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INTERNET INFRASTRUCTURE DEVELOPMENT IN TRANSITION ECONOMIES

Part II

Survey carried out by the UN/ECE secretariat

Background

As requested by the Committee for Trade, Industry and Enterprise Development at its 1999 session, this Survey is being provided as part of the substantive preparations for the Forum on Electronic Commerce for Transition Economies in the Digital Age to be held on 19 and 20 June 2000, at the Palais des Nations, Geneva, and for the follow-up activities to be considered by the Committee on 21-23 June 2000.

It provides an overview of the current status of Internet infrastructure development in transition economies by addressing major issues relevant to the Information Society and, in particular, to Internet enterprise development in the region. The Survey is divided into two parts:

I. Overview, Internet Use, National Policy Initiatives and Conclusions (TRADE/2000/18)
II. Internet Infrastructure, Domain Name Systems, Service Providers and Competition Levels

Given the rapid changes in the Internet environment, the current accuracy of the figures and statistics cannot be guaranteed. However, the secretariat welcomes any contributions to updating this information.

Mention of a company or enterprise in this survey does not imply that the UN/ECE makes any judgements or recommendations in respect of the quality or reliability of the services or products provided by that company or enterprise.

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Executive Summary

- Part II of the Survey examines the technical indicators of Internet development in the region, focusing on Internet network backbone infrastructure, Internet hosts including secure servers, Internet service providers, Internet exchanges and the Domain Name System. It also includes a profile of telecommunication services. Part I of the Survey (TRADE/2000/18) provides an overview for the region, and by subregion, of the survey results, it examines the level of internet access and use by country, provides a reference list of National Information Society Initiatives and then draws some conclusions. The appendices (TRADE/2000/18/Add.1) include reference material such as a compilation of recent telecommunications legislation and a brief inventory of international organizations' work on e-commerce.

- The preliminary findings indicate that although Internet connectivity and e-commerce are growing very fast, many of the countries surveyed lack the necessary infrastructure in physical, technical and regulatory terms to participate fully in the Information Society.

- A pattern of uneven development is emerging in several sectors of Internet development, as well as in the rate of growth for each country. The central European and Baltic countries currently have more Internet hosts, secure servers, percentage of Internet users, and a wider range of services available over the Internet than the other regions of the transition economies.

- In the Black Sea region we can see a pattern of positive development on the whole; however, there are wide variations in some elements of the Internet environment. Ukraine has a particularly large network, but relative to the size of the population, its network ranks in the lower half of the transition economies; and the Caucasus and Central Asian CIS countries have significantly lower levels of development than the Central European and Baltic countries.

- However, on the micro level of Internet development, this Survey indicates that, despite the significant barriers to Internet connectivity that remain, there is substantial new potential for economic opportunities. In most of the transition economies, there is an increasing effort to tap the potential of a relatively high-speed Internet connection at a lower cost.

- The Survey has identified a series of actions required to increase the participation of the region in the knowledge-based economy. These include increased access to the Internet and new communications technologies, competitive pricing mechanisms for Internet connectivity, capacity building and the promotion of a skilled workforce to tap the potential of Internet-based enterprise development in the region.

- Governments and enterprises in the region may wish to consider how to give a new momentum to building the Information Society in order to make the accumulated experiences and the current process of transition towards a market-based economy fully compatible with the rapid technological change in global markets. To this end, the role of Governments could be further explored in accelerating the new Internet-based transition process; in particular for those areas in which public-private sector partnerships could benefit from closer collaboration with international organizations.

- The Committee for Trade, Industry and Enterprise Development may wish to make some recommendations for action by both national Governments and regional international organizations such as the UN/ECE which could be developed further to achieve the aforementioned goals in an efficient and effective way.

CONTENTS

Introduction

1. Within information and communications technologies, it is the Internet which is revolutionizing the way the world economy is being developed. A new knowledge-based economy is starting, and the traditional patterns and practices of private sector development are ceding to the Internet-based enterprise development. It is imperative that transition economies move quickly to meet the challenges and seize the opportunities of the new digital age and the promises of the new economy.

2. The current survey aims to provide an overview of the existing status of Internet infrastructure development in transition economies and assess the emerging pattern of network-based economy. To this end, we have identified and analysed the key determining factors for Internet development. Following you will find an overview of the content of part of the survey.

Content overview

Chapter I Internet Infrastructure Development

3. This chapter presents an overview of the technologies that are essential to the basic framework of the Internet. We present a brief survey of current networking technologies and their potential capacity for data transmission. We then examine the existing networking institutions in transition economies, such as academic and private sector data networks, as well as Internet exchanges which are a key factor in the growth of regional interconnectivity. Finally, we present the results of our initial investigation into the connectivity between national data networks and the international backbones that make up the core of the Internet.

Chapter II Domain Name System

4. In this chapter, we provide an introduction to standards and protocols that enable the decentralized coordination of the World Wide Web. We present a survey of the regulatory bodies and standards that make up the system of domain names, which are used to identify individual websites that are connected to the Internet. We then examine the system of Internet Protocol (IP) addressing which is used to identify specific Internet host computers on the Internet. Finally, we consider the role of Internet registries, which are the companies who have purchased and thus control IP addresses, within each country.

Chapter III Internet Service Providers

5. Following a survey of the various institutional forms of organizations that provide Internet connectivity (Internet Service Providers – ISPs), we present the initial results of our investigation into the range of services that are available in transition economies, as well as the current lowest prices for basic Internet connectivity available at the time of the survey.

Chapter IV Level of Competition in Telecommunication Services

6. In this chapter, we present brief regional analyses of the current state of competition in several sectors of telecommunication services. We also present a country-by-country survey of the level of competition in sectors of telecommunication services, including long distance and international call services, analog and digital cellular, paging and cable TV services.

Appendices (TRADE/2000/18/Add.1)

7. We have included several appendices as reference material in document TRADE/2000/18/Add.1. These include a country-by-country summary of legislative actions relevant to the telecommunications sector; a complete list of all the local companies in each country who are Internet registries, along with their respective IP address allocation; a list of the signatories to two international agreements dealing with intellectual property rights; and finally, a summary of the various non-governmental, international and regional organizations that are active in Internet development.

Methodology of the Survey

8. In the present study an attempt was made to provide an overview of the Internet infrastructure on a national level. Most of the data were collected from sources located on the Internet; however, several offline sources were also consulted.

9. The majority of the indicators, therefore, represent the results of our investigations into online sources based in each individual country. The lack of any international centralized system of reporting for many sectors of Internet development has meant that the data presented herein were the best available data that our research was able to locate in websites of both public and private organizations. For example, in trying to determine the degree of Internet use in each country, we were only able to locate statistical surveys in a subset of transition economies, and these surveys often did not clearly define the nature of 'Internet Use' that was measured, nor did they provide a clear description of their methodology. Some surveys defined Internet use as 'used the Internet once within the past month', others as within the past six months, and yet others as weekly. The sometimes ambiguous nature of the sources for these Internet indicators places a limitation on their applicability for cross-country comparison, let alone for rigorous statistical analysis.

10. Finally, the focus on national comparisons does not necessarily present a picture of the potential experience for individual users of Inter services within each country. The variation between subregions, as well as the level of services available to particular users, can offer very different perceptions of the experience of the Internet. Therefore, a more detailed analysis at a micro level, which takes into account general social and economic development, is required if we are to present an overall description and analysis of the factors driving the development of the Internet. However, this is beyond the scope of both this report, and the available data. We have, thus, prepared a Survey of the currently available information for several key factors in the development of the Internet, which might be used as a framework for future research.

I. INTERNET INFRASTRUCTURE DEVELOPMENT

National Backbones

11. Despite the conventional wisdom that the Internet allows anyone with a computer and a modem to plug into a local phone line and immediately connect to a global network, the reality of the unequal development of the Internet infrastructure undermines the myth of universal access. For businesses and customers to take advantage of the competitive advantages offered by access to a global information network, the local Internet infrastructure must provide a high quality service, at competitive prices, and in the quantities required. The level of service experienced by the end-user will be, in large part, determined by the quality of the Internet infrastructure at the local level. Therefore, the development of national and regional backbones is crucial to the competitive success of local businesses and end-users.

12. The bulk of the international Internet infrastructure is made up of high-speed fibre optic and satellite connections whose performance is constantly improving with the introduction of new technologies, e.g. laser wave-splitting wave star optic air technology[1]. Recent developments have created networks that permit the transfer of data at speeds of several Gigabits per second and the technology for transferring Terabits per second is within reach. However, before tapping into a network with these kinds of speeds, the end-user must typically go through two layers of network connections before reaching the high-speed backbone network.

13. The first layer, also known as the 'last mile', involves the connection between the end-user and the Internet Service Provider (ISP – See the following ISP section) which can be carried out over:

- Local telephone lines which are either :
  - analog – permitting speeds of up to 33.6 Kbps.
  - digital – enabling Digital Subscriber Lines with a theoretical speed of up to 1.5 Mbps or

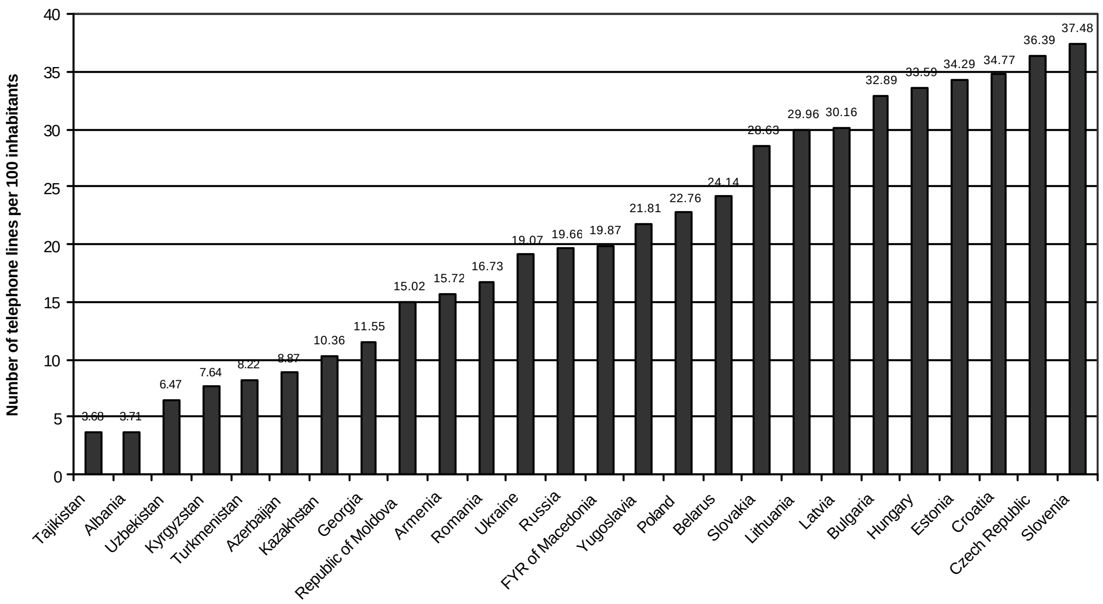
1 See http://www.lucent-optical.com for more information.

even 6 Mbps for Asynchronous DSL depending upon the distance to the ISP.

- ISDN lines which require the installation of a physical line and ISDN modem.
- Leased-lines –high-speed physical lines with, or without, a guaranteed bandwidth.
- Cable modems via the cable television network.
- Wireless networks and mobile phone connections.

The most common type of connection for the first layer is, by far, the analog phone line. Given the remaining widespread monopoly of national telecoms over local telephone service, the national telecoms continue to play a crucial role in the end-user's experience of the Internet infrastructure (see below the graphic on teledensity in transition economies).

Teledensity in 1998 from the UNDP 1999 Human Development Report



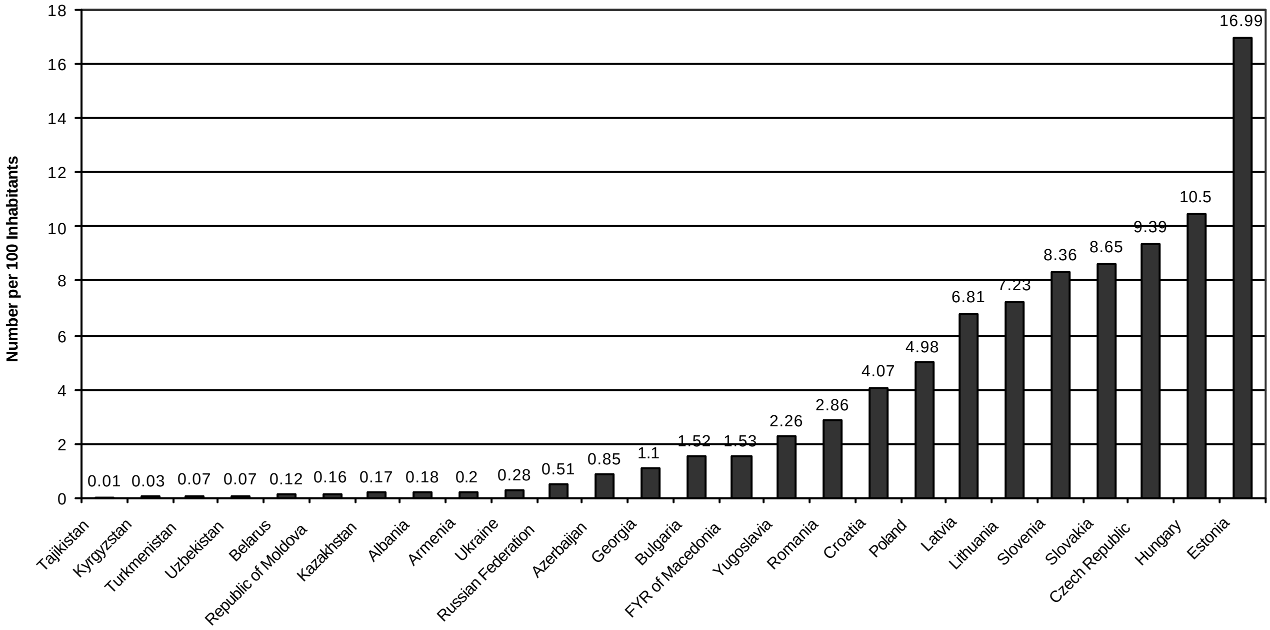
(Note: Detailed information on Bosnia and Herzegovina was not available; source, 'Internet and Telecommunications Indicators', ITU, ppA-4 to A-7.)

14. Another type of first-level Internet connection is wireless access via mobile phones. With almost five million new mobile users every month at the global level, ITU estimates that wireless access will likely overtake fixed access to global telecommunications early in the 21st century[2].

15. The penetration rate of the mobile telephone in transition economies is at present relatively low, but the potential substitution of mobile for fixed line connection could be largely felt across the region due to the competitive market structure in this segment. The chart below is an overview of the cellular Mobile subscriber density in transition economies.

2 The new 3rd generation mobile services offer a variety of data services, e.g. Internet access, videoconferencing and financial transactions. See, "The Fixed, Wireless and Internet communications growth", Millennium World Telecom, Special Issue for the ITU Telecom Interactive 99, 1999, p.20-21.

Chart 2: Cellular Mobile Subscriber Density in Transition Economies, 1999



(Note: Detailed information on Bosnia and Herzegovina was not available; source, 'Internet and Telecommunications Indicators', ITU, 1999, ppA-25 to A- 28.)

16. The second level of connection between the end-user and the high-speed backbone is the network connection between the ISP and the international backbone. The most direct connection to the international backbone would be to establish a physical link, via T1-type line or by fibre optic cable, to one of the main Internet hubs[3]. Despite the recent reductions in the prices for international bandwidth, the opportunities to establish direct connections outside of major European capitals remains rather limited. The establishment of a direct link to the Internet backbone requires the expensive undertaking of constructing a long-distance fibre optic network. For the

3 Network connection speed is measured in terms of 'Bits per second', or bps, which is the number of 0 or 1's that can be transmitted per second. The size of information transmitted over the net, in the form of files such as .doc or .gif, is measured in terms of 'Bytes' which is made up of 8 bits. A 33.6 Kbps modem is, therefore, one that can transmit information at speeds of 33,600 bits per second or 4,200 bytes per second.

Connection Type	Bits per Second	Bytes per Second	Download Time of a 100 MegaByte (MB) Zip Disk
14.4 K modem	14,400	1,800	16 hours
28.8 K modem	28,800	3600	8 hours
33,6 K modem	33,600	4,200	7 hours
56 K modem	56,000	7,200	4 hours
64k ISDN Channel	65,535	8,192	3 hours and 30 min.
128k ISDN Channels	131,072	16,384	1 hour and 42 min.
T1 (DS-1)	1,536,000	192,000	9 minutes
T2 (DS-2)	6,144,000	768,000	130 seconds
ADSL	7,168,000	896,000	112 seconds
Cable modem	27,000,000	3,375,000	28 seconds
T3 (DS-3)	46,080,000	5,760,000	19 seconds
OC-1	51,000,000	6,375,000	16 seconds
OC-3	155,000,000	19,375,000	5 seconds

Source : 'Explaining Bandwidth' by Dennis Cox, http:// www.durrow.com/explaining_bandwidth.html

Note : Integrated Services Digital Network (ISDN): A collection of protocols to enable the development of a digital network. Built upon digital lines connecting the end-user to the local telephone switching station which requires ISDN specific modems at both ends of the line; *T1*: A set of twenty-four 64 Kbps channels, or standard phone lines, which are multiplexed into a single framed data stream. T2 = 4 T1s; T3 = 28 T1s.; *OC-1*: Fibre optic cable using Asynchronous Transfer Mode (ATM) technology.

individual ISP which cannot afford to build its own fibre optic connection to the closest backbone hub, the alternative solution is to employ satellite technology to bridge the distance to an Internet hub which can be located anywhere on the planet. Thus, an ISP can typically establish a satellite connection of between 2 and 6 Mbps to a major backbone provider in Western Europe or the United States.

17. The importance of national backbones emerges, despite the possibility of satellite connections from individual ISPs, when we consider the quality of service at a local level. If two end-users in the same region, but connected via different ISPs, attempt to communicate via the Internet, then we might encounter a situation where one user's network connection, established via an analog phone line, is routed by an ISP to a backbone connection in the US, which is then sent across the Atlantic to the other end-user's ISP connection in Sweden, and then back through the second user's local analog phone line, resulting in a very inefficient connection.

18. The construction of national Internet backbones enables local and regional ISPs to share network resources, such that it allows for more efficient and high speed local traffic routing, as well as creating shared multiple links to the international backbone. The growth of a national backbone might begin with the deployment of a fibre optic cable between several buildings in a single urban centre, or with a wireless network that connects several regions, or with a fully deployed national fibre optic ring. However, the key issue in the development of a national backbone is the degree of openness of the network as the benefits of bringing greater numbers of local users into the local network will hopefully outweigh the costs of implementing and maintaining an exclusive, closed network.

Development of Backbones

19. In the well-known history of the Internet, the earliest form of the network that would become the Internet, ARPANET, was built by the United States military in order to coordinate research that was taking place at several research and academic centres around the country. During the 1970s and 80s, the U.S. National Science Foundation administered network (NSFNet) expanded as more educational institutions established connections and added hosts. The network was gradually opened up to commercial data transmission until 1994 when the NSF awarded contracts to replace the NSFNet's Internet backbone with commercially funded networks.

20. Private data networks have long been in use, in particular by banks, insurance companies and trading networks. The question of data security kept access to these networks limited to internal use. However, the development of widespread public networks provided a cheap alternative infrastructure for those companies without the resources to construct their own proprietary network. As more and more users and services became available on the public networks, there was an even greater incentive for private networks to interconnect with the public infrastructure. The evolution of the Internet backbone, from both public and private sources, continues as new academic networks ('Internet 2' in the U.S.) and more and more private networks interconnect via the TCP/IP protocol.

21. In the transition economies, the initial development of Internet backbones often takes place through a partnership between a government ministry of communications and/or education along with major academic centres of scientific research. Alternatively, backbone networks have been developed by the major national telecoms; banks and other financial institutions; or other private corporations such as foreign telecoms or international ISPs.

Academic Networks

22. Several countries have managed to develop very high speed academic and research networks.

- The Croatian Academic Research Network (CARNet) had, by 1995, already established a 155 Mbps fibre optic link between two research institutions within Zagreb. The Croatian backbone has since expanded to include 155 Mbps ATM connections to every city in the country with more than one major research centre, furthermore, the backbone within Zagreb reaches speeds of 622 Mbps. (http://www.carnet.hr/index_eng.html)
- Estonia's Educational and Research Network (EENet) similarly provides ATM network connections to all 15 counties in Estonia, offering fibre optic and ATM connections to educational, scientific or cultural institutions. (http://www.eenet.ee/englishEENet/index.html)
- The Hungarian Academic and Research Computer Network (connects 25 regions of the country to Budapest, via

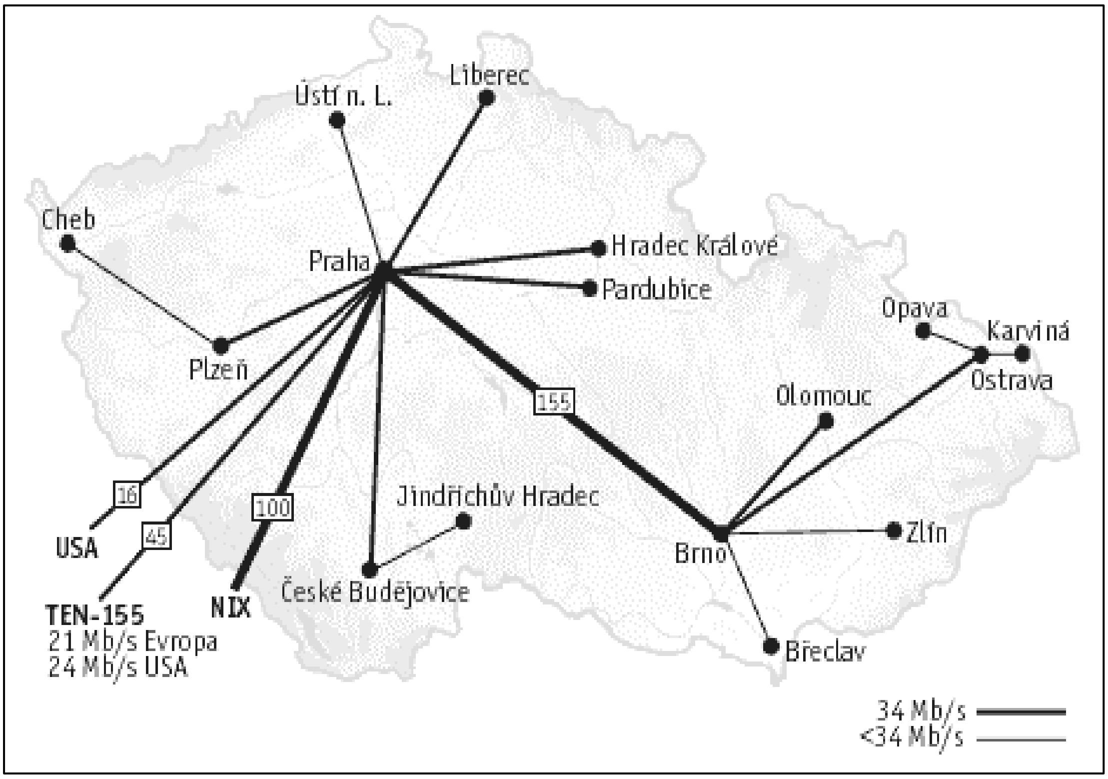
the fibre optic ATM HBONE network, which is then connected to the European TEN-34 project (see Czech example description below). (http://www.hungarnet.hu)

- Poland's Research and Academic Computer Network (NASK) consists of a country-wide Wide Area Network (WAN), made up of 43 nodes across the country, connected to a 34 Mbps network via Frame Relay and ATM technologies. There are also several regional academic high-speed networks. (http://www.nask.pl/english/)
- Romania has both the Romanian Education Network (RoEduNet) and the Romanian National Computer Network that connect regional Local Area Networks (LAN) and research and educational institutions. RoEduNet connects six cities via 2 Mbps connections, in addition to a 1.5 Mbps connection to Norway and a 4 Mbps connection to the U.S. (http://www.roedu.net/old-index.html)
- Other major academic networks include Russia's FreeNet, Slovakia's SANet, and Slovenia's ARNES.

The Czech Example

23. Under the initial funding of the Czech Ministry of Education, the Czech Education and Scientific Network (CESNET), comprised of the Czech universities and the Czech Academy of Sciences, began the development of a national backbone infrastructure. In the mid-1990s, the Czech Republic participated in the development of the TEN-34 network, which evolved from an academic network into an open (commercial) network. By 1997, the TEN-34 network connected eight major cities and many academic institutions at speeds of 34 Mbps. Since then, the network has continued to expand geographically and enhance its bandwidth capacity. In 1998, the first 155 Mbps line was established between Prague and Brno and there are ongoing upgrades of the internal network to 155 Mbps lines with pure ATM technology. Thus, the Czech Republic has a highly integrated national network with an especially high-speed corridor between Prague and Brno. Although the technology for speeds greater than 155 Mbps is currently in use in some European and American cities, the TEN-155 network represents a comparatively highly- advanced level of Internet connectivity.

Figure. The Czech Example



(Gif Source: http://www.ten34.ces.net/english/technol.html)

24. The early stages of development of many of the academic networks was facilitated through participation in the Central and Eastern European Networking Association (CEENet). The principal external sources of support for the development of publicly-shared networks are non-governmental organizations, such as the Soros Foundation's Open Society Initiative, international organizations, such as the UNDP, the World Bank and the Eurasia Foundation, or other national entities, such as the USAID program. In Belarus, the UNDP and the Open Society Institute are working together with the Unibel Academic Internet Service Provider (http://unibel.by) to develop a national Internet backbone. The network currently connects many institutions in the areas of research, education, culture and other non-profit communities, such as the Belarussian State University and the Polytechnic Academy.

Private Networks

25. In addition to the academic networks, private corporations also establish their own local national backbone that may or may not be directly connected to the international backbone, but which can offer high speed connections to resources that also exist on its internal network.

26. In Bulgaria, several international backbone providers have developed local networks with Points of Presence (POPs) across the country. The European EUNet corporation, which is itself part of the KPN-Qwest international backbone corporation, has established its own local network within Bulgaria under the name Digital Systems (http://www.digsys.bg/navbar/bottom10.html). (EUNet also operates networks in the Czech Republic, Estonia, Latvia, Lithuania, Romania and Slovakia.) Global One, (http://www.gocis.bg/en/index.html) an international partnership between Sprint, France Telecom and Deutsche Telecom, has also established a national ATM backbone for Bulgarian broadband network traffic. In addition, the Bulgarian Telecommunications Company (BTC - http://www.btc.bg/btc/index.htm) has developed a national ATM data network that permits regional access via a centralized number to its internal Internet network.

27. In partnership with Global One Russia, the Kazakh company, Astel (http://www.astel.kz/frame.html), has created a national data communications (X.25 based) network, KazNet, that connects 22 regional nodes, covering every major city in Kazakhstan. Through a combination of fibre optic and satellite connections they are able to offer X.25 data transmission, as well as integrated telecommunications services over their network. However, the national telecom, Kazaktelecom (http://www.online.kz/enprofile.html), is also in the process of establishing a national fibre optic backbone that will link 19 cities.

28. As the telecommunications markets are liberalized, more and more companies are beginning to offer full data communication networks, enabling voice telephony, broadcasting and high speed data transmission, based upon frame-relay, X.25 or ATM protocols, in addition to the transmission of Internet traffic over the TCP/IP protocol. However, the cost of implementing national networks remains high and international carriers, in partnership with local subsidiaries dominate the market.

29. For countries where there are regulatory barriers, or excessively high entry costs, to the establishment of a fixed wire/fibre optic data network, a technological alternative is the development of an Internet backbone based on wireless technology. In Latvia, the former academic network based at the University of Latvia, LATNET (http://www.latnet.lv/LATNET/English/), developed a wireless backbone by connecting over 200 locations to wireless Local Area Networks (LANs) via twenty-two central antennas located around the country. However, in order to maintain the quality of the wireless signal, fibre optic and other fixed lines are used to connect the central antennas to the Internet backbone itself. The latest wireless technology enables connection speeds of up to 11 Mbps. The principal advantages of wireless networking technologies are the ability to be quickly independent of the existing communications infrastructure, fast and low cost installation and maintenance, and relatively high-speed connections.

30. As the cost of fibre optic networks continues to drop and new technological alternatives emerge, the development of national networks becomes more and more within reach of local businesses, in particular local ISPs with an existing customer base. The challenge for locally owned networks is to develop to such an extent that they can enter into peering relationships with international backbone providers.

Internet Exchanges (IX)

31. The development of what we might call a 'national backbone' is, in fact, rarely a single, centrally coordinated, network with universal coverage, but rather, it is a combination of overlapping segments of separate networks, made up of a variety of technologies, operating at different speeds, with unequal national coverage. In order to improve the overall efficiency of Internet traffic at the national level, some degree of coordination and sharing of network resources is required. Once the elements of a national Internet backbone are in place, and are being shared by several Internet service providers, the next stage in the infrastructure evolution is to establish a Local Internet Exchange.

32. The Internet Exchanges are a network node, housing routers and modems with potentially high-speed direct connections to each ISP, and a very high-speed (including the new Gigabit Ethernet switches) internal switching network. Each local ISP establishes a high-speed connection to the local node and, within the node, the local ISPs establish very high-speed connections to one another via the Ethernet switch. The function of an Exchange is to equitably and efficiently coordinate traffic in the local backbone network. The Exchange allows the flow of data from each ISP's individual network through new routes created via the Internet exchange node, rather than the more inefficient scenario described above, whereby data travelling between local ISPs would be routed via each ISP's connection to an international backbone and then back via the other international backbone to the other local ISP.

33. Internet Exchanges, therefore, increase the potential of both bandwidth and access for the ISP's client base not only by increasing the local connection speeds, but also by sharing the access to one another's international connections. Every ISP exchange member's potential bandwidth is increased when local traffic is redirected to the higher speed local network paths and international traffic is redirected to the most efficient and/or highest speed international connection. The ISP's local customers also benefit from increased access to content produced from within the region itself, such that the content service providers and the local customers are brought more directly together. The interconnection of the local networks, containing both hosted content providing sites and the end-users of this content, should mutually promote both a greater number of locally produced sites and a growing number of Internet users. The following table lists all the Internet Exchanges currently deployed in the transition economies:

Country	Local Internet Exchanges
Czech Republic	Neutral Internet eXchange http://www.nix.cz
Hungary	BIX – Budapest Internet eXchange http://www.nic.hu/bix/
Latvia	GIX http://www.nic.lv/gix.htm
Romania	Bucharest IX http://www.buhix.ro
Russia	M9-IX in Moscow http://www.ripn.net/IX/M9/ SPB-IX in St. Petersburg http://www.ripn.net/IX/SPB/
Slovakia	The Slovak Internet eXchange http://www.six.sk/

34. The Budapest Internet Exchange (BIX) in Hungary is composed of four nodes with 100 Mbps connections between the local routers. The Latvian Global Internet Exchange (GIX) is composed of two primary nodes with a 100 Mbps connection between the nodes and 3 Gbps internal Ethernet switches. The Slovak Internet Exchange (SIX) operates with 100 Mbps connections. The Russian M9 Internet Exchange in Moscow offers connections to the local node at speeds of 10, 100 or 155 Mbps.

Internet Growth and the Problem of Routing

35. One of the technical disadvantages of the use of Internet exchanges is the growing complexity of the system of directing Internet traffic, or 'routing', when new meshes of pathways are created at the local level. The Internet is a vast collection of individual networks interacting on a global scale. The growth of the Internet is incorrectly visualised by the image of a tree which extends into higher and higher levels of branches and leaves, because as new networks attach themselves to the Internet infrastructure, they are not simply extensions of the pre-existing core network, but rather are simultaneously developing connections amongst themselves. The reality of the existing network infrastructure can only be captured by the messy representation of a globe covered in dots, with a constantly increasing number of lines drawn between each and every dot.

36. If a network wants to use the most efficient pathway between its network and a site located on another network, it must follow a pre-given path based upon the existing physical infrastructure that is stored on the network in 'routing tables'. As the physical infrastructure grows and potentially more efficient pathways are created, the routing tables must be updated to include the new route. However, the tables do not reflect the pathways between a fixed number of points, but must deal with the ever increasing number of points and, thus, exponentially increasing number of pathways.

37. The technical reality of the situation of exploding routing tables is that the memory required to hold the table of the entire Internet universe has risked exceeding the capacity of the routers which house this information. There are, at present, several international working groups developing new protocols and technological solutions to the routing problem. (e.g. RIPE Routing Working Group, http://www.ripe.net/wg/routing/index.html) However, these technological limitations should not be taken as discouraging the establishment of Internet Exchanges, but rather, a note of caution that as the complexity of local connections increases, there is a greater need for international coordination of standards and shared information.

Membership Issues – Peering and Settlement

38. In their initial stages, Internet Exchanges are primarily composed of 'first-tier' ISPs, i.e. the ISPs that are operating at the closest level to the actual backbone, if not backbone providers themselves. In order to benefit from the partnership of membership in an Exchange, the ISPs should have their own international backbone connection, be registered members with RIPE as Local Internet Registries, have an autonomous system (AS) number registered in the RIPE database, and offer clients access services including their own primary DNS server, email, www and news servers.

39. When all the members of the Internet Exchange are first-tier ISPs with their own international connectivity, then the reciprocal benefits allow for a multilateral 'peering' relationship between all of the ISP members. Peering relationships presume that the interconnectivity provided by the Internet Exchange will produce a relatively equitable traffic flow between the member ISPs. Under a peering relationship, the distribution of the costs involved in the exchange of Internet traffic is 'settlement-free', under the belief that each ISP's costs are similarly distributed. The nature of the peer relationship comes into question once the nature of the individual ISPs begin to vary in terms of both their bandwidth capabilities and their access needs.

40. The differences might be generally classified in terms of ISPs that are net-exporters and those that are net-importers of Internet traffic. The flow of Internet traffic is such that very small amounts of data are sent upstream as requests for information, i.e. by clicking on a URL or hyperlink, followed by large amounts of information that are returned to the user from the website host. A net-exporter would be a network that is primarily in the business of hosting websites and a net-importer would be a network that is mainly geared towards connecting end-users to the Internet. Once imbalances in the flow of information emerges, then those networks that are bearing the burden of the greater traffic, and subsequently experiencing a greater proportion of the operating costs, will inevitably attempt to shift the distribution of costs to reflect the unequal traffic patterns.

41. The inequitable distribution of costs is especially present when both first-tier and second-tier ISPs are admitted as members to the Internet Exchange. The danger posed by this situation is that the first-tier ISPs are likely to try and use their market dominance, in terms of essential backbone connectivity, to attempt to alter the relationship between themselves and the second-tier ISPs, and thus the distribution costs, from one of peering to that of client. The concerns of the first-tier ISPs is that the sharing of distribution costs undermines the competitive advantage they have gained through their investments in developing international backbone connections. The first-tier ISPs may threaten to deny connectivity between their network and the second-tier ISP that refuses to accept the settlement fees of a client relationship. However, the threat by the first-tier ISPs to disconnect another network has the consequence of removing access to the host sites on its network from the potential users on the second-tier network, as well as denying access to its own users to sites on the competitors. The peering relationship is therefore more stable when inter-network traffic flow, i.e. communication between users and hosts within the same national territory but on separate networks, has developed to a sustainable level such that the competitive advantages of the peering relationship outweigh the need for a redistribution of network costs.

42. In the Czech Republic, the Local Internet Exchange is known as NIX (Neutral Internet eXchange - http://www.nix.cz/) and is composed of the following ISPs: Bohemia.Net, CESNET, Contactel, CZCOM, Czech Online, DirectNet-EOS, EUNet-Czechia, Global One, GTS CzechNet, IBM, INEC, InWay, IPEX, Luko Czech Net, Mopos, NetForce, SPT Telecom, PVT, Telenor CR, Telenor Internet. The list of members (http://www.nix.cz/clenovee.html) includes both local ISPs, such as Czech Online and Telenor, as well as international ISPs, such as Global One and EUNet.

43. The organizational structure of NIX has the form of a registered association of the Internet Service Providers in the Czech Republic. As an association, NIX permits bilateral peering-settlement relationships such that the members can be peered within the NIX node, peered outside of the NIX node, or simply have settlement arrangements between its members. The Slovakian Internet Exchange (SIX - http://www.six.sk/) is similarly structured and permits bilateral peering-settlement relationships. Under this organizational structure, not all member ISPs have equal and open access to the shared network resources insofar as the non-peered relationships require that client ISPs pay for the access to the superior backbone connections. The advantage of an open structured association that permits bilateral peering-settlement relationships is that it provides a greater incentive to the international ISPs to participate in network resource sharing when they already have relatively high speed access to their own international backbones.

44. It is also possible for the coordination of local network traffic to take place outside of the context of a formal Internet Exchange, when several local ISPs with international connections enter into peering relationships and establish interconnectivity without a central node, or a formal organizational structure. In Bulgaria, several of the major, or top tier, ISPs have signed a peering rules agreement which establishes the technical requirements for a national peering system. The academic and research network for Lithuania (LITNet - http://www.litnet.lt/index_en.html) has also established peering relationships with all the main ISPs in Lithuania. However, the lack of an independent coordinating agency leaves open the possibility of a single monopoly agency controlling the local peering relationships, which is the case when the national telecom controls all international backbone connections, or for the formation of a cartel of the top tier ISPs which could deny access to newly created ISPs.

45. Therefore, the establishment of an Internet Exchange is a crucial element in the development of national and regional inter-network communication.

- Internet Exchanges provide for more efficient and competitive access to international backbone connectivity.
- An Internet Exchange must decide on the characteristics required for membership, i.e. restricting to first-tier or open to all ISPs, and must decide on whether there will be multilateral peering relationships between all the member ISPs or whether individual peering-settlement relationships will be permitted within the exchange node.
- It must be decided whether the establishment of the exchange and the nature of the peering relationships will be organized under the model of an Association of ISPs, as an independent but commercial Internet Exchange, or as a government regulatory agency.

International Backbones

46. One potential measure of the level of Internet development in a country is the total bandwidth that connects the local backbone to various points on the international backbones. For example, in the Republic of Moldova there are five ISPs that have international connections:

- The most significant being the national telecom, Moldtelecom, with its 2 Mbps fibre optic connection to Teleglobe.
- Riscom operates a 128 Kbps fibre optic link to the European Ebone network.
- DNT has a 512 Kbps satellite link to NetSet.
- MegaDat has a 128 Kbps satellite connection to Deutsche Telecom.
- Relsoft has a 1 Mbps satellite connection to the Norwegian Taide Networks.

Therefore, the total raw international bandwidth for the Republic of Moldova is approximately 4 Mbps. There is also some exchange of international backbone access as some of theMoldovan ISPs have established peering relationships and, thus, Moldtelecom has evolved into an unofficial Internet exchange. However, the precise figure of total international backbone remains difficult to determine as new ISPs and new technologies are constantly being introduced in the market.

47. One major factor in the growth of international backbone connectivity is the proximity to established high-speed networks. The central European countries, such as the Czech Republic and Hungary benefit from their ability to directly connect to such European backbones as the TEN-155 project and EBONE. The Baltic countries have benefited from partnerships with Finland, Sweden and Norway, which possess highly developed national networks, as well as locally based international backbone providers such as Taide and Telia.

48. The CIS, Caucasus and Black Sea countries might look towards the Russian backbone networks, however, the sheer size of the region and the fact that the development of the backbone remains limited to urban areas, means that direct link, i.e. fibre optic, connections will require significant financial and hardware resources. The quickest and most cost-effective solution for those countries that are some distance away from the nearest land link to an international backbone is to establish a satellite connection, enabling connection speeds of up to 2 Mbps.

49. Armenia, Azerbaijan and Georgia have all established satellite connections of varying speeds to backbone providers in the United States, although Georgia also has a satellite connection to Russia. However, the possibility of a direct backbone link will be made possible as the German firm Siemens, in partnership with regional telecoms, is in the process of finishing the Trans-Asia-Europe fibre optic line which will connect Frankfurt to Shanghai, passing through the Caucasus and Central Asian CIS countries.

Country	**International Backbone Information (Fastest available connections)**
Albania	Albania Online has a frame-relay connection via satellite to the US Internet backbone. http://WWW.ALBANIAONLINE.NET/
Armenia	Arminco Global Telecommunications has a 128 Kbps satellite channel to MCI in the US. http://www.arminco.com/
Azerbaijan	AzInternet Services has a 512 Kbps satellite connection. (http://www.azeri.com/)
Belarus	No information on international backbone connections available.
Bosnia and Herzegovina	No information on international backbone connections available.
Bulgaria	Several major international backbone companies have connections to their local ISP subsidiaries, including EUNet, Global One and UUNet.

Country	International Backbone Information (Fastest available connections)
	Bulgarian Telecom has a 6 Mbps fibre optic link to Deutsche Telecom, 2 Mbps fibre link to Teleglobe and a 2 Mbps satellite connection to MCI. (http://www.btc.bg/btc/index.htm)
Croatia	CARNet has a 128 Kbps connection to EBONE in Vienna and a 1 Mbps connection to MCI. (http://www.carnet.hr/index_eng.html)
Czech Republic	Connected to the European international backbone project TEN-155 at 155 Mbps, as well as numerous private high-speed connections to backbones such as EBONE, UUNet, and Global One. (see Czech example section above)
Estonia	EENet has a 4 Mbps connection to NORDUNet in Finland. (http://www.eenet.ee/englishEENet/index.html) EUNet has connections to Qwest and EUNet backbones. (http://www.data.ee/en/)
Georgia	SANet operates a satellite connection to the UUNet (US) backbone. (http://www.sanet.ge) Infocom has a link to Moscow's Sovam Teleport network. (http://www.iberiapac.ge)
Hungary	Most important connection is via the European TEN-34 backbone at 34 Mbps. (http://www.hungarnet.hu) Also includes connections from GTS Group, KPN and PSINet.
Kazakhstan	Astel operates satellite connections to Global One (Russia) and Frontier (US) backbones. (http://www.astel.kz/frame.html) NURSAT operates satellite connections to backbones in Moscow, New York and London. (http://www.nursat.net/content_eng.html)
Kyrgyzstan	No information on international backbone connections available.
Latvia	LATNET operates a 3 Mbps satellite connection to Sprint in the US, 2 Mbps satellite link to Taide in Norway and a 1 Mbps link to Uunet in Sweden. (http://www.latnet.lv/LATNET/English/)
Lithuania	EUNet has a 1 Mbps connection to the EUNet backbone in Amsterdam. (http://www.eunet.lt/ENGLISH/Products&Services/products_services.htm) LITNET operates a 1.5 Mbps fibre optic link and a 512 Kbps satellite link to European backbones. (http://www.litnet.lt/index_en.html) Omnitel operates a 2 Mbps connection to Telia in Sweden. (http://www.omnitel.lt/index-e.html) Taide (of Norway) runs a 2 Mbps satellite connection and a 2 Mbps fibre link to its backbone in Norway. (http://www.taide.lt/inter-services/1.htm) Takas (the Lithuanian Telecom's ISP) has an 8 Mbps connection to Sweden and a 6 Mbps satellite connection to Canada. (http://www.sprendimai.lt/Internetas_e.html)
Moldova (Republic of)	DNT, an NGO, operates a 1 Mbps satellite connection. (http://www.dnt.md/en.html) MoldTelecom has a 2 Mbps land connection to Teleglobe (http://www.moldtelecom.md/Internet.html), Relsoft has a 1 Mbps satellite connection to Taide (http://www.relsoft.md/), and Riscom has a 128 Kbps link to the Ebone. (http://www.riscom.md/index.html)
Poland	The NASK network has a 155 Mbps link to Sweden. (http://www.nask.pl/english/)
Romania	RNC operates a 2 Mbps connection to a U.S. backbone. (http://www.rnc.ro/new/welcome.shtml) RoEduNet has a 1.5 Mbps connection to Taide and a 4 Mbps satellite connection to a U.S. backbone. (http://www.roedu.net/old-index.html)
Russia	Golden Telecom (GT), Global Teleystems' (GTS) Russian subsidiary, has acquired **2.4 Gbps** of capacity between Moscow and Stockholm from Sonera. (http://www.telecoms-data.com/comms/070200.htm#story4)

Country	International Backbone Information (Fastest available connections)
The former Yugoslav Republic of Macedonia	The Macedonian Telecom provides all Internet backbone connectivity via a 2 Mbps fibre link to the UK, a 256 Kbps satellite connection to Teleglobe and a 128 Kbps satellite link to MCI. (http://www.mt.com.mk/who.htm)

It should be noted that the data in the table above are based on a web search of all the major ISPs in each country and represents the best available data published on the www at the time of research. Given that many ISPs do not publish the specifications of their international Internet connectivity, the table should not be taken as a comprehensive summary of the total bandwidth available in each country, but rather as an anecdotal sampling of the varying level of connectivity. Because there is no centralized administration of international Internet connectivity it is extremely difficult to present an accurate account of the total available international bandwidth.[4]

II. DOMAIN NAME SYSTEM (DNS)

Domain Name Registries

50. The Domain Name System is the process by which IP addresses are converted into the Internet domain names with which most users are familiar, e.g.www.un.org or www.georgia.net.ge. As a text substitute for IP addresses, the domain name represents a computer or network server that is connected to the Internet. In contrast to the IP address system which somewhat reflects the physical infrastructure of the network, the domain name system can be thematically or geographically organized, depending upon the choice of the registry responsible for each top level domain (TLD), i.e. the component terms might be chosen to represent types of industry or selected geographical regions.

51. The domain name is composed of several hierarchically organized components: the top level domain name is the portion that appears to the right of the last period, or dot, as in ‘dot com’ for those domain names that end in ‘.com’. A top-level domain name (TLD) can either be an ISO country code, such as .ge for Georgia, or one of the generic top level domains (gTLD) such as .com, .org, .net. The second and third level domain names are the components that are to the left of the top-level domain with ‘un’ as the second level domain and ‘www’ as the third level domain.[5]

52. The TLDs are administered by a Domain Name System (DNS) registry which can be a government agency, an independent body or a private company operating in the region, or in some exceptional cases even administered from outside of the region, for those TLDs that belong to a country code. In the case of generic TLDs (.com, .net, .org), the DNS registry was under the exclusive control of InterNIC Registration Services (also known as Network Solutions, Inc.) on assignment from the U.S. Government but InterNIC’s control of the gTLD domain, as well as the expansion to include other gTLDs is in the process of being transferred to The Internet Corporation for Assigned Names and Numbers (ICANN - http://www.icann.org), a non-profit corporation. [6]

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4 For additional information please see: Kenneth Neil Cukier, ‘Peering and Fearing : ISP Interconnection and Regulatory Issues’, http://ksgwww.harvard.edu/iip/iicompol/Papers/Cukier.html; Geoff Huston, ‘Interconnection, Peering and Settlements’, January 1999, http://www.telstra.net/gih/peerdocs/peer.html; Dr. Milton Mueller, Dr. Joseph Y. Hui, Che-hoo Cheng, ‘The Hong Kong Internet Exchange : A Case Study in the Economics, Evolution and Connectivity of Asian Internet Infrastructure’, http://ksgwww.harvard.edu/iip/cai/mueller.html; OECD Report, ‘Internet Traffic Exchange : Developments and Policy’ prepared by Dr. Sam Paltridge of the OECD’s Directorate for Science, Technology and Industry, for the Working Party on Telecommunication and Information Services Policies, Paris, 1999.

5 To register a second level domain name (.net.ge) or a third level domain name (e.g. aaa.gov.cz) a user needs to apply to the domain name registry with the delegated authority for the TLD or gTLD. Each registry administers its own policies and sets its own prices, however, the global nature of the Internet demands certain technological and policy requirements. On the technological side, the DNS name must fit the format and required information of the established system of DNS servers such that the domain names can be translated into any IP address and thus any computer on an Internet-connected network.

6 At the international level, the newly established ICANN will likely take a leading role in co-ordinating policy issues relating to domain names, such as the exclusion of famous marks, the development of new generic TLDs (some proposals include .store, .web and .rec), as well as setting guidelines for a uniform DNS dispute resolution policy. See also, ‘Net Group agrees to direct elections’, International Herald Tribune, 13 March 2000, p.11

53. The following are the DNS Registries and the published requirements for the country code top-level domains (ccTLD):

Country	**ISO Code as TLD**	**Domain Name System Registry for the ccTLD**	**Domain Name System Regulations**
Albania	.al	http://www.inima.al/Domains.html	▪ Restricted subdomains: .gov, .edu, .org, .com, .net ▪ Organizations must have legal representative inside the territory of Albania, along with official registration in Albania. ▪ Non-educational organizations must pay 100 USD for two years. ▪ Administered by the Authority for Regulations of Telecommunication in Albania (ART).
Armenia	.am	http://www.amnic.net	▪ No residency requirements. ▪ Price is 200 USD for foreign residents and 20 USD for residents of Armenia. ▪ Administered by Armenia Network Information Center.
Azerbaijan	.az	http://www.az (not yet available)	▪ No DNS information available.
Belarus	.by	http://unibel.by (not yet available)	▪ No DNS information available.
Bosnia and Herzegovina	.ba	N/A	▪ No DNS information available.
Bulgaria	.bg	http://www.digsys.bg/bg-nic/bg-domain.html	▪ No residency requirements. ▪ Initial registration fee is 50 USD, plus 20% VAT, and a yearly maintenance fee costs 50 USD .
Croatia	.hr	http://noc.srce.hr/web-eng/DNSindex.htm	▪ No residency requirements (except for additional domains). ▪ No charge for domain names.
Czech Republic	.cz	http://www.nic.cz	▪ Applicant must have a contact address in the Czech Republic. If the applicant is a legal entity it must either be established in the Czech Republic or must do business and have a contact address in the territory of the Czech Republic. ▪ Initial registration fee is 45 USD (1600 CZK), yearly maintenance fee is 22.5 USD (800 CZK).
Estonia	.ee	http://www.eenet.ee/services/subdomains.html	▪ Registration process is only open for organizations and individuals having permanent Internet connections in Estonia. ▪ Registration is free of charge.

Country	ISO Code as TLD	Domain Name System Registry for the ccTLD	Domain Name System Regulations
Georgia	.ge	http://www.nic.net.ge	▪ Organizations requesting for domain registration under .GE must have a real local presence in Georgia and must use the requested domain name only on the territory of Georgia. The Organization and the Administrative contact must be in Georgia. ▪ Registration is free.
Hungary	.hu	http://www.nic.hu	▪ Registration process is supervised by the association, the Council of Internet Service Providers. The administrative contact person should have a postal address in Hungary and should be able to communicate in Hungarian. ▪ Prices for domain names are set by the individual ISPs
Kazakhstan	.kz	http://www.domain.kz	▪ No residency requirements for registration. ▪ Registration fee is 100 USD.
Kyrgyzstan	.kg	http://www.domain.kg	▪ No DNS information available.
Latvia	.lv	http://www.nic.lv/DNS	▪ No residency requirements. ▪ Registration fee is 100 USD or 60 LVL.
Lithuania	.lt	http://www.domreg.lt/	▪ No residency requirements. ▪ Registration fee is 50 USD (200 LTL) and 20 USD (80 LTL) for the yearly maintenance fee.
Moldova (Republic of)	.md	http://www.nic.md	▪ No DNS information available
Poland	.pl	http://www.nask.pl/dns.html	▪ No residency requirements. ▪ Registration fee is 73 USD (300 PLZ).
Romania	.ro	http://www.rnc.ro	▪ No residency requirements. ▪ Registration fee is 61 USD (including VAT).
Russian Federation	.ru	http://www.ripn.net/nic/dns/en	▪ No DNS information available
Slovakia	.sk	http://www.eunet.sk/sk-nic	▪ No DNS information available
Slovenia	.si	http://www.arenes.si/si-domene	▪ No DNS information available
Tajikistan	.tj	http://www.nic.tj	▪ No DNS information available

Country	ISO Code as TLD	Domain Name System Registry for the ccTLD	Domain Name System Regulations
Turkmenistan	.tm	http://www.nic.tm	▪ No DNS information available
Ukraine	.ua	http://nic.ua.net	▪ No DNS information available
Uzbekistan	.uz	http://www.ufn.net	▪ No DNS information available
Yugoslavia	.yu	http://www.nic.yu	▪ No DNS information available

54. The key issues that are open to be determined by the DNS registry of each country code TLD include:

Residency – i.e. whether the registrant of a domain name is only open to sites that are hosted on networks physically within the territory in question; or the registrant must be a citizen or resident of the region; or the registrant must have an administrative contact in the area; or registration is open to any entity regardless of their physical presence.

- Countries which have no residency requirements include Armenia, Bulgaria, Croatia, Kazakhstan, Latvia, and Lithuania.
- Countries which require a local point of contact include the Czech Republic and Hungary.
- Countries which require either legal representation or a fixed local Internet presence include Albania, Estonia, and Georgia.

Price - the registry is free to establish a price for initial registration and/or for a yearly maintenance fee; the registry may allow or deny intermediary registrants such as host ISPs to set prices for DNS registration; or the registration may be free of charge.

- Countries which do not charge for DNS registration include Estonia and Georgia.
- Armenia has the highest cost for registration for foreign residents at 200 USD but has a below average price, 20 USD, for local residents.
- Kazakhstan and Latvia's general registration fee of 100 USD remains the highest for local residents.
- The Czech Republic and Lithuania charge 50 USD for the initial registration fee and have yearly maintenance fees of approximately 20 USD.
- The DNS registry for Hungary does not itself collect registration fees but rather requires the registration be made via participating ISPs which are free to set their own administrative fees.

Internet Protocol (IP) Addresses

55. An essential element of the basic infrastructure of the Internet is the assignment of Internet Protocol (IP) addresses. IP numbers are used to identify and route information to individual computers that are connected to a network based upon the TCP/IP protocol. Every computer in a network is assigned a number which enables information to be exchanged between any specific machines that are connected to the network. When a computer has a permanent connection to the network, it can be assigned a static IP address; when a computer is only intermittently connected to the network, i.e. a connection is established via a modem only when necessary, then the computer can be assigned a dynamic IP address. The dynamic address might reflect a static address assigned to the modem that the computer is currently connected to and does not permanently reflect the identity of the connected computer.

56. The format of IP numbers are four sets of numbers between 0 and 255 (2 to the 8th power, or an 8 bit number in base 2 such that the number 24 would represent the 8 bit number 00011000) divided by periods, ex. 187.24.220.100, which produces a 32 bit digit. As a crude example, a network might be represented by all the numbers in the series from 187.24.220.000 to 187.24.220.100 with individual IP addresses being assigned dynamically and statically within the series.

57. Private networks may use the TCP/IP protocol, but if the addresses are to be used across private networks, or be connected to the Internet, there must be a coordination of IP address allocation. The current version of IP (IP version 4 or IPv4), which was standardized in 1981, created a pool of 4,294,967,296 IPv4 addresses. (Source: Chuck Semeria, "Understanding IP Addressing: Everything You Ever Wanted To Know", http://www.3com.com/nsc/501302.html) The task of coordinating the assignment of IP addresses was originally taken up by the Internet Assigned Numbers Authority (IANA) but was subsequently redistributed to three regional bodies: APNIC (Asia-Pacific Network Information Center), ARIN (American Registry for Internet Numbers) and RIPE NCC (Reseaux IP Européens Network Co-ordination Centre). The overall supervision of the allocation of IP addresses is in the process of being transferred from the US Government-contracted IANA to the non-profit corporation, ICANN, the Internet Corporation for Assigned Names and Numbers.

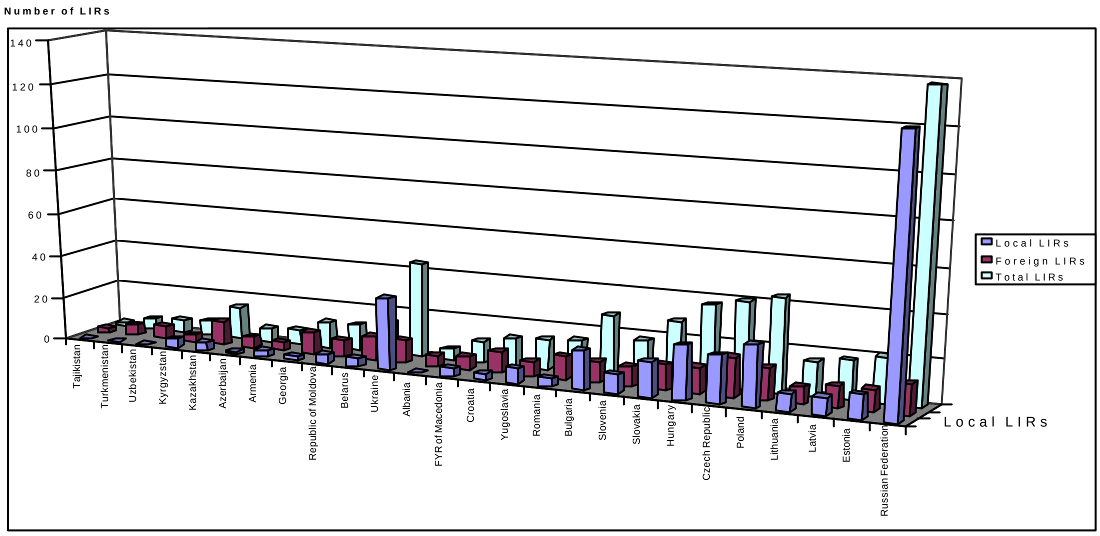
58. Under this hierarchical system, local networks request IP address allocations from the sub-regional authorities that have been assigned a set block of IP numbers. The allocation of IP addresses within transition economies falls under the authority of RIPE NCC http://www.ripe.net, which subsequently allocates addresses to Local Internet Registries (LIR). The local Internet registries may be local companies or may also be an international network that includes a specific country within its area of competence; they may reserve IP addresses for their internal network needs or sell off addresses to further sub-registries. Companies which are registered with RIPE are classified as small, medium, large and enterprise members. Each new registered local Internet registry receives a block of IP addresses, usually a "/19" block, which means that the first 19 digits of the 32 bit IP address are already pre-assigned, thus leaving a 13 bit block of numbers, or 2 to the 13th, i.e. 8192 addresses.

Internet Registries

Country	Number of Local IRs	Total IP Address Allocation for Local IRs	Number of Foreign IRs	Total Number of IRs
Albania	0	0	5	5
Armenia	3	24576	4	7
Azerbaijan	1	8192	5	6
Belarus	4	32768	11	15
Bosnia and Herzegovina	N/A	N/A	N/A	N/A
Bulgaria	18	237568	10	28
Croatia	3	155648	10	11
Czech Republic	22	843776	18	40
Estonia	11	188416	10	21
Georgia	2	16384	10	12
Hungary	25	671744	12	37
Kazakhstan	4	114688	11	15
Kyrgyzstan	4	32768	3	7
Latvia	8	112880	10	18
Lithuania	8	180224	8	16
Moldova (Republic of)	4	32768	8	12
Poland	28	1310720	15	43
Romania	4	253952	11	15
Russia	124	1392640	14	138
Slovakia	16	417792	12	28
Slovenia	9	270336	9	18
Tajikistan	0	0	2	2
The former Yugoslav Republic of Macedonia	4	40960	6	10
Turkmenistan	0	0	5	5
Ukraine	33	434176	11	44
Uzbekistan	0	8192	6	6
Yugoslavia	7	163840	7	14

(Source: RIPE, http://www.ripe.net)

Chart 3: Internet Registries in Transition Economies



(Note: Statistics for Bosnia and Herzegovina not available; source, RIPE, http://www.ripe.net)

59. The function of IP address allocation and the role of local Internet registries are overlooked elements in any discussion of Internet infrastructure indicators. By examining the list of local Internet registries in a given country (the full list of countries is available at http://www.ripe.net/ripencc/mem-services/general/indices/index.html), we are able to identify the country of origin of each LIR, the size (as classified by RIPE) of the company, as well as the size of the IP address allocation.

60. We are; therefore, able to produce a list of the number of local and foreign owned LIRs and determine the size of their individual IP address allocation. A careful consideration of the exact make-up of the set of LIRs is crucial to obtaining an initial overview of the nature of the Internet infrastructure since the companies who are in control of IP addresses are an essential link between end users and global Internet backbones.

61. It should be noted that the number of LIRs, both foreign and domestic, are not necessarily the all-encompassing indicator of local Internet use since it is possible for local ISPs to receive address allocation from a registry outside of its national boundaries. If a local company establishes a direct satellite link to a foreign backbone then they might obtain IP address allocation from the upstream ISP. As soon as there is any Internet development at the local level, however, especially in terms of coordination between local ISPs in local Internet exchanges, then the need for IP address allocation at the national level increases greatly. Therefore, for countries with an already low level of Internet infrastructure development, the number of LIRs will not necessarily be directly representative of the number of potential Internet users. However, once the size of the Internet community grows, the make-up of the body of local Internet registries should provide a relatively deep level of insight into the types of enterprises involved with the Internet at a national level.

Foreign Internet Registries (FIR)

62. Based upon the same country lists of Internet Registries (IRs) (http://www.ripe.net/ripencc/mem-services/general/indices/index.html), we can observe that the region with the greatest concentration of Foreign

Internet Registries (FIR)[7] is Central Europe. Given the proximity of Western European countries with their extensive network of international backbones, it is clear that the backbone providers and Internet infrastructure companies will be interested in expanding their services into the nearby markets of Central Europe.

- The Czech Republic and Poland have the largest number of FIRs, surpassing even Russia. The FIRs in the Czech Republic include such backbone providers as TeleDanmark, Global One, EUNet, Taide, Teleglobe and Ebone, as well as the German infrastructure manufacturer Siemens.
- Poland's list of FIRs similarly includes, TeleDanmark, Global One, Taide, Teleglobe, Siemens, as well as SAP-AG.
- In addition, companies based in Central Europe have themselves become developers and FIRs in other transition economies. Hungary's BankNet Kft has become an important provider of banking data networking, with a presence in a majority of the transition economies.

63. The Baltic countries reveal a tilt towards connections to Sweden, Norway, Finland and Russia in the geographical origins of their foreign IRs, along with the major backbone players such as Global One and EUNet, and Siemens. The Eastern European and Central Asian CIS countries and Russia reveal many of the same major FIRs as the Central European countries, i.e. Global One, Teleglobe, Siemens and Taide, suggesting a similar openness to Internet development, only slightly further geographically removed.

64. In the Caucasus, Georgia stands out with a similar level of FIRs to Russia and the Eastern European and Black Sea CIS countries, whereas Azerbaijan and Armenia are mainly served by Teleglobe and Taide. In the Central Asian CIS, Kazakhstan is the exception because, in addition to the standard European backbone IRs, it benefits from investments from several Russian backbone providers. However, the rest of the region is primarily limited to Teleglobe and Taide with Tajikistan having the lowest level of FIRs in the study.

Local Internet Registries (LIR)

65. The number of local Internet registries (LIRs) will give us an approximate indication of the size of the local ISP market. If it is small then it might mean that the local population of Internet users is itself quite small, or it might mean that one or two major players dominate the ISP market, or there might be a restrictive regulatory environment that makes setting up ISPs rather difficult[8].

66. The chart below indicates the number of IP address allocations per million of inhabitants for LIR. In other words, this is the number of IP addresses available from networks that are owned and operated from within each country. This data does not provide a representation of the total number of users within each country since it is quite possible that a significant portion of the Internet connectivity is provided by internationally based networks. For example, Albania, Tajikistan and Turkmenistan have no local networks providing IP addresses, and it must be presumed that any Internet connections in these countries are ultimately directly connected to international networks.

67. By calculating the total number of per capita IP address allocations in each country, by local networks, we can get a more precise estimate of the capacity for each country to connect its residents to domestic networks.

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7 IP addresses managed beyond the territory will be useful to the following types of companies:

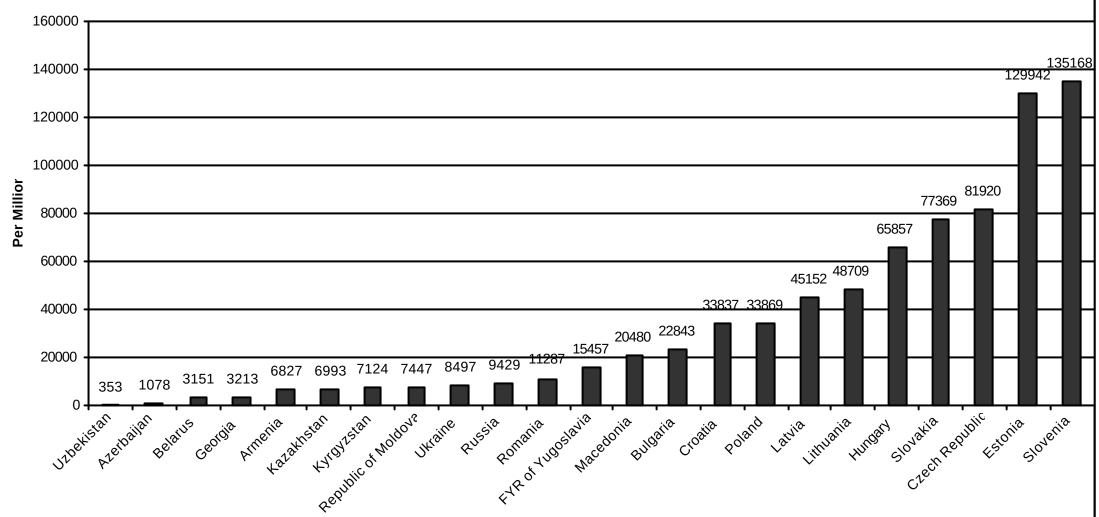
- International Internet backbone companies, such as Teleglobe, Taide, Global One, MCI Worldcom (UUNet, EUNet), who will resell IP addresses to ISPs that connect to their backbones.
- Manufacturers of IT infrastructure components such as fibre optic networks, routers, satellite dishes such as Siemens or Cisco.
- Banks and any large financial institution requiring secure WANs or LANs connected to the Internet.
- Corporations involved in international ecommerce that require a sufficiently large internal network, that is also connected to the Internet.

8 For a complete list of the allocation of blocks of IP addresses of local LIRs per country, please see the appendix which produces the local LIR country information available from RIPE (in TRADE/2000/18/Add.1).

Whereas the total number of local and foreign IRs gives an indication of the diversity of the marketplace, it is difficult to make meaningful cross country comparisons in other dimensions because we are not given an indication of the nature of each network's capacity for connectivity. (Note: Statistics for Bosnia and Herzegovina not available; source, data calculated by totalling the IP address allocation block for each local LIR listed, per country, in the RIPE database)

68. Both local and foreign IRs might simply be large companies who have reserved a/19 block of IP addresses to provide Internet connectivity for their internal use, without the intention to provide content on hosts connected to the Internet. Russia and the Ukraine have a relatively large number of LIRs, the vast majority of whom have only reserved the minimum block of addresses. It is clear from the table above that Estonia and Slovenia have a significant advantage in the number of IP addresses, and thus potential hosts, available to its citizens on local networks.

Chart 4: Number of IP Addresses Allocated by Local Internet Registers (LIR)



69. By examining the original totals of the number of IP address allocations from local LIRs, presented in the above table 'Local Internet Registries: Local and Foreign Owned', and taking into consideration the total IP address allocation per million inhabitants in the table immediately above, the following observations can be drawn:

<u>Low numbers of local LIR:</u> The Central Asian CIS region has the smallest numbers of locally owned LIRs with none located in Tajikistan, Turkmenistan and Uzbekistan. The extremely low level of locally owned LIRs, with Kazakhstan and Kyrgyzstan leading the two regions at four each, indicates that there is a very limited diversity of locally based ISPs.

<u>High percentage of local ownership of LIRs:</u> Russia and the Ukraine stand out for the comparatively large number of locally owned LIRs, as well as the significantly high proportion that local LIRs represent of the total number of LIRs. Russia's local LIRs represent 90% of its total number of LIRs and the Ukraine's make up 75% of its total. The next closest percentages of local to total number of LIRs are Hungary with 68%, Poland with 65%, Bulgaria with 64%, Slovakia with 57% and the Czech Republic with 55%. One conclusion that might be drawn from the percentage of locally owned LIRs to the total number of LIRs is the extent to which a country's network is internally oriented, i.e. the users of a network are primarily involved with connections to other users within the same national networks and are not as dependent upon, or even oriented towards, international connections.

70. The case of Poland

Poland has 28 locally owned LIRs and 15 foreign owned LIRs. The high number of locally owned LIRs is not directly the result of an exceptionally diverse ISP market, although this may still be the case. When we examine the list of local IP address allocations, we can discover that the registries include several University Research and Computing Centres, as well as several Metropolitan Area Networks (MANs). This information reveals that the development of the backbone in Poland has, to a large extent, been driven by academics in the field of computing and regional, or municipal, Governments that have supported the development of local backbones.

(Source: for the Poland LIR information, see http://www.ripe.net/ripencc/mem-services/general/indices/PL.html)

71. The Central European countries share similar percentages of local to total number of LIRs going from 50% in Slovenia up to 68 % in Hungary. With the exception of Russia and the Ukraine, all of the Central European countries fall within the upper tier of the number of locally owned LIRs, indicating a relatively high diversity of ISP services, as well as a developed local network, represented by the blocks of IP addresses that each LIR represents.

72. Mid-level number of local LIRs: The Baltic countries have almost identical numbers of locally owned LIRs, as well as the percentage of local to total numbers of LIRs and their overall size falls within the midrange of the overall survey. In the Eastern European countries, Bulgaria stands out with an above average number of locally owned LIRs that is more than the double of its next closest competitor in the region. Albania finds itself without any locally owned LIRs.

73. Both the Domain Name System and Regional Internet Registries provide examples of the international coordination of standards by non-governmental agencies, whereby administration takes place at a local level, in some cases by governmental agencies, but also by private corporations. In the case of local Internet registries, RIPE provides extremely useful sources of information on the allocation of IP addresses and the nature of organizations and companies that operate as LIRs in each country. This information can be used by member Governments to identify sectors of the national Internet infrastructure that could be further developed. In particular, RIPE might be invited to provide local workshops in order to inform better local professionals involved in network development of the formal requirements of becoming a local Internet registry, including routing and backbone requirements.

III. INTERNET SERVICE PROVIDERS (ISP)

74. Internet Service Providers (ISPs) can be both commercial providers and non-profit organizations offering Internet access to institutional and individual users. In many cases in the countries under study, the earliest providers of Internet access were academic networks with very slow (9 Kbps) UUCP connections that simply provided e-mail access. However, the academic networks, either under the supervision of a government ministry or an academic department, often evolved into the principal national backbone, connecting most government and non-profit organizations, or even offering commercial Internet connectivity. [9]

75. In its most basic form, an ISP could be set up with a minimum of hardware (servers and modem pool) and a connection to a 'second-tier' ISP via an analog phone line; these ISPs are commonly found in the more remote areas of countries that do not have developed national backbones. In some cases, a 'national network' has been formed through an association of a number of regional ISPs who then establish higher speed connections between the various nodes.

9 The UNDP and the Soros Foundation Open Society Initiative were also active participants in providing connectivity to international backbones, through sponsored satellite connections and website hosting, as well as training computer users and administrators. Several of their projects have evolved into commercial ISPs, such as Dynamic Network Technologies of Romania which now offers basic dial-up, leased lines, cable tv, radiowave and GSM Internet connectivity. See, http://soros.org/inetpages/country_projects.html

76. ISPs with access to another provider's national network and international connections might concentrate on bringing in customers via faster connections, e.g. ISDN, DSL or T1 lines, in the 'last mile', i.e. the connection from the home, or office, to the closest local access point to a backbone. Alternatively, they might also focus on website hosting by providing access to a large number of servers that can host locally produced websites, which are then connected to an upstream provider.

77. ISPs with their own proprietary backbone networks often focus on larger business clients who require permanent dedicated bandwidth connections. They can also provide the framework for Wide Area Networks (WANs), using protocols such as ATM, X.25 or Frame Relay, that can handle all of the internal and external data transmission needs of larger corporations, including the potential for video broadcast and voice telephony, leading finally to the creation of 'Virtual Private Networks' (VPNs). In some cases, the ISPs are involved in establishing proprietary fibre optic rings or direct satellite connections for private WANs, for example Hungary's BankNet (http://www.banknet.net/) which focuses on financial services networks and has subsidiaries in several transition economies.

78. International Internet connectivity is, for the most part, provided by North American and European companies, such as MCI/Worldcom's UUNet, or Norway's Taide, or Canada's Teleglobe. These international companies, therefore, are in the best position to provide large scale networking connectivity for large corporations and organizations. As local backbones develop further, and establish more and more connections to international backbones, local ISPs will be able to integrate their networks more directly to a high speed Internet connection and, thus, be able to offer competitive network services. As the chart below indicates, the vast majority of transition economies already have local ISPs offering large-scale WAN networking technologies.

Diversity of Services and ISP Pricing

79. The present state of the evolution of Internet connectivity can be captured by the diversity of services currently being offered by local ISPs. (For an overview of Internet connectivity speeds and terminology, see the section on Backbone Infrastructure). The information gathered below on the range of services is based upon the information published on the websites of the important ISPs in each country. The level of information available in English varied widely, as well as the access to pricing information. However, the number of ISPs in each country usually provided a range of pricing and service information.

80. The following table indicates the diversity of service options available in each country.

> Basic dial-up service: This is the mode of Internet connection most widely used by the general population. It consists of establishing an Internet connection from a modem located in a home or office, over local analog or digital phone lines, via a modem to the ISP. In this first layer of connectivity, speeds are usually limited to 33 Kbps, but in some cases speeds of up to 56 Kbps are theoretically possible. The service requires as a minimum, a local telephone connection, a PC and an analog modem.
>
> ISDN, or Integrated Services Digital Network: This is a set of protocols that are associated with the development of digital telecommunications network. A digital phone line is installed between the home or office and the local PSTN switch box and ISDN-specific digital modems must be installed at both ends of the installed line. In some cases, two lines are installed to increase the connection speed by dividing incoming and outgoing traffic. Speeds of up to 128 Kbps are available. The high costs of installing a new line and two modems for the limited increase in connection speed have resulted in the limited popularity of this technology. Although the level of digitalization of the PSTN varies across the countries under study, the technology is rather widespread because it does not require the installation of expensive cables, but rather is built upon existing digital phone lines. The only countries where no offers for ISDN connections were identified are Armenia, Belarus, Georgia and Lithuania.
>
> Wireless Technology: This can be as simple as cellular phone based modem connection via individual computers, but in most cases it refers to a wireless Local Area Network (LAN) where individual computers are networked together via antennas and wireless LAN adapter cards. The technology was first applied in

the context of network computers within a building or cluster of buildings because it provided a cheaper alternative to laying down T1 lines or fibre optic cables throughout the building. Increases in the size and power of the antennas permits the network to be expanded to distances of up to 40 km at connection speeds of up to 2 Mbps at a relatively low cost. This technology is especially useful where the local PSTN infrastructure is underdeveloped and permits Internet connectivity to remote regions without a huge investment in the telecommunications infrastructure. Although it is a relatively new technology and not widespread in Western Europe or North America, wireless technology is rather widespread in the transition economies, which is not surprising given that the technology is particularly appropriate for the existing infrastructure and geography of the more remote countries. Latvia was one of the pioneers in the use of wireless technology and has since exported its knowledge of building wireless networks to other countries including the Republic of Moldova. Wireless Internet connectivity is offered in Albania, Armenia, Azerbaijan, Bulgaria, the Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Latvia, Lithuania and the Republic of Moldova.

Leased-Lines: These are phone lines that are installed between the end-user and the ISP which are dedicated to Internet traffic. A T1 line is a set of twenty-four 64 Kbps lines that are multiplexed together to produce a potential connection speed of 1.536 Mbps. (See DSL section) A network connected via a T1 line could support approximately 200 to 300 computers at speeds limited to 28.8 Kbps. ISPs in transition economies typically offer leased-line connections from 14 Kbps to 1.5 Mbps. As this technology is built upon existing telephone lines, leased-lines are available as the basis for Internet connectivity in every country in the study.

Cable TV: This network access involves establishing Internet connectivity via the pre-existing cable television infrastructure via a special cable configured modem to the PC. In most cases, the ISP will be the cable television provider, or an ISP in partnership with the cable television company because cable television lines are in most cases a proprietary network that is not open to access by any user. The benefits of this technology are connection speeds of up to 30 Mbps over pre-existing infrastructure. The limitations, however, include the fact that cable technology was designed primarily to send data downstream and thus the constricted upstream flow means that Internet applications such as video conferencing, or streaming media are impractical, in some cases a separate line is established such that downstream traffic comes in via the cable and upstream traffic goes out over a phone line. A further limitation is that the cable infrastructure splits the bandwidth such that the greater the number of users directly impacts each users connection speeds, resulting in typical connection speeds of approximately 1 Mbps, which remains significantly faster than other available technologies. Given that TV set density varies from 4.37 per 100 inhabitants in Kyrgyzstan to 59.28 in Latvia, the existence of large numbers of cable television subscribers who would be interested in Internet access is not yet the case in the transition economies. However, the technology is currently offered in Romania, Poland, Lithuania, Hungary, Estonia and Albania.

DSL, or Digital Subscriber Line : This is a technology which permits digital signals to travel across existing analog copper wire phone lines by installing a DSL modem at both ends of the signal. By operating at a higher frequency over the existing phone lines, DSL technology permits the user to maintain a permanent high-speed connection without interfering with traditional phone service. The use of copper wires results in the need for a certain amount of infrastructure investment on the part of ISPs since the speed of the connection diminishes over the distance travelled along the copper wire, thus requiring intermittent DSL modems to boost along the signal. DSL technology permits speeds from 1.5 Mbps, and recent technological modifications (VHDSL – Very High-data-rate DSL) propose potential speeds of 52 Mbps of downstream traffic over existing copper wires. Although DSL technology is being heralded as the emerging broadband access standard, it has only recently begun to be employed to any significant degree in certain regions of North America, and remains relatively unknown in Western Europe. At present, only Estonia, the former Yugoslav Republic of Macedonia, Poland and Romania claim to offer DSL as a method of Internet connectivity.

WAN, or Wide Area Networks : These networks often involve fibre optic technology and are based on X.25, ATM (Asynchronous Transfer Mode) or Frame-relay protocols. An ISP that offers WAN technological solutions requires an advanced degree of expertise and access to sophisticated resources in order to meet the needs of the corporate and institutional clients requiring such services. However, given the current widespread presence of first-tier ISPs, or international backbone providers, in the majority of the countries under study, the technologies to deploy ATM or X.25 data networks are widely available. These networks can form the basis of an IP network, such as a second-tier ISP, or can provide business to business data transmission, such as banking networks, or other financial institutions, or information services such as Reuters. The only countries where no advertisements for corporate network solutions were found are Albania, Azerbaijan, Belarus and Croatia.

81. Overall, there is a surprisingly varied degree of Internet connectivity services offered in each country. Basic dial-up services and leased lines are by far the most common, and as digitalization of the existing PSTN increases, DSL technology should quickly emerge as the next generation broadband connection standard. ISDN lines are widely used but their speed limitations and costs relative to DSL technology will probably mean that the technology will be abandoned over the medium to long term. It remains to be seen whether cable TV providers will make any inroads into the various regions given the high costs of deploying cable networks and the low level of TV density in many of these countries. Wireless networks seems to be the technology that has been most effectively employed by the various transition economies and will probably enable many countries to establish WANs and regional backbones until such time as local fibre optic loops become available.

Pricing

82. The survey of ISP pricing was based upon basic dial-up service, i.e. speeds of up to 33.6 Kbps over analog phone lines. The price does not include the initial registration or installation fees, VAT taxes, or the cost of local metered telephone calls, where applicable. The price listed for 20 hours of service was based on the lowest available price calculated from either a base price plus an hourly charge or a pre-given rate for 20 hours of service during daytime hours in each country. The price for unlimited service is based on the lowest available offer for unlimited monthly service; N/A indicates that no unlimited offer was available in the country.

83. The price for 20 hours of service ranges from 6.5 USD from Estonia's Mainor Ainet ISP (http://www.anet.ee/) to 57 USD per month from Elcat (http://www.elcat.kg/) in Kyrgyzstan. The price for unlimited monthly service ranged from 8 USD from Estonia's Uninet (http://web.uninet.ee/english.html) to 200 USD at Azerbaijan's AzerIn ISP http://www.azerin.com/). At this point in time, the 'free to air' model of Internet pricing which is currently becoming widespread in Western Europe and North America has made few inroads into the transition economies. However, as the average price continues to drop in each country, the level of difference between the pricing for 20 hours of service and the price for unlimited monthly service continues to decrease, making the unlimited monthly packages more and more appealing to consumers.

84. The data resulted from a survey of all the websites of the major ISPs that were located within each country, therefore, the lowest available price was the best available offer found from online sources by at least one ISP in the country at the time of the survey.

Country	**ISP with lowest price for 20 hours**	**Price for Dial-up 20 hours**	**ISP with lowest price Unlimited**	**Price for Dial-up Unlimited**
Albania	http://www.icc-al.org/	25 USD	http://www.abissnet.com.al	32 USD
Armenia	http://www.web.am/	20 USD	http://www.amilink.net/index-e.htm	50 USD
Azerbaijan	http://www.bak.net.az/	20	http://www.azerin.com/	200
Belarus	-	N/A	-	N/A
Bosnia and Herzegovina	N/A	N/A	N/A	N/A
Bulgaria	http://www.otel.net/index-en.html	10	http://www.bol.bg/	15

Country	**ISP with lowest price for 20 hours**	**Price for Dial-up 20 hours**	**ISP with lowest price Unlimited**	**Price for Dial-up Unlimited**
Croatia	http://www.iskon.hr/	7.92 USD (60 HRK)	http://www.hinet.hr/english/services/index.html	13 USD (99 HRK)
Czech Republic	-	N/A	http://www.iol.cz/iolangl/index.html	13.7 (489 CZK)
Estonia	http://www.anet.ee/	6.5 USD (100 EEK)	http://web.uninet.ee/english.html	8.1 USD (125 EEK)
Georgia	http://www.caucasus.net	12 USD	-	N/A
Hungary	http://www.dravanet.hu/0elofizet/elofizet_e.html	9.75 USD (2500 HUF)	http://www.dravanet.hu/0elofizet/elofizet_e.html	15.6 USD (4000 HUF)
Kazakhstan	-	N/A	-	N/A
Kyrgyzstan	http://www.elcat.kg/	57 USD	-	N/A
Latvia	http://www.junik.com/en/index.sql	25.7 USD (15 LVL)	http://www.vernet.lv/	40 USD (21 LVL)
Lithuania	http://www.5ci.net	10 USD (40 LTL)	http://www.aiva.lt/en/we_offer.html	24 USD (95 LTL)
Moldova (Republic of)	http://www.riscom.md/index.html	25 USD	http://www.moldpac.md/en-index.shtml	10 USD
Poland	http://www.bch.com.pl/txt/gb/services/prices.html	7 USD (30 PLZ)	http://www.medianet.pl/	10 USD (40 PLZ)
Romania	http://www.rnc.ro/new/welcome.shtml	9 USD	http://www.rnc.ro/new/welcome.shtml	20 USD
The former Yugoslav Republic of Macedonia	http://www.medismk.net/english/index_a.htm	15 USD	http://www.medismk.net/english/index_a.htm	65 USD 200 hours

Note: (-) denotes non-identified. currency exchange calculated based upon rates of Monday, December 13, 1999, otherwise prices were originally provided in US Dollars. Statistics for Bosnia and Herzegovina are not available. See appendix for a directory of ISPs including service information (in TRADE/2000/18/Add.1).

85. In the Caucasus, the price for 20 hours of Internet connection is only 12 USD in Georgia but 20 USD in both Armenia and Azerbaijan. The 200 USD per month for unlimited monthly service in Azerbaijan remains the highest reported price in all of the transition economies. Pricing information for most of the Central Asian CIS and Black Sea Region was not yet available, however, the Republic of Moldova's National Informatics Center, a government sponsored ISP, offers one of the lowest available prices for unlimited monthly service at 10 USD. In the Baltics, Estonia offers the lowest overall price for both 20 hour and unlimited monthly connection packages, Lithuania at 10 USD and 24 USD respectively falls in the middle range and Latvia is at the upper end of the scale with 25.7 USD and 40 USD for 20 hour and unlimited monthly connection fees.

IV. LEVEL OF COMPETITION IN TELECOMMUNICATION SERVICES

Introduction

85. There is an evident increase in the levels of competition throughout the newer telecommunications services in European and CIS regions. The traditional telephone services such as local, long distance, and international services remain primarily controlled by monopolies. However, with the transition to market economies most of the countries are seeing an increase in competition in the more innovative communication markets. With the growing popularity of digital cellular phones, paging devices, and Internet Service Providers, newer companies are

discovering profitable opportunities in the consumers market for these products. By looking at the table of European and CIS levels of competition, one can see the obvious trend towards competition spreading across the table to the newer communication services. However, countries like Bosnia and Herzegovina, Tajikistan, and the former Yugoslav Republic of Macedonia still have telecommunications markets with monopolistic and duopolistic competition.

Central Asian CIS (Tajikistan, Kazakhstan, Kyrgyzstan, Turkmenistan, Uzbekistan)

86. This region has a wide range of competition levels spanning from the monopolistic markets of Tajikistan to the competitive service arena of Kazakhstan. Uzbekistan and Turkmenistan also have communication industries that are, for the most part, controlled by monopolies and duopolies. However, in addition to Kazakhstan, Kyrgyzstan also has relatively competitive markets throughout its industry with the exception of monopolistic competition in its long distance and international calling services.

Caucasus (Armenia, Azerbaijan, Georgia)

87. The nations of this region share similar levels of competition across the communication service sectors. Monopolies and duopolies control most of the telecommunication services in Armenia, Azerbaijan, and Georgia. By analysing the table it is evident that larger companies have taken over the markets in the local, long distance, and international calling services as well as in the mobile and fixed satellite industries. However, competitive markets exist in the cellular phone, paging, cable television, and ISP service areas. These newer services have attracted more companies because the market is so new that the larger, monopolistic companies have not had time to form economies of scales in order to capture the entire market.

Black Sea and Russia (Belarus, Republic of Moldova, Russia, Ukraine)

88. In this region there seems to be monopoly and duopoly domination in most of the local, long distance, and international phone markets. However, like most of the other regions in the study, there is strong competition in the digital cellular phone, paging, and cable markets. By contrast, Russia’s local, long distance, and international phone markets are dominated by duopolistic competition.

Eastern Europe (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, the former Yugoslav Republic of Macedonia, Romania, Yugoslavia)

89. The majority of Eastern Europe is categorized as having monopolistic competition in its local, long distance and international phone services. There is competition, however, in the cellular phone, cable, and ISP markets. The former Yugoslav Republic of Macedonia has the least amount of competition in its telecommunication markets. Yugoslavia is the exception in Eastern Europe, as it boasts of competition in all services aside from the fixed satellite industry in which there is a monopoly.

Central Europe (Czech Republic, Hungary, Poland, Slovakia, Slovenia)

90. This region, for the most part, has one or two companies controlling the local, long distance, international and some cellular phone markets. There are high levels of competition in most of the paging and cable service sectors and the ISP market. The Czech Republic, Slovenia and Slovakia all have monopolistic competition in the analog cellular phone industry, but duopolistic competition in the digital cellular phone markets.

Baltics (Estonia, Latvia, Lithuania)

91. In this subregion, similar trends of monopolistic and duopolistic competition surface in the local, long distance, international, and analog cellular phone markets. The remainder of the market is completely competitive in Estonia and Lithuania. However, Latvia still has less competitive markets in the digital cellular phone and leased lines industries, where monopolies and duopolies control the market.

Competition in Telecommunications Services: Local, Long Distance, International Call, and Analog Cellular Services

	Local Services	Long Distance Services	International Call Services	Analog Cellular
Albania	M	M	M	-
Armenia	M	M	M	-
Azerbaijan	M	M	M	C
Belarus	C	M	M	M
Bosnia and Herzegovina	M	M	M	M
Bulgaria	M	M	M	C
Croatia	M	M	M	C
Czech Republic	C	M	M	M
Estonia	D	M	M	M
Georgia	M	D	D	D
Hungary	M	M	M	M
Kazakhstan	C	C	C	C
Kyrgyztan	C	M	M	M
Latvia	M	M	D	M
Lithuania	M	M	M	C
Republic of Moldova	M	M	M	-
Poland	D	M	M	C
Romania	M	M	M	M
Russian Federation	D	D	D	C
Slovakia	M	M	M	M
Slovenia	M	M	M	M
Tajikistan	M	M	M	C
The former Yugoslav Republic of Macedonia	M	M	M	-
Turkmenistan	C	M	M	C
Ukraine	D	M	C	C
Uzbekistan	D	D	D	C
Yugoslavia	C	C	C	C

Key: M= Monopoly; D= Duopoly; C= Competition;
- = data not-available. This table reflects what is legally permissible; therefore it may not reflect the actual number of operation in the market.
(Source: ITU World telecommunication Regulatory Database, 1999)

Competition in Telecommunications Services: Digital Cellular, Leased Lines, Data, Paging, Mobile and Fixed Satellite, Cable TV, GMPCS and ISP Services

	Digital Cellular	Leased Lines	Data	Paging	Mobile Satellite	Fixed Satellite	Cable TV	GMPCS	ISP
Albania	M	C	C	C	C	C	C	C	C
Armenia	M	C	C	M	M	M	C	M	C
Azerbaijan	C	M	C	C	M	M	C	M	C
Belarus	C	M	C	C	C	C	C	-	-
Bosnia and Herzegovina	M	M	M	M	M	M	M	-	-
Bulgaria	C	M	C	C	-	-	C	-	C
Croatia	C	M	C	C	C	M	C	-	C
Czech Republic	D	C	C	D	C	C	C	-	C
Estonia	C	C	C	C	C	C	C	C	C
Georgia	C	M	D	C	D	D	C	-	-
Hungary	D	C	C	D	C	C	C	-	C
Kazakhstan	D	C	C	C	-	C	C	C	-
Kyrgyztan	C	M	C	C	C	-	C	C	C
Latvia	D	M	C	C	C	C	C	-	C
Lithuania	C	C	C	C	C	C	C	-	-
The Republic of Moldova	C	M	C	C	-	-	C	-	C
Poland	C	C	C	C	-	M	C	-	C
Romania	C	M	C	C	-	-	C	-	C
Russian Federation.	C	M	C	C	D	D	C	-	-
Slovakia	D	C	C	C	C	C	C	C	C
Slovenia	D	C	C	C	-	-	C	-	C
Tajikistan	-	M	D	D	D	D	D	-	-
The former Yugoslav Republic of Macedonia	M	M	C	-	-	M	-	-	C
Turkmenistan	C	D	M	D	D	D	-	-	-
Ukraine	C	M	C	C	C	C	C	-	-
Uzbekistan	C	D	D	C	D	D	C	-	-
Yugoslavia	C	C	C	C	-	M	C	-	-

Key: M= Monopoly; D= Duopoly; C= Competition; - = data not-available. This table reflects what is legally permissible; therefore it may not reflect the actual number of operators in the market.
(Source: ITU World telecommunication Regulatory Database, 1999)

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