Local Switch and Equipment:** This is similar equipment to Originating Local Switch and Equipment.
- viii. **Terminating Local Connection:** This is any local connection to a local telephone company.
- ix. **Terminating Meet Point:** This is a meet point with the local telephone, IP, or other networks.

4.2 Land and Expand

The network strategy of “Land and Expand” can best be shown as follows. The Company has built an international network which looks as shown below:



The network shown above originates in the U.S. and “lands” in multiple locations throughout Europe. It creates entry portals in all of the markets in which the Company operates. The network then “expands” in a country as shown below for Italy.



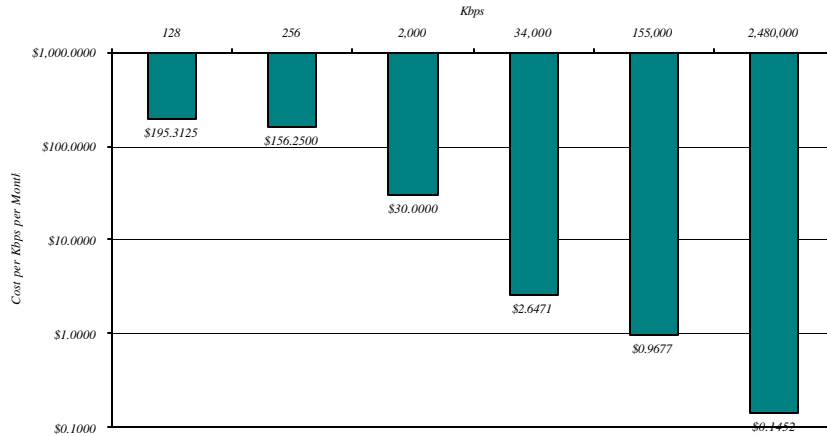
The “expand” portion of the strategy provides the following advantages:

- a) From a termination perspective, the cost to terminate a call anywhere, whether it is an international or domestic long distance call, is minimized. The local call terminations in a country may be less than \$0.02 per minute and decreasing. The long distance calls are also lower since agreements are made with local carriers for volume discounts providing long distance at an average of \$0.06 per minute. The current Company network is sufficiently deep to enable

70% of the country to be accessed at local termination rates. On a weighted average basis, the termination rates are \$0.014 for local and \$0.018 for LD thus giving a total of \$0.032 in the current configuration.

b) From an origination perspective, the EIs that go to the approximately 26 locations can carry both voice and IP traffic from ISPs, content providers, and broadband Internet users. Thus the efficiency of the circuit loading is maximized.

The above network evolution plan shows the importance of having control over an in region backbone facility. Each country is “expanded” as was shown before. The costs of the network as we add higher capacity bandwidth are shown in the following Graph. This is the compelling reason to build out the infrastructure as well as the fact that it reduces time to market. The telling number is that the cost per Kbps per month drops from \$195 to less than \$1 with an STM. With ownership of network infrastructure the cost per Kbps falls to nearly zero.



5. CURRENT PLAYERS AND STRATEGY

The following Tables present a summary of the key players and their current strategies.

Sector	Company	Strategy
ILD		
	Net2Phone	<i>Net2Phone has positioned itself as an Internet telephone company with web based access. They, as have all the other recent Internet telephony companies, “bought” relationships with portal operators. Namely, the buy space on the portal and claim this as a strategic relationship. Net2Phone is the strongest contender since it was based on the IDT network. Their focus has been on domestic as well as international traffic.</i>
	iBasis	<i>iBasis is Internet based ILD company. iBasis uses Cisco and is a Cisco “partner” which means that they get co-marketing service from Cisco.</i>
	ITXC	<i>ITXC started as a gateway, collecting various ISPs around the world into a common Lucent/VocalTec platform base. They provide the ISP with equipment in a franchise mode and then interconnect or transit traffic from their facilities in New Jersey. They are all Internet based, have no presence in any country and have no business other than the “franchised” relationships.</i>
	Deltathree	<i>Deltathree is an offshoot of RSL, which acquired them in 1997. As a matter of history, had a joint venture with Delta Three in 1996-1997 but the strategy of private IP networks was not part of the Delta Three approach.</i>

Sector	Company	Strategy
Internet Data Services		
	Exodus	<i>Exodus has Internet data centers which provide customers with secure facilities that can house servers and other equipment necessary to support mission critical Internet operations. The company has a backbone network in the US with in excess of 5,000 Mbps of capacity. The company has 154 public and 48 private peering agreements.</i>
	Concentric	<i>Concentric Network Corporation provides complete, easy-to-use Internet business solutions for small to medium-sized companies and customized Virtual Private Network and data center services for larger organizations.</i>
	InterNAP	<i>InterNAP offers Internet interconnectivity services that significantly improve performance. The company has secured agreements with amazon, TheStreet, Go2Net, WebTV, Microsoft and Apple. The company has a Private Network Access Points (NAP) system allowing the company to control the traffic in a more efficient fashion.</i>

The following Table is a summary of the IP cost advantages as compared to the competition.

	Cost Elements	IP Based	ATM	Standard Telephony	Advantage
ILD				TPSA	
	IPL	\$0.005 per min	\$0.025 per min	\$0.05 per min	<i>Uses 10:1 compression and uses a clear IP channel allowing 6 million min per month per E1.</i>
	Local Termination	\$0.015 per min	\$0.05 per min	\$0.05 per min	<i>IP based network allows for low cost transmission directly to local termination</i>
	Switching Equipment	\$200 per access line	\$350 per access line	\$900 per access line	<i>IP equipment is generally 3 to 5 times less per access line than standard technology.</i>
	Operations Support	\$0.001 per min	\$0.015 per min	\$0.020 per min	<i>IP equipment is designed with SNMP protocol set whereas regular telecom does not support TMN protocols thus increasing costs.</i>
	Billing	\$0.005 per CDR	\$0.015 per CDR	\$0.020 per CDR	<i>IP allows for per packet billing and reduces the CDR costs.</i>

	Cost Elements	IP Based	ATM	Standard Telephony	Advantage
High Speed Internet					
Wireless					
	Internet Backbone Access	\$1,500 per month per E1	\$15,000 per month per E1	\$15,000 per month per E1	<i>IP Uses the IPL IP backbone to connect directly to the NAP in the US for high speed interconnection.</i>
	Local Distribution	\$300 per month per E1	\$8,000 per month per E1	\$8,000 per month per E1	<i>Uses the local network sharing IP voice and data over same backbone network</i>
	Backbone Capital Equipment	\$100 per access line	\$200 per access line	\$400 per access line	<i>IP routers have lower capital per user than other existing technologies.</i>
	End User Interface	\$200 per end user using Lucent equipment	\$500 per end user	\$500 per end user	<i>IP dedicated has an advantage via its partners who have licenses and facilities</i>
	Operations	\$0.001 per min	\$0.015 per min	\$0.020 per min	<i>Incremental since already at the location.</i>

	Cost Elements	IP Based	ATM	Standard Telephony	Advantage
Local Exchange Carriage					
	Long Distance	\$0.005 per minute	\$0.015 per minute	\$0.015 per minute	<i>Use of the IP backbone network allows for the implementation of the long distance service at lower costs.</i>
	Capital Costs	\$100 per access line	\$200 per access line	\$400 per access line	<i>IP routers have lower capital per user than other existing technologies.</i>

Cost Elements	IP Based	ATM	Standard Telephony	Advantage
	access line	access line	access line	other existing technologies.
Enhanced Services	\$0.25 per month per AL	\$2.00 per AL per month	\$2.00 per AL per month	IP edge devices and IP based Unified messaging is lower costs than any others
Operations	5-8% of Gross Revenue	10-15% of Gross Revenue	10-15% of Gross Revenue	Incremental since already at the location

Cost Elements	IP Based	ATM	Standard Telephony	Advantage
Internet Access Services				
		Concentric, Exodus, InterNAP	PTT, TPSA, KT, CAT	
Backbone Access	\$1,200 per month per E1 equivalent	\$24,000 per month per E1 equivalent	\$24,000 per month per E1 equivalent	Use the backbone network to connect directly into MAEAST and other appropriate NAPs.
In Country Access	\$200 per month per E1 equivalent	\$2,400 per month per E1 equivalent	\$2,400 per month per E1 equivalent	Use the in country network to allow connectivity, via a virtual private IP network, to the Warsaw hub, and allowing both content providers and ISPs to have common meet points on marginal cost basis.
Operations Overhead	2-5% Overhead Costs	10-15% Overhead Costs	10-15% Overhead Costs	Incremental since already at the location.
Capital Plant	\$12,000 per E1 equivalent	\$24,000 per E1 equivalent	\$36,000 per E1 equivalent	Use shared Routers and Hubbing equipment as well as transmission equipment

6. CONCLUSIONS

This paper is an update on the status of international IP telecommunications. It focuses on the evolving markets and strategies that have been developed to provide the services that are being demanded in diverse international markets. There are certain observations that should be made concerning the international market as compared to the domestic US market. These observations can best be made in the context of the acceptance of wireless communications in Europe, East and West, as compared to the US. There are more mobile phones in Italy than there are fixed. European mobiles are growing at a rate twice that of the US and penetrations twice that of the US. The reasons are threefold: availability, prices, and lack of infrastructure. The Central European markets are growing a twice the rates of the Western European markets. Again it is lack of infrastructure which is driving demand. It is believed that the same will happen with an IP base. More importantly, as Western Europe was a greenfield for mobile, Central Europe is a Greenfield for IP. This means that one may expect to see the most rapid and innovative growth in those markets.

7. REFERENCES

1. Gompers, P., J. Lerner, *The Venture Capital Cycle*, MIT Press (Cambridge, MA), 1999.
2. LGT Capital Management, *EUROPEAN TECHNOLOGY SUCCESS STORIES*, (London), October 1999
3. European Union's Tacis Programme, *A UNIQUE REFERENCE WORK ON NIS VENTURE CAPITAL*, 1999.
4. Morgan Stanley, *The European Internet Report*, June 1999.
5. McGarty, T. P., *Alternative Networking Architectures; Pricing, Policy, and Competition*, Information Infrastructures for the 1990s, John F. Kennedy School of Government, Harvard University, November, 1990.
6. McGarty, T. P., *Information Architectures and Infrastructures; Value Creation and Transfer*, Nineteenth Annual Telecommunications Research Conference, Plenary Address and Paper, Solomon's Island, September, 1991.
7. McGarty, T. P., *Alternative Networking Architectures*, B. Kahin Editor, McGraw-Hill (New York), October, 1991.

8. McGarty, T. P., Access to the Local Loop; Options, Evolution and Policy Implications, Kennedy School of Government, Harvard University, Infrastructures in Massachusetts, March, 1993.
9. McGarty, T. P., Access Policy and the Changing Telecommunications Infrastructures, Telecommunications Policy Research Conference, Solomon's Island, MD, September, 1993.
10. McGarty, T. P., Internet Architectural and Policy Implications, Kennedy School of Government, Harvard University, Public Access to the Internet, May 26, 1993.
11. McGarty, T. P., From High End User to New User: A New Internet Paradigm, McGraw Hill (New York), 1995.
12. McGarty, T. P., Internet Voice: Regulatory and Legal Implications, Presented at the VocalTec Seminar on September 9, 1996, New York, NY.
13. McGarty, T. P., Competition in the Local Exchange Market: An Economic and Antitrust Perspective, *Federal Communications Law Journal*, submitted and to be published, 1997.
14. McGarty, T. P., The Economic Viability of Wireless Local Loop, and its Impact on Universal Service, Telecommunications Policy, Elsevier (London), 1997.
15. McGarty, T. P., Comparative Deregulation of Far Eastern Telecommunications Markets, Telecommunications Policy research Conference, Washington, DC, September 28-30, 1997.
16. McGarty, T. P., Telecommunications Infrastructure, Technology, and Policy in Russia, A Plan for the Development of an Information Based Economy, Russian Freedom Channel Report, September, 1997.
17. McGarty, T. P., IP Telecommunications Architecture, MIT Internet and Telephony Consortium Working Group, November, 1999
18. McGarty, T. P., IP Telecommunications QoS (Quality of Service), Is Service Quality a Sustainable Metric?, Presented at MIT ITC Meeting, at Telecom Italia, L'Aquila, Italy, June 8, 1999
19. McGarty, T. P., International Internet Telephony, To be published in MIT Press Book. Draft date October 29, 1998.