The Diffusion of the Internet

in Mexico

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Executive Summary

The Internet in Mexico has developed in four distinct phases. These phases are the introductory phase, the developmental phase, the duopoly phase and the competitive phase. Each phase has unique characteristics and has presented Mexico with unique challenges.

During the introductory phase, the first Internet connections were established and the regional backbones were created. This phase lasted from 1989 through 1993. Growth of the Internet during this period was spurred primarily by academia. The Monterrey campus of El Instituto Tecnologico y de Estudios Superiores de Monterrey (ITESM) established the first direct connection to the Internet in 1989. In the following years, regional networks were established which connected the nations' major universities. At this time, no national backbone existed, so the regional networks could not share information and many services were duplicated.

The developmental phase was lead by the combined efforts of government and academia. This phase lasted through 1994 and 1995. In 1994, the Mexico's government agreed to finance the development of the first national backbone. This backbone linked the regional academic networks and provided direct connections to the United States.

The duopoly phase was sparked by the need to develop commercial applications for the Internet. The efforts of industry, academia and government were needed during this phase. The RTN, or the National Technology Network, was established. This organization marketed the academic backbone for commercial applications. Mexico's telephone company, Telmex, began marketing backbone provider and ISP services. Telmex quickly dominated the industry. This phase lasted from 1996 through 1998.

The competitive phase was brought about by the desire for increased market efficiencies. The primary drivers of this phase were market demand, industry and governmental deregulation. This phase began in 1999. Mexico is still in this phase. The first step towards this phase occurred in January 1997 when Telmex lost legal protection of its monopoly position as a telephone company and its duopoly position with RTN as Internet providers.

Although legal barriers to competition were removed, several factors impeded the development of competition in Mexico. The most significant of these was established infrastructure. Both Telmex and the RTN had national backbones. Any potential competitor had to develop their own infrastructure before being able to compete. Still, with the help of foreign investment, competing backbones developed quickly. By 1999, Alestra and Avantel had established themselves as strong competitors in the larger markets and smaller competitors were beginning to enter the market.

The amount of bandwidth offered in Mexico has grown tremendously during the competitive phase. Cost of access has gone down while the quality of service has increased. Mexico is now well established as one of the industry leaders in Latin America.

Although competition during this phase has provided Mexico with many benefits, it has also created challenges. The largest of which is balancing the need for competitive efficiencies with the desire to provide services for a larger segment of the population. Before the competitive phase, Telmex had a mandate to increase the level of service in poorer, rural areas of the nation. Services provided to these areas were provided at low profit levels or at a loss. Services in these areas were subsidized by the more profitable services offered in the larger, urban markets. The advent of competition has reduced prices in the larger markets, but eliminated Telmex' ability to use profits from these markets to provide services in smaller, less profitable markets.

The government of Mexico has addressed this challenge by developing the e-Mexico project. The e-Mexico project is a $400 million project designed to provide Internet access to all of Mexico's population. Both government and industry contribute to the project. This six-year project was announced in 2001. Whether this project will successfully reach its goals has yet to be determined.

Methodology

An analytical framework that is used by the Mosaic Group for the Global Diffusion of the Internet (GDI)[1] is used in this paper. This framework has been used to analyze Internet diffusion in more than 30 nations. Using the framework, the state of Internet diffusion is analyzed in terms of six variables, or dimensions. These dimensions are pervasiveness, geographic dispersion, sectoral absorption, connectivity infrastructure, organizational infrastructure and sophistication of use.

More information on the framework used can be found in the following article, "A Framework for Assessing the Global Diffusion of the Internet." This article was published in the Journal of the Association for Information Systems in November 2001[2]. A copy of this article is published on the Mosaic Group's website at:

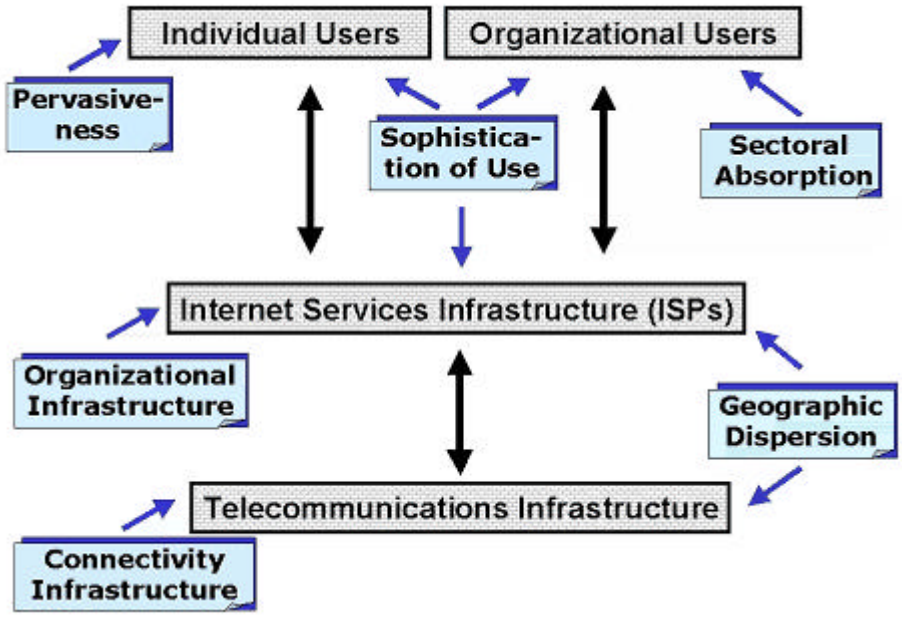
http://mosaic.unomaha.edu/2001_GDI_Framework.htm

The manner in which the Internet becomes diffused in a nation is quite complex. Other methods for analysis often have been limited to a single measurement variable, such as the number of hosts or the number of users in a nation. Although information derived from the use of a single variable can be useful, such information does not describe the intricate complexities of Internet diffusion within a nation. By using six dimensions, the GDI framework provides a tool for analysis that allows for greater depth.

Each dimension in the framework effects the other dimensions. Also, each dimension has differing effects of individual users, organizational users, Internet service providers (ISPs) and the infrastructure of telecommunications. This interrelationship can be thought of as the Internet technology cluster. The article on the GDI framework noted above provided a model for the

Internet technology cluster and shows how the dimensions interrelate. This model is reproduced in Figure 1.

Figure 1. Constituents of the Internet Technology Cluster



The model has three levels. The top level involves the capability and desire of users and potential users to access the Internet and to access and use related technologies. This level involves three dimensions, pervasiveness, sectoral absorption, and sophistication of use. Pervasiveness is the overall number of Internet users within a nation as a percentage of the population. Sectoral absorption considers the differences between the rates of adoption of the Internet within different segments of the population. Sophistication of use considers how complex the usage of the Internet is within a nation.

The middle level concerns how Internet access is provided. Three dimensions influence this level, organizational infrastructure, sophistication of use and geographic dispersion. Organizational infrastructure involves the number, sophistication and competitiveness of ISPs.

Geographic dispersion concerns how ISPs, as well as the telecommunications infrastructure, is geographically distributed within a nation.

The bottom level involves national telecommunications infrastructure. Without infrastructure, no Internet activity can occur. This level involves two dimensions, geographic dispersion and connectivity infrastructure. Connectivity infrastructure concerns the underlying network infrastructure of a nation.

The GDI framework provides standards for measuring dimensions of Internet diffusion. These standards are subject to revision as the Internet continues to develop, but will be considered current for the purposes of this discussion. These standards for measurement are given and discussed for each dimension in the section on that dimension. The change in each dimension is analyzed historically over time. Finally, the changes in all dimensions over time are summarized through the use of Kiviat diagrams.

The GDI framework prefers to use whole number estimates of each measurement criterion in order not to overstate the precision of measurement. This convention is used most commonly in this paper, but exceptions to this have been made. When the estimate lies exactly half way between two measures, a middle value is chosen. Also, when the difference between the measures has changed significantly between two time periods, but measurement in integers does not reflect this change, decimals are used. Unless otherwise specified, rankings for a year are end of year estimates.

According to the GDI framework, dimensions are effected by other factors. These factors are called determinates. Determinates can be thought of as the proximate causes of the states of dimensions.

Pervasiveness

Mexico is currently one of the leading nations in Internet connectivity in Latin America. To say that recent growth of the Internet in the whole of Latin America has been tremendous would be an understatement. According to TeleGeography, Latin America's international Internet bandwidth grew by 479.2% between 2000 and 2001. International Internet bandwidth for the region grew to 16,132.5 Mbps in 2001.[3]

Internet connectivity in Mexico in recent years is a good example of this growth. According to a study published by Cofetel, Mexico's regulatory body for the telecommunication's industry, the number of Internet users in Mexico grew from 39,000 in 1994 to 3,636,000 in 2001.[4] This study was conducted by Mexico's General Directorship of Rates and Corporate Statistics and uses information from Select-IDC's database.

This study breaks down Internet usage by year as well as by population segment. The table below provides the data on overall users for 1994 through 2001 from this study. Data for different population segments will be discussed in the section on sectoral absorption. Population figures for Mexico provided in Table 1, which follows, are either taken directly or derived from a report by Mexico's National Institute of Statistics, Geography and Computer Science (INEGI) titled Mexico's Population, By State, 1895-2000.[5]

This report provides population figures for 1990, 1995 and 2000. Figures for 1995 and 2000 are taken directly from this report. Population for 1994 is estimated based upon the average growth rate between 1990 and 1995. Populations for 1996 through 1999 and for 2001 are estimated based upon an average growth rate of 1.58%, which was the average growth rate for 1995 through 2000. Different methods were used to estimate populations because another INEGI

report stated that the average population growth rate in Mexico had decreased substantially between the periods of 1990-1995 and 1995-2000. According to the report, the average population growth rate for 1990-1995 was 2.1%. The growth rate of 1.58% for 1995-2000 is significantly lower.[6]

The percent of the population using the Internet and the percent change in Internet usage over the prior year are calculated by combining the data from both the Cofetel and the INEGI reports.

Table 1 provides data on the number of Internet users in Mexico per year from 1994 through 2001, the percent of the population using the Internet for those years, the estimated population for each of those years and the percentage change over prior years during the time frame. Figures 2, 3 and 4 which following Table 1 display the information in Table 1 in a graphical format.

Table 1. Estimated Internet Users in Mexico
(All population and number of user figures are in thousands)

Year	1994	1995	1996	1997	1998	1999	2000	2001
Percent of Population Using the Internet	0.044%	0.103%	0.202%	0.634%	1.279%	1.877%	2.782%	3.672%
Estimated Number of Users	39	94	187	596	1222	1822	2712	3636
Percent Change in Internet Usage Over Prior Year	N/A	141%	99%	219%	105%	49%	49%	34%
Estimated Population	89,177	91,158	92,599	94,062	95,548	97,057	97,483	99,024

Figure 2. Internet Users in Mexico

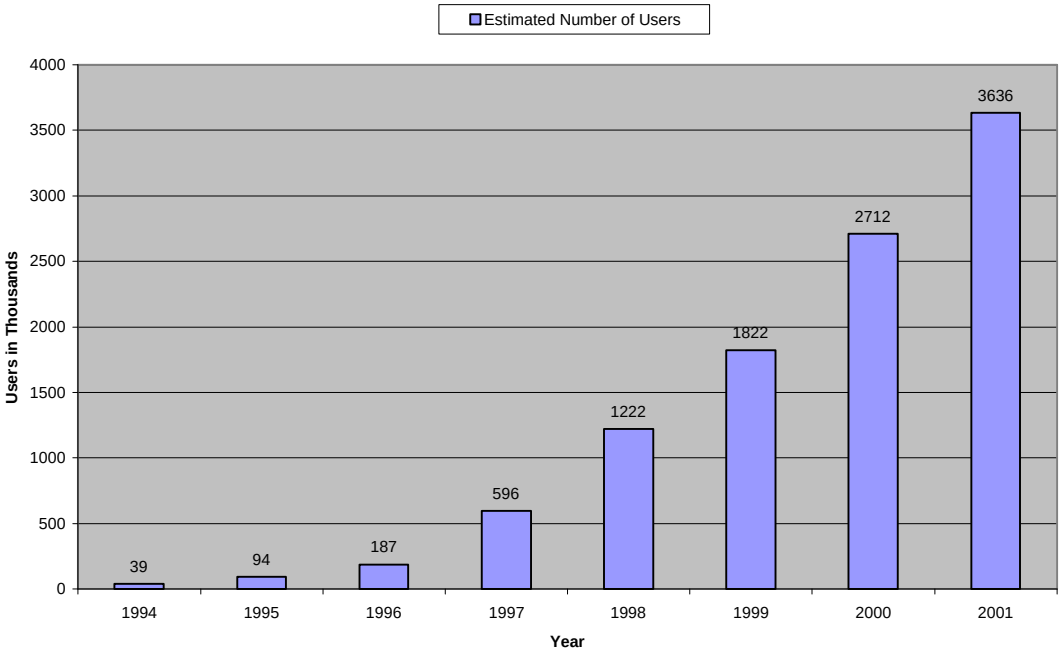


Figure 3. Percent Using The Internet

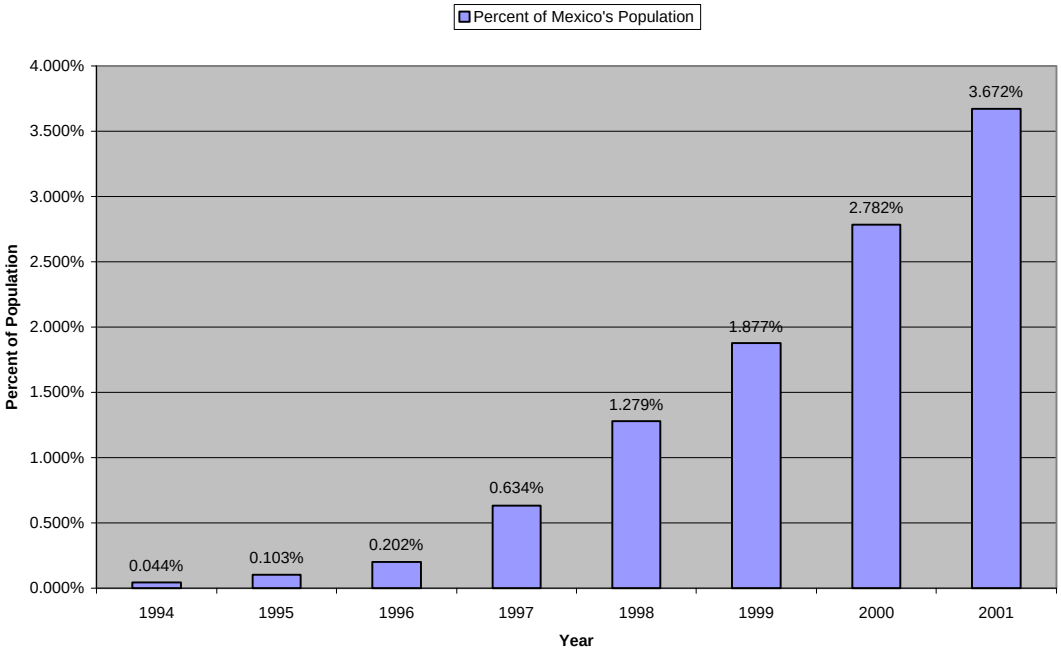
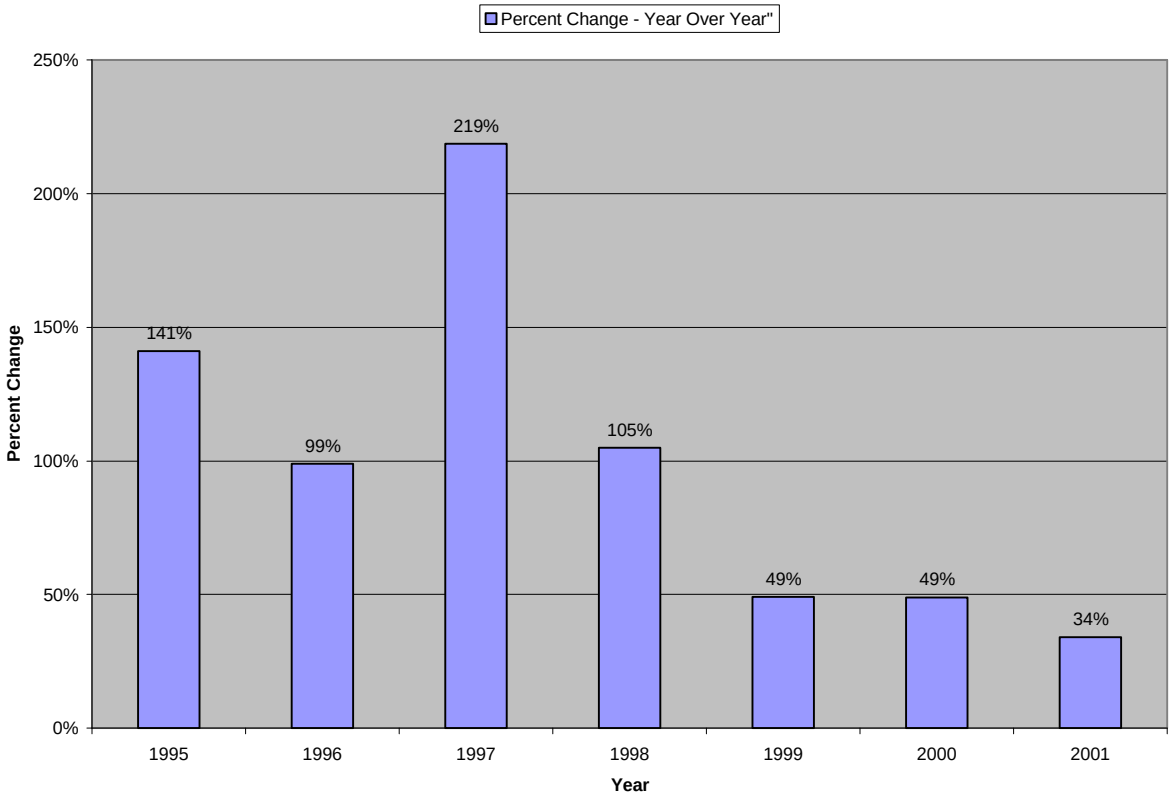


Figure 4. Percentage Growth Over Prior Year



The growth of Internet pervasiveness in Mexico has been rapid and consistent for the past several years. There have been no years of slow, flat or declining growth. For every year surveyed, except for 1999, the increase in the number of Internet users has increased by more than the increase for the prior year. Even for 1999, the number of users grew by 600,000, which is quite close to the growth of 626,000 for 1998.

Although percentage growth year over year is increasing at a decreasing rate, as time progressed, the base of users has increased. The number of actual users is still increasing at an increasing rate, with the exception of 1999. Although growth for 2001 over the prior year was only 34 percent, this represented an increase in the total number of users of over 900,000. By comparison, the peak year for percentage growth, year over year, was 1997, with a growth rate of

219 percent over the prior year. Although this was a much higher percentage growth rate than in 2001, the increase in the number of users of 409,000 was substantially lower than in 2001.

At the end of 2001, 3.672 percent of Mexico's population were Internet users. According to the GDI framework, this gives Mexico a third level ranking for pervasiveness. This ranking ranges from 1 percent to 10 percent Internet usage per capita. Even with Mexico's tremendous Internet growth rate, increasing Internet usage to the fourth ranking level is likely to take several years. Table 2 provides a description of each ranking level in the GDI scale on pervasiveness and shows Mexico's ranking in early 2002.

Table 2. Ranking Internet Pervasiveness in Mexico – Early 2002

Level 0	**Non-existent:** The Internet does not exist in a viable form in this country. No computers with international IP connections are located with the country. There may be some Internet users in the country; however, they obtain a connection via an international telephone call to a foreign ISP.
Level 1	**Embryonic:** The ratio of users per capita is on the order of magnitude of less than one in a thousand (less than 0.1%).
Level 2	**Nascent:** The ratio of Internet users per capita is on the order of magnitude of at least one in a thousand (0.1% or greater).
Level 3	**Established:** The ratio of Internet users per capita is on the order of magnitude of at least one in a hundred (1% or greater).
Level 4	**Common:** The ratio of Internet users per capita is on the order of magnitude of at least one in 10 (10% or greater).

The GDI framework uses a logarithmic scale for evaluating the pervasiveness of the Internet within nations. This scale allows for more detailed analysis of the early stages of Internet adoption within a nation. Table 3 provides rankings for Internet pervasiveness in Mexico by year including the years of the development of the Internet in Mexico. Most of the rankings are derived from the information provided in this section. For years before 1994, Internet usage is assumed not to have decreased year over year. The first direct Internet connection in Mexico was

established in 1989.[7] Consequently, the rankings for 1989 through 1994 are at level one and the rankings for years before 1989 are at level zero.

Table 3. Internet Pervasiveness Rankings For Mexico Over Time

Year	**Before 1989**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Ranking	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**2**
Year	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002 (Projected)**	
Ranking	**2**	**2**	**3**	**3**	**3**	**3**	**3**	

Growth throughout Latin America has occurred in spite of several impeding factors. These include limited phone lines, low ownership of personal computers per capita and low per capita income.[8] These impeding factors have been offset by several factors that encourage growth. Such factors include increased demand for Internet services throughout the region, reduced costs for technological products and services, increased quality and bandwidth of Internet connection services, deregulation of the telecommunications industry and the infusion of foreign investment capital. All of these factors have influenced the development of the Internet in Mexico.

Sectoral Absorption

Internet usage has been increasing rapidly in all major population segments. The same study used in the pervasiveness section, Estimated Internet Users in Mexico, provides a great deal of information on sectoral absorption.[9] The study provides estimated numbers of users by segment over time. Segments include business, home, education and government. Table 4 summarizes the data from the study. Figure 6 shows the number of users in each segment in 2001 side by side. Figures 7 through 10 show the number of users per segment per year.

Table 4. Estimated Internet Users in Mexico by Segment
(All population and number of user figures are in thousands)

	Year							
Segment	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Business	16	47	84	299	740	1,010	1,177	1,608
Home	4	10	29	141	297	478	1,066	1,390
Education	17	33	69	142	154	166	276	354
Government	2	3	5	14	31	167	193	284

Figure 6. Internet Users by Segment - 2001

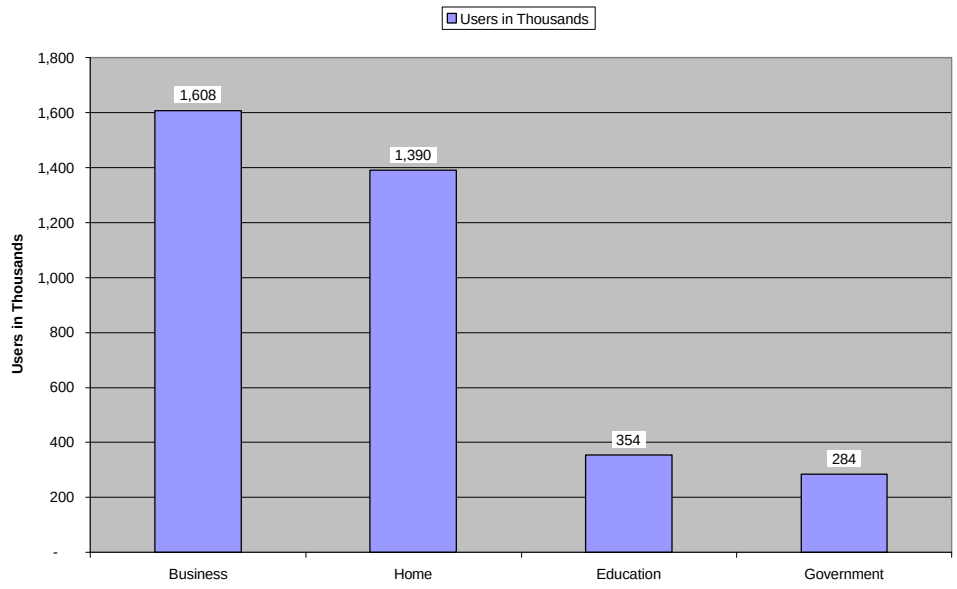


Figure 7. Business Internet Users in Mexico

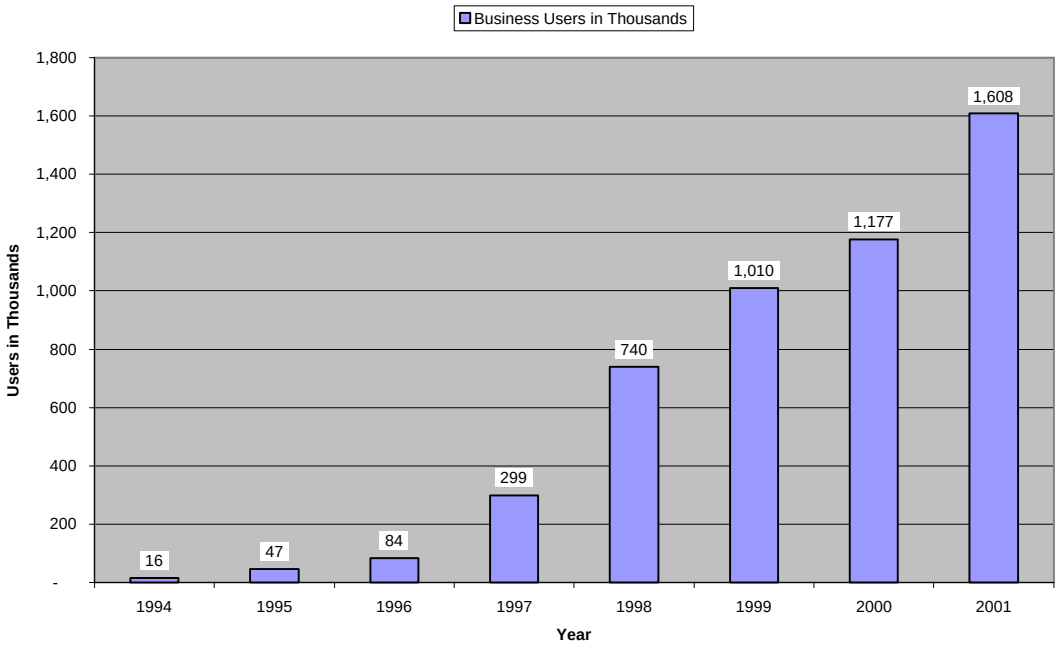


Figure 8. Home Internet Users in Mexico

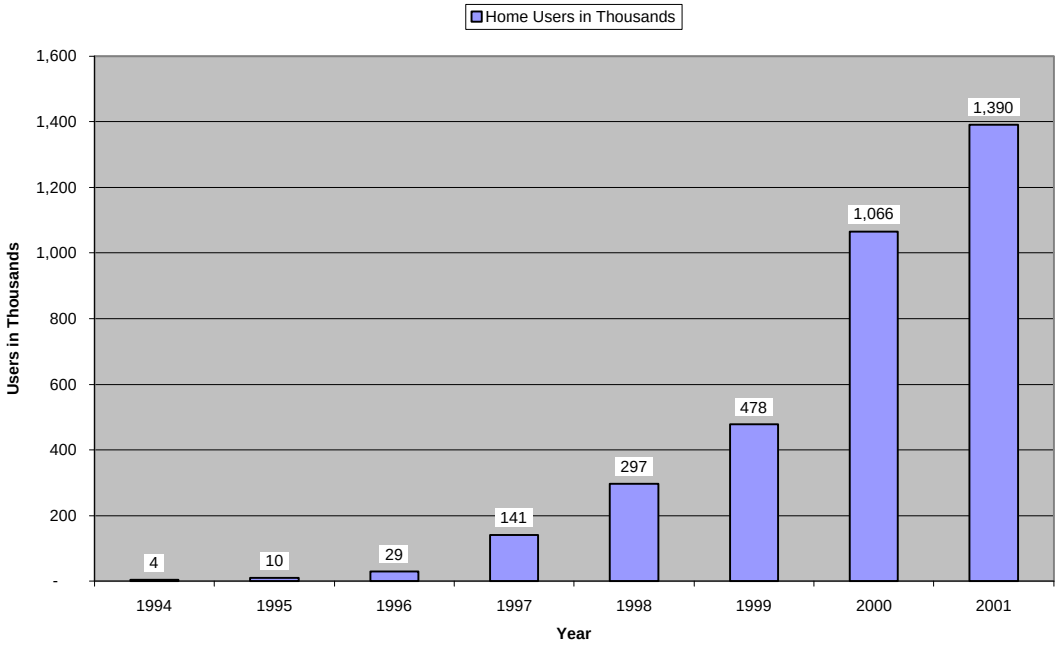


Figure 9. Education Internet Users in Mexico

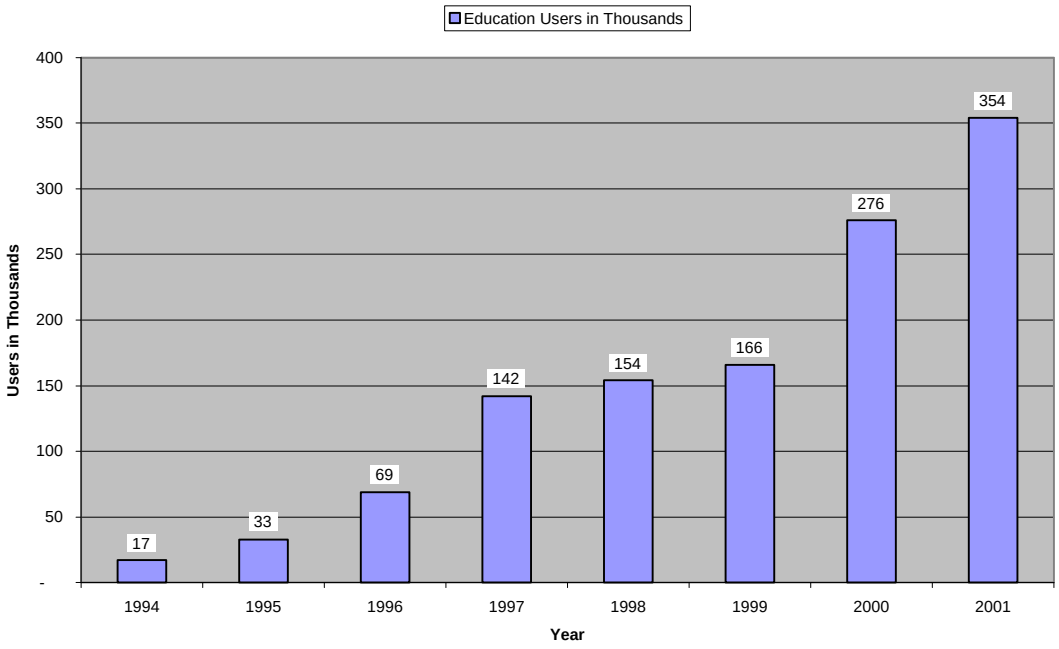
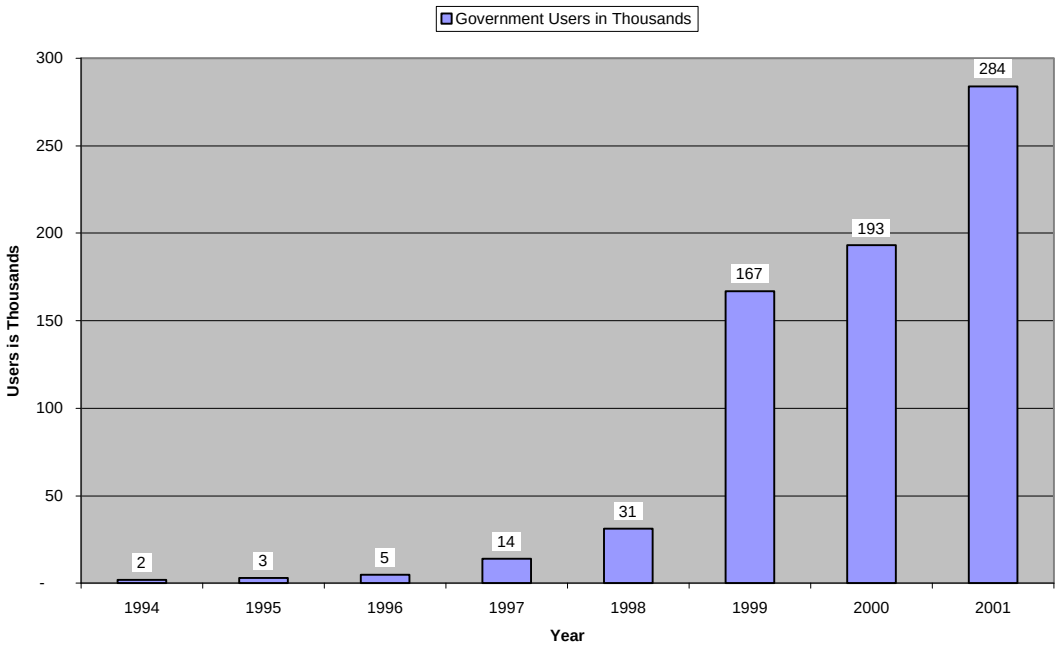


Figure 10. Government Internet Users in Mexico



Although growth in all segments has been dramatic, segments have grown at differing rates at different times. Correspondingly, at different times, the needs of different segments have sparked overall growth.

Before 1995, education drove growth. This segment had the largest number of users until 1995. Internet availability and use at this time was centered in Mexico's university system. Mexico's universities developed extensive regional networks. Universities were highly instrumental in the development of Mexico's first national backbone, which connected their regional networks.

The development of the first national backbone enabled the development and use of commercial Internet applications. Since 1995, the business segment has had the largest number of Internet users. The number of business users grew by over 1000 percent between 1996 and 1999 at a time when competition between IP providers was developing.

Home use in the early years was limited. The number of home users did not reach one percent of the population until 2000. Home use has been growing tremendously in recent years, though. The number of home users is now approaching the number of business users.

Governmental use of the Internet also started slowly. Extensive use of the Internet by government began in 1999. The number of governmental Internet users increased by over 500 percent in that year alone.

Tying the information from the Estimated Internet Users in Mexico (Cofetel) study to the GDI framework is more difficult for sectoral absorption than for pervasiveness. Cofetel's education, business and government categories correspond well to GDI's academic, commercial and public sectors. The Cofetel study has data on home usage, but this is not a GDI sector for analysis. The GDI framework requires analysis of the health sector and the Cofetel study

provides no data on this sector. Also, INEGI studies do not provide definitive figures for underlying sector populations. Consequently, estimated rankings for sectoral analysis are less precise that for pervasiveness.

Table 5 provides the GDI framework criteria for each sector and rankings are given for each sector for early 2002. The GDI framework establishes sectoral absorption rankings based upon leased line connectivity and percentage of Internet servers per sector. The Cofetel study provides users per sector. Although these are quite different statistics, both indicate access and usage within sectors. Consequently, leased line connectivity and the percentage of Internet servers are assumed to correspond to and rankings are approximated from the number of users per sector.

Although academia was one of the drivers of the development of the Internet in Mexico and Internet use is well-entrenched in Mexico's university system, the GDI criterion for academia also includes Internet usage in secondary education. The use of the Internet is not nearly as extensive in secondary schools as it is in universities in Mexico. Health sector rankings are assumed to correspond to commercial rankings. Although federal government use of the Internet is widespread, Internet usage by state and local governments is less common and less sophisticated.

Table 5. Ranking Sectoral Absorption for Mexico by Sector – Early 2002

Sector	Minimal	Medium	Great Majority
Academic	<10% have leased-line Internet connectivity	10-90% have leased-line Internet connectivity	>90% have leased-line Internet connectivity
Commercial	<10% have Internet servers	10-90% have Internet servers	>90% have Internet servers
Health	<10% have leased-line Internet connectivity	10-90% have leased-line Internet connectivity	>90% have leased-line Internet connectivity
Public	<10% have Internet servers	10-90% have Internet servers	>90% have Internet servers

Table 6 provides the GDI criteria for developing an overall sectoral absorption ranking and provides a ranking for early 2002. Under the GDI framework, sectors with a minimal rating receive one point, with a medium rating receive two points and with a great majority rating receive three points.

Table 6. Overall Sectoral Absorption Ranking for Mexico – Early 2002

Sectoral Point Total	Level	Absorption Dimension Ranking
0	0	Nonexistent
1-3	1	Rare
4-6	2	Moderate
7-9	3	Common
10-12	4	Widely Used

Table 7 provides overall sectoral rankings for Mexico over time. Sectoral absorption could not exist before the creation of the first direct link, so the overall ranking was nonexistent. Use outside of academia was rare until the development of the first national backbone, so the ranking for 1989 through 1994 was rare. With the development of the national backbone, sectoral absorption could progress to common in 1995 and 1996. With the advent of competition and its corresponding benefits, overall sectoral absorption increase to the ranking of common in 1997 and have remained in this range through early 2002. Although usage has increased dramatically between 1997 and 2002, Mexico is not likely to reach the fourth level, widespread use across sectors in the next few years.

Table 7. Overall Sectoral Absorption Rankings for Mexico Over Time

Year Range	**Sectoral Point Total**	**Level**	**Absorption Dimension Ranking**
Before 1989	0	0	Nonexistent
1989-1994	1-3	1	Rare
1995-1996	4-6	2	Moderate
1997-2002	7-9	3	Common
	10-12	4	Widely Used

Connectivity Infrastructure

Mexico's Current Connectivity Infrastructure

The Mosaic Group for the Global Diffusion of the Internet project analyzes Internet connectivity infrastructure in nations using four criteria: the domestic backbone, international links, Internet exchanges and access methods. Current results for Mexico follow.

Table 8. Ranking Connectivity Infrastructure for Mexico's Internet Early 2002

Level	Domestic Backbone	International Links	Internet Exchanges	Access Methods
0: Nonexistent	None	None	None	None
1: Thin	<3 Mbps	<129 Kbps	None	Modem
2: Expanded	3-200 Mbps	129 Kbps-45 Mbps	1	Modem 64Kbps DDN lines
3: Broad	201 Mbps-100 Gbps	46 Mbps-10 Gbps	More than 1; bilateral or open	Modem >64 Kbps leased lines
4: Extensive	>100 Gbps	>10 Gbps	Many; both bilateral and open	<90% modem >64 Kbps leased lines

The rapid growth of Internet connectivity in Mexico makes the study and analysis of Mexico's current Internet backbones somewhat difficult. Many of the backbones of Mexico have grown substantially during the time in which this paper was being written. This section of this paper describes the state of Internet backbones of Mexico in late 2001 and early 2002. The

growth during this time makes exact identification of the structure of the backbones difficult. Additionally, some companies do not publicly update their current backbone capabilities on a regular basis so some information may be slightly out of date. Other companies think of their backbone infrastructure as being proprietary knowledge and do not want to reveal the details of their backbone infrastructure publicly. For these reasons, some of the results presented are approximate.

Overall Connectivity Ranking

Mexico's Internet connectivity infrastructure is currently ranked at the third level, broad connectivity, overall. On each of the four criteria, as shown in Table 8, Mexico has a third level rank as well. On all of these criteria, Mexico is quite close to moving to the fourth ranking of extensive Internet infrastructure. Mexico currently has many Internet backbones. Each of the large competitors in the market has their own backbone. The largest competitors are Telmex, Avantel and Alestra. Other organizations with backbones include the RTN, Bestel, Axtel, Megacable, Intervan and Protel. Internet2 also has a backbone, but Telmex provides the circuits. Most of these backbones have expanded recently and have further plans for further growth.

Table 9. Mexico's Backbone Providers

Leading Backbone Providers	Telmex, Avantel, Alestra
Other Competitors	The RTN, Bestel, Extel, Megacable, Intervan, Protel

International Links and Domestic Backbones

Mexico's international links are quite extensive. Although the combined links were ranked within the range of 46 Mbps to 10 Gbps, the links either are on the edge of growing to the 10 Gbps level or may have already exceeded this level. Telmex, through Red Uno, has three international connections. Two are STM-1 connections with 155 Mbps bandwidth. The primary connection was an STM-4 connection with 622 Mbps bandwidth. Early in 2002, this connection was being upgraded to an STM-16 connection with 2.5 Gbps bandwidth. Telmex has plans to upgrade this connection further to an STM-64 connection in the near future.[10]

Other competitors are increasing their bandwidth. In December 2001, Avantel's website stated that Avantel had 2 international STM-1 connections.[11] In March 2002, Avantel's site stated that the company had international connections, "at levels of STM-4, STM-1 and DS3."[12]

Most other competitors, such as Alestra, do not publish their backbones' connectivity, but are assumed not to have more capacity than the industry leaders, Telmex or Avantel. Two exceptions, which do publish their infrastructure, are Bestel and the National Technological Network, or RTN. Bestel is a small, growing Internet backbone provider. Their site has a detailed map of their Internet backbone. This map[13] is provided in Appendix 1. The RTN was the first commercial Internet backbone provider in Mexico.

The RTN, which was key in the development of the Internet in Mexico, is not growing. The RTN currently has two international links with only a bandwidth of 2 Mbps each. The combined bandwidth of all of the RTN is only 18 Mbps. Infotec has six E1 links, ITESM – Monterrey Campus has one E1, the University of Sonora has one E1 and the University of Guadalajara also has one E1.[14] A map of the topology of the RTN backbone is included in Appendix 2.[15] Although the RTN was spearheaded initially by academic, as well as

governmental, interests, most large universities use private sector backbone providers due to the RTN's limited bandwidth capacity.

The domestic backbones within Mexico are quite well developed. By GDI criteria, they are broad and are approaching the level of being extensive, if that level has not been reached yet. Almost all competitors offer E1 lines to customers for backbone access. The larger ones offer E3 lines. The infrastructure is developed enough that end user organizations often contract two companies to provide backbone service for redundancy. For example, each campus of ITESM has two providers for their virtual private network. The Hermosillo campus has an E1 line with Telmex as its primary provider. If problems arise with that link, the campus switches to its secondary provider. The campus has an E1 line from Alestra as well.[16] Even though the University of Sonora manages the international E1 line for the RTN, the University also contracts for backbone service with Avantel and Telmex. Similarly, the University of Guadalajara is a participant in the RTN's network and contracts with Alestra for service.[17] Although there is substantial backbone infrastructure in the larger cities, in more rural areas, Telmex is the only provider.

Internet Exchanges

There are Internet exchanges and by law they are open, but they only exist in the three largest cities of the nation, Mexico City, Guadalajara and Monterrey. Consequently, users cannot switch back and forth freely between services. Also, if data needs to be transmitted from one backbone to another, the data must travel through an exchange point in a large city even if the source of the data is near the end point of the data.[18]

Access Methods

Access methods are definitely well developed. This criterion is quickly approaching the extensive level. As stated previously, the use of E1 leased lines is commonplace and E3 lines are available. High-speed access is available to end users through several companies. For example, Megacable provides high-speed cable access and Telmex offers DSL service. Still, not enough information was found to be able to definitively state that more than 10 percent of access was obtained through methods other than modems.

As stated, several of these criteria are expected to reach the fourth level ranking shortly. The domestic backbone and international links will reach this level, if they have not done so already, in the near future. Access methods and Internet exchanges may reach this level, but this is less certain. Following is an estimate of what a connectivity infrastructure table researched early in 2003 is likely to look like. Whereas the overall ranking is currently 3.0, in early 2003 the overall ranking is likely to be 3.5 or higher.

Table 10. Ranking Connectivity Infrastructure for Mexico's Internet – Projected - Early 2003

Level	Domestic Backbone	International Links	Internet Exchanges	Access Methods
0: Nonexistent	None	None	None	None
1: Thin	<3 Mbps	<129 Kbps	None	Modem
2: Expanded	3-200 Mbps	129 Kbps-45 Mbps	1	Modem 64Kbps DDN lines
3: Broad	201 Mbps-100 Gbps	46 Mbps-10 Gbps	More than 1; bilateral or open	Modem >64 Kbps leased lines
4: Extensive	>100 Gbps	>10 Gbps	Many; both bilateral and open	<90% modem >64 Kbps leased lines

The History and Development of Mexico's Initial Backbone

Mexico was among the first nations in Latin America to realize the potential of the Internet. Mexico also realized that in order to take advantage of the Internet, it needed to invest in developing quality connectivity infrastructure. Developing this infrastructure required the combined efforts of industry, government and academia.

Academia was the initial driving force for developing a strong national connectivity infrastructure. This was sparked by the academic resources and interactions that Internet connectivity can provide. The first direct Internet connection was established in February1989 by the Monterrey Campus of El Instituto Technoligico y de Estudios Superiores de Monterrey (ITESM). With a direct connection to the Internet, a system for assigning and registering domain names needed to be established. The Network Information Center – Mexico, NIC – Mexico, was

created to oversee the creation and assignment of domain names. The first domain name ending in .mx, dns.mty.itesm.mx, was assigned.[19]

Following is a connectivity infrastructure table for 1993. The estimated overall connectivity rank was 0.625.

Table 11. Ranking Connectivity Infrastructure for Mexico's Internet 1993

Level	Domestic Backbone	International Links	Internet Exchanges	Access Methods
0: Nonexistent	None	None	None	None
1: Thin	<3 Mbps	<129 Kbps	None	Modem
2: Expanded	3-200 Mbps	129 Kbps-45 Mbps	1	Modem 64Kbps DDN lines
3: Broad	201 Mbps-100 Gbps	46 Mbps-10 Gbps	More than 1; bilateral or open	Modem >64 Kbps leased lines
4: Extensive	>100 Gbps	>10 Gbps	Many; both bilateral and open	<90% modem >64 Kbps leased lines

As worldwide Internet usage grew, the need for an organized, national network soon became apparent. The creation of such a network would be costly, but would provide infrastructure for the nation. In 1994, the Mexican government's National Council for Science and Technology (CONACYT) agreed to finance the nation's first national backbone. The backbone was built with the cooperation of universities located in Mexico's major cities. Through this backbone, Mexico's major universities became part of the first nationwide network in Mexico, MEXNET. A map of the initial topology of backbone of MEXNET is provided in

Appendix 3. The National Technological Network (RTN) was established as the primary Internet access provider for businesses.

This first national backbone initially connected Mexico's four main cities, Mexico City, Guadalajara, Monterrey and Puebla. Additionally, several regional networks were allowed access to the backbone. In all, more than twenty cities were connected.

Prior to the creation of the national backbone, universities within Mexico had grouped together to form five regional networks. These five regions were the northwest region, the northeast region, the western-central region, the southern region and the Mexico City region. Each of these five regional networks had developed independent, network based libraries and other network based resources. The national backbone allowed these different regions to share resources. This reduced both costs and regional variations in access to educational resources.

The backbone replaced a dependence on satellite links with faster fiber optic lines. Mexico's only telephone carrier at the time, Telmex, owned these lines. The linkages were called the Integrated Digital Network or RDI. The connections provided by Telmex increased capacity from 64 kilobits to 2 megabits. The creation of this backbone dramatically increased the speed, quality and stability of the Internet in Mexico.[20] Table 12, which follows, is a connectivity infrastructure table for 1995, shortly after the advent of MEXNET. The estimated over connectivity rank was 1.375.

Following Table 12 is Table 13, which provides Internet connectivity rankings through 2002. Although estimates within the text of this section have been in decimal format in order to be more descriptive, the estimates are rounded to the closest integer in Table 13. This matches the GDI framework format. The estimated ranking for 2002 is a projected end of year ranking. The projected ranking for early 2003 was 3.5 for connectivity. The ranking is likely to be 3.5 or

higher, but it is not likely to be lower than 3.5. For this reason, the ranking was rounded to four instead of to three.

Table 12. Ranking Connectivity Infrastructure for Mexico's Internet 1995

Level	Domestic Backbone	International Links	Internet Exchanges	Access Methods
0: Nonexistent	None	None	None	None
1: Thin	<3 Mbps	<129 Kbps	None	Modem
2: Expanded	3-200 Mbps	129 Kbps-45 Mbps	1	Modem 64Kbps DDN lines
3: Broad	201 Mbps-100 Gbps	46 Mbps-10 Gbps	More than 1; bilateral or open	Modem >64 Kbps leased lines
4: Extensive	>100 Gbps	>10 Gbps	Many; both bilateral and open	<90% modem >64 Kbps leased lines

Table 13. Connectivity Infrastructure Rankings For Mexico Over Time

Year	Before 1989	1989	1990	1991	1992	1993	1994	1995
Ranking	0	1	1	1	1	1	1	1
Year	1996	1997	1998	1999	2000	2001	2002 (Projected)	
Ranking	2	2	3	3	3	3	4	

Deregulation and the Advent of Competition

Trends in the Internet IP provider industry are related to trends in the broader telecommunications industry. In order to understand the trends effecting the Internet in a nation, one must look at the trends in telecommunications. In Mexico, the deregulation and privatization of the telecom industry, particularly the loss of monopoly status for Telmex as a telephone service provider, coincided with Telmex' loss of duopoly status with the RTN as an IP provider.

As in many other nations, Mexico only had one telephone company for most of its history. That telephone company was a publicly held monopoly. Mexico's phone company was privatized and the telecommunications industry has been deregulated, but both of these events are comparatively recent.

Privatization efforts began in during the 1982 debt crisis when Mexico signed a letter of intent with the International Monetary Fund. In this letter, Mexico agreed to reduce its debt by reducing expenditures. Part of the debt reduction plan included divesting certain government owed ventures.

Carlos Salinas, during his presidential campaign in 1988, promised the privatization of Mexico's phone company. In 1990, Telmex was partially privatized. The government sold 44 stock, but retained 56 percent. Of the stock sold, 51 percent was sold to Grupo Corso. The remaining stocks were sold to foreign investors. Southwestern Bell and France Telecom each bought 24.5 percent of the 44 percent sold. This sale generated US$1.67 billion. The government sold additional shares in 1991 and 1992. The total paid for all Telmex stock sold was US$6.2 billion.

Gradual privatization of telephone utilities has occurred in other nations. For example, the United Kingdom began privatizing their telephone company, British Telecom, in 1981 with British Telecommunications Act of 1981. The British government sold 50.2 percent of British Telecom's shares in 1984. The government did not sell any more British Telecom stock until 1991, when they sold half of their remaining shares.[21]

Although Telmex was privatized in the early 1990's, the company was still a monopoly in the telephone service provider industry. Telmex maintained its monopoly position until January of 1997. During the early and mid 1990s, Telmex had not increased efficiencies or reduced prices. Mexican economist Rocio Mejia noted that, while international long distance charges dropped by 10 to 15 percent in 1996, domestic long distance charges increased by a comparable amount.[22]

While Telmex was being privatized, the company was also establishing itself as a duopoly power with the RTN in commercial Internet backbone access. In 1995, Telmex bought a 50 percent share of Red Uno. In 1996, the company introduced Uninet, the Universal Network of Telephones in Mexico.[23]

In anticipation of deregulation, new competitors formed that planned on competing with Telmex. Alestra was incorporated in October 1993[24] and Avantel in January 1996[25]. Each of these firms brought in extensive foreign capital and expertise.

With the deregulation of the telephone service industry came the deregulation of the Internet backbone provider industry. Competitors were allowed to enter the market and compete with Telmex. Competitors, such as Avantel and Alestra, began competing with Telmex in the backbone provider industry as well as the telephone services industry. These new competitors were presented with the challenge of overcoming the significant advantages that Telmex had developed while it had protected status in order to compete.

The Current State of Competition

The current markets for both IP providers and telecommunications companies in general in Mexico are highly competitive. The three largest backbone access providers are Telmex, Avantel and Alestra. Telmex is by far the largest of these three. Revenue and net income from Telmex' consolidated financial statements for 2001 were 111 trillion pesos and 23 billion pesos respectively.[26] Comparatively, Alestra's overall revenue for 2001 was slightly under 4 billion pesos. The company suffered a net loss of 631 million pesos for the year.[27] These results are from consolidated statements and reflect the companies' overall performance, not just the performance of their IP provider services. Additionally, several smaller competitors exist. Many of the competitors are growing rapidly.

Many of the larger competitors offer the same services. Most of the companies are vertically integrated. Most provide IP service, ISP service, leased lines and long distance telephone service. The largest difference comes in the geographical dispersion of service. Telmex currently provides service in more rural areas of the nation, whereas the other

competitors only offer service in the larger, urban areas. A comparison of services provided by the three largest competitors is provided in Table 14.

Table 14. Current Services Provided by Major Telecom Competitors

	Largest Current Competitors		
Services Provided	**Telmex**	**Avantel**	**Alestra**
Nationwide Rural Service	Yes	No	No
Nationwide Urban Service	Yes	Yes	Yes
IP Service	Yes	Yes	Yes
ISP Service	Yes	Yes	Yes
Long Distance Service	Yes	Yes	Yes
Leased Line Service	Yes	Yes	Yes
Dial Up Access	Yes	Yes	Yes

Although competition in the telecommunications industry in Mexico is a recent development, competition has developed quite rapidly. Increased levels of competition have been sparked by foreign investment. Still, Telmex remains the dominant company in the industry. Telmex has a distinct first mover advantage. This first mover advantage is magnified in areas of the industry that require significant time and investment capital to develop. The Internet backbone provider industry area of the larger telecommunications industry is one such area.

As the developer and owner of the initial, privately held, national backbone, Telmex is well entrenched as the market leader in the segment. In order for competing backbones to take market share, they must not only install completely new infrastructure, but also provide compelling reasons for customers to switch services. Installing competing infrastructure is capital intensive and takes time.

Even if competitors can provide compelling reasons, there are switching costs present. These costs include the significant financial costs that an ISP or large business would incur by switching as well as the cost of the lost relationship between the business and its well-established supplier, Telmex. The reasons to change service must be compelling enough not only to overcome objections based on the ongoing price and quality of the service provided, but must also overcome these switching costs.

Telmex benefits from economies of scale. Redundant processes within Telmex have been reduced and, in some cases, eliminated by the company. The company has taken many steps to increase efficiency. In 2000, Telmex received ISO 9001, ISO 9002 and ISO 9000 certifications.[28]

The company also benefits from economies of scope. Telmex is not only the nation's primary Internet backbone provider, but is the nation's largest ISP and telephone service provider as well. These are related industries and allow opportunities for reduced costs by integrating some of the functions performed by the varying divisions. Also, the company has become a model for competing firms. All the major competitors IP providers in Mexico are also ISP providers. Although there are hundreds of independent ISPs in Mexico, the largest and most successful firms provide IP, ISP and long distance telephone services.

Competitors have had to overcome Telmex' advantages and create and exploit competitive advantages of their own. Avantel and Alestra have been quite successful at penetrating the Mexican market. Their success lies in focusing their efforts in particular market segments. These companies focused their efforts on developing infrastructure and competing only in the larger markets. Initially, these companies developed infrastructure to service only the three largest cities, Mexico City, Guadalajara and Monterrey. Currently, they compete in all the

major and midsize markets in Mexico, but they still do not have the infrastructure to compete throughout all of Mexico.

While Telmex has the infrastructure to provide service in many more markets than its competitors, this is not necessarily an advantage for the company. The markets in the large metropolitan areas are the most profitable markets. The costs of providing service to the more rural and less affluent areas are much higher than providing service to the more urban and more affluent areas. As a monopoly, Telmex used some of its profits from the larger markets to subsidize the development of smaller markets. With the advent of competition, Telmex no longer has this luxury.

Avantel and Alestra have developed their own backbones and links to the United States in the past few years. This heightened competition greatly. The bandwidth of these new backbones was not as close to capacity as that of Telmex' backbone, so access was quicker, which provided competitive advantage. Avantel states that they have an independent network assigned exclusively for the Internet. They also have two connections to a backbone in the United States.[29] Avantel announced its contract with Alcatel of France to build the terrestrial fiber optical backbone in August of 2000.[30] The development of these links to the United States and of independent backbones was executed rapidly.

Other competitors are entering the market as well. Axtel is a growing company with a unique source of competitive advantage. The company, like most competitors, provides both ISP and IP services. They provide wireless ISP service. This is unique because customers do not have to have a terrestrial telephone line to get service. Bestel has been growing rapidly. Protel, with Ciena, announced their intentions to enter the Internet backbone provider market in Mexico in late 2000. Protel is a telecommunications company from Mexico and Ciena is a global,

intelligent, optical networking provider. Their plan was to connect 17 Mexican cities with an advanced fiber-optic network.[31]

Although the national networks in Mexico effectively replaced slower satellite technologies in the middle to late 1990s, satellite technologies are still finding ways to compete. Tachyon signed an agreement with GTSI in September 2000. The companies agreed to provide governmental customers in the United States, Europe and Mexico with 2-way Internet access via satellite at speeds up to 2 Mbps.[32]

Although competitors to Telmex have entered the market with Telmex, Telmex has taken steps to help secure its position as market leader. Telmex frequently upgrades their network and international connections. Also, in May of 2001, Ericsson announced a contract with Telmex to provide Telmex with Ericsson's ENGINE Integral network solution. Ericsson's ENGINE gives Telmex the ability to provide new services and increases efficiency while using current infrastructure.[33]

The Role of Foreign Investment

Foreign investment has played a significant role in the development of Mexico's connectivity infrastructure. Foreign nations have infused great amounts of capital into the Internet industry in Mexico. This capital has sparked the development of network backbones and of competition in the industry.

Most commonly, major competitors have the maximum amount of foreign ownership allowable by law. Under Mexican law, foreign investors cannot own more than 49 percent of a company. One of the concerns in Mexico about the maquiladora industry is that all the significant financial gains leave Mexico.[34] By requiring that companies maintain primarily Mexican ownership, the government is attempting to keep a majority of the capital gains from

the Mexican economy in Mexico while still encouraging the infusion of foreign capital into the economy.

Southwestern Bell and France Telecom were the initial foreign investors in the Mexican telecommunications industry. They purchased part of Telmex when the company was initially being deregulated. MCI owns 49 percent of Avantel and AT&T owns 49 percent of Alestra. If fact, foreign influence on these firms is so significant that the companies are often referred to by industry professionals in Mexico as MCI Mexico and AT&T Mexico. Large investors in the three leading telecom companies in Mexico are provided in Table 15.

In addition to direct foreign investment, strategic alliances between Mexican firms and foreign firms is quite common. Although these alliances effect the overall performance of the companies, they do not directly effect the connectivity infrastructure of the firms. For example, Telmex has strategic alliances with Prodigy and Microsoft.[35] Although these significantly influence the ISP and web portal segments of the industry, they have little direct effect on the development of Telmex' national backbone.

Table 15. Primary Investors in Mexico's Larger Telecom Companies

	Primary Investors	
Company	**Foreign**	**Domestic**
Telmex	Southwestern Bell, France Telecom	Grupo Corso
Avantel	MCI	Banamex
Alestra	AT&T	Alfa, Bancomer

The Role of Government

The government of Mexico is currently in the difficult position of balancing goals that are sometimes conflicting. The government wants to encourage competition. Competition often raises efficiency and reduces costs. The government has also wants Internet access to be provided to a larger portion of the nation's population. In recent years, the government has leaned toward deregulation and increased competition. As pointed out previously, historically, Telmex has used profits made in the high profit areas, such as urban and industrial areas, to supplement low or no profit rural access. The advent of competition makes this no longer possible. Trying to balance conflicting goals has created a great challenge.

Government has responded by promoting partnership between industry and the government to find solutions to this challenge. President Fox announced an initiative in March 2001 called the e-Mexico project. The e-Mexico project is a 6-year, $400 million program. The goal of the program is to provide Internet access to all of the population of Mexico.[36] Many companies are also participating in the e-Mexico project, such as Telmex, Alestra, Avantel, Bestel, Axtel and Microsoft.

Such government investment is not uncommon in Mexico. One of the reasons the Internet backbone developed so rapidly in the early and mid 1990's was government investment. The government, with academia, facilitated the adoption of the Internet in Mexico by developing the initial backbone for the Internet before such a venture would have been financially profitable for private concerns. The government still operates this Internet backbone. Still, since competition has developed, the government has not chosen to increase the bandwidth of the RTN network to match the bandwidth of private sector networks.

The government has encouraged competition through the deregulation of the telecom industry including the loss of protected monopoly status for Telmex. The deregulation is still not fully complete. In many areas, Telmex still has monopoly or near monopoly status. Telmex' control of these areas is still being challenged in the courts and in regulatory agency hearings.[37] Even though the deregulation is not complete in all areas, the Internet backbone provider area is one of the areas where deregulation took effect relatively rapidly.

Although competition is encouraged, the industry is still regulated. The regulatory agency in charge of regulating the telecommunications industry is La Comision Federal de Telecomunicaciones, or Cofetel. All competitors are required, by law to post their rates for services on Cofetel's website. These rates are the maximum rates that the companies can charge. The rates are updated frequently. Although the published rates are the most companies can charge, they rarely reflect the rates a customer would actually be charged. Rates are often negotiated far below the published, book rates. The published rates are likely to be charged in areas with little competition, like rural areas.[38]

Appendix 4 provides Telmex' monthly rates for private, virtual, multiservice networks.[39] These rates do not include charges for establishing the linkages for networks. Rates are given in pesos. Spanish terms in the text, notes and references of this document have been translated into English. The appendices are taken directly from Spanish language sources and do contain Spanish terms. A glossary of Spanish terms used in the appendices is provided after the appendices.

Geographic Dispersion

Regional Variation in Backbone Distribution

The initial backbone connected the nation's major universities and was well distributed throughout the country. This developed later into the RTN which, consequently, is well distributed. Telmex had a mandate to provide service throughout the country and was well distributed. Newer backbones are not as well distributed.

The new competitors focused on the more profitable regions first. Avantel and Alestra entered the large urban markets of Mexico City, Guadalajara and Monterrey first and then extended their networks outward from there. Other newer competitors, such as Bestel, are also following this model.

Competitors also focus on the northern region of Mexico. Although the market potential is not as high the densely populated, major urban areas, companies still focus on the northern region for three reasons. The average income per capita in the north is higher than in the rest of the nation. A great amount of industry and trade exists in the north that requires infrastructure. Also, to reach the largest cities of Guadalajara and Mexico City, almost all companies run cables from connections in the United States through the northern region. The one exception to this is Avantel, which runs cable through the Gulf of Mexico. Consequently, providing service to northern cities incurs little marginal costs.

Establishing service to the southern region incurs higher costs with less market demand. Although the marginal costs required in order to provide backbone service in the rural, central region are not that high, the demand is relatively low.

These variations in regional dispersion of the Internet backbone should be reduced with time. Increased maturation of major markets will force competitors to find other markets including those that aren't as lucrative. Also, the e-Mexico initiative will bring infrastructure to areas with less profit potential.

Ranking Geographic Dispersion

The ranking for geographic dispersion in early 2002 is at level three. Currently, Internet points of presence are located in all first-tier political subdivisions in the nation. Mexico does not yet warrant a rank of level four. Although the Internet is commonly available in urban areas, it is not commonly available in rural areas. Table 16 provides a description of the GDI framework's criteria for geographic dispersion rankings and Mexico's ranking in early 2002.

Table 16. Ranking Geographic Dispersion of the Internet in Mexico – Early 2002

Level 0	**Nonexistent:** The Internet does not exist in a viable form in this country. No computers with international IP connections are located within the country.
Level 1	**Single Location:** Internet points of presence are confined to one major population center.
Level 2	**Moderately Dispersed:** Internet points of presence are located in multiple first-tier political subdivisions of the country.
Level 3	**Highly Dispersed:** Internet points of presence are located in at least 50% of the first-tier political subdivisions of the country.
Level 4	**Nationwide:** Internet points of presence are located in essentially all first-tier political subdivisions of the country. Rural access is publicly and commonly available.

Before the first Internet connection was established in Mexico in 1989, geographic dispersion was at level zero. Between 1989 and 1994, geographic dispersion was limited to a few points of presence with slow connections. Although there was more than one point of presence though much of this period, access was effectively limited to academia in a small number of institutions. This limited access does not warrant a ranking of moderately dispersed. During this

period, five regional networks were established that linked more than twenty different universities. These regional networks were not generally connected to the Internet or each other before 1995. These regional networks did provide the basis for wide geographic dispersion starting in 1995. When the first national backbone was created in 1995, it linked these regional networks to the Internet and to each other. Suddenly Mexico's geographic dispersion jumped from level one to level three.

Table 17 shows how geographic dispersion of the Internet in Mexico has progressed over time.

Table 17. Geographic Dispersion Rankings For Mexico Over Time

Year	**Before 1989**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Ranking	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**3**
Year	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002 (Projected)**	
Ranking	**3**	**3**	**3**	**3**	**3**	**3**	**3**	

Organizational Infrastructure

The Current State of Organizational Infrastructure in Mexico

The state of organizational infrastructure for the Internet in Mexico is currently quite robust and deserves a level four ranking by the GDI criteria. Descriptions of the levels for ranking by the GDI criteria for this dimension and Mexico's current ranking are provided in Table 18. NIC Mexico currently lists 601 ISPs that do business in Mexico.[40] Barriers to entry for ISPs are relatively low. The larger ISP and IP providers have their own international links. There is competition for domestic infrastructure in the urban areas and exchanges do exist.

Although Mexico currently has a level four ranking, there are constraints on the vitality of the organizational infrastructure of the nation. Although there are few barriers to entry for ISPs and many ISPs exist in the country, there are substantial barriers that inhibit ISPs from becoming significant competitive forces in the market. Large, vertically integrated, companies that also provide IP services dominate the market. The economies of both scale and scope of these companies make it difficult for smaller ISPs to compete.

The market leader, by far, is Telmex. The former monopoly still held 60% of the ISP market as of September 2000.[41] Avantel and Alestra are also large competitors. The RTN also still provides Internet service to a large number of customers. Smaller competitors often have to find a specialized niche, or unique product or service, to compete. For example, Megacable has been successful in the market by providing high-speed cable Internet access. Axtel has been able to compete by providing wireless Internet access.

Even though competition is fierce in urban areas and for large industrial facilities, Internet access is limited for those in rural areas. Some areas do not have Internet service at all. In many areas, either only Telmex or only Telmex and the RTN provide service.

Table 18. Ranking Organizational Infrastructure of the Internet in Mexico – Early 2002

Level 0	**None:** The Internet is not present in this country.
Level 1	**Single:** A single ISP has a monopoly in the Internet service provision market. This ISP is generally owned or significantly controlled by the government.
Level 2	**Controlled:** There are only a few ISPs and the market is closely controlled through high barriers to entry. All ISPs connect to the international Internet through a monopoly telecommunications service provider. The provision of the domestic infrastructure is also a monopoly.
Level 3	**Competitive:** The Internet market is competitive. There are many ISPs and low barriers to market entry. The provision of domestic infrastructure is open to competition, or vice versa.
Level 4	**Robust:** There is a rich service provision infrastructure. There are many ISPs and low barriers to entry. International links and domestic infrastructure are open to competition. There are collaborative organizations and arrangements such as public exchanges, industry associations and emergency response teams.

The Historical Development of Organizational Infrastructure in Mexico

The development of the organizational infrastructure of the Internet in Mexico is closely tied to the development of connectivity infrastructure. Before 1989, no ISPs existed because no direct links to the Internet existed. Mexico's organizational infrastructure had a level zero ranking until 1989. Between 1989 and 1994, no national backbone existed for ISPs to use. There was limited access primarily through international links and regional backbones, which were controlled through academia and the government. Most users of the Internet during this time were in academia. During this time, Mexico's ranking was at level one.

In 1995, the first national backbone was created linking the regional networks of the universities in Mexico. Telmex and the RTN began providing ISP services on a national scale commercially. The first year there were more business Internet users than academic users in Mexico was in 1995. Large competitors to Telmex and the RTN were allowed to form, like Alestra and Avantel. Many smaller ISPs were formed. Although these competitors were allowed to exist by law, Telmex and the RTN were the dominant Internet service providers between 1995 and 1997 due to market power and the fact that they controlled the domestic infrastructure. Between 1995 and 1997, Mexico's ranking was at level two.

In 1998 and 1999, competitors started to have a significant role in the marketplace. As discussed in the connectivity infrastructure section, Avantel ran fiber optic lines from Texas, across the Gulf of Mexico, and into the heart of Mexico. Earnest competition in both the IP and ISP markets in Mexico's three largest cities, Mexico City, Guadalajara and Monterrey, began. This made Internet access cheaper and more accessible for business customers. As a result, the number of Internet users in the business sector increased by 247.5 percent between the end of 1997 and the end of 1998. At the end of 1997, there were 299,000 business sector Internet users. By the end of 1998, there were 740,000 users.[42] During these two years, Mexico's organizational infrastructure ranking was at level three.

Since 2000, Mexico's ranking has been at the fourth level, robust. Competition has become more heated. Although this competition does not yet extend to rural areas, it does exist in all major urban areas of the nation. Small competitors, like Megacable and Axtel, are able to compete. Many of the larger competitors and some of the smaller ones have their own national networks. This current robust infrastructure has been a significant contributor to the increase in the pervasiveness of the Internet in recent years. In the two years after Mexico obtained the

robust ranking level, the pervasiveness of Internet usage in Mexico increased by 199.6 percent. Between the end of 1999 and the end of 2001, the total number of Internet users increased from 1,822,000 to 3,636,000.[43]

A summary of the rankings for organizational infrastructure for Mexico over time is provided in Table 19.

Table 19. Organizational Infrastructure Rankings For Mexico Over Time

Year	**Before 1989**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Ranking	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**2**
Year	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002 (Projected)**	
Ranking	**2**	**2**	**3**	**3**	**4**	**4**	**4**	

Sophistication of Use

The Current Level of the Sophistication of Use of the Internet in Mexico

The level of sophistication of use of the Internet in Mexico is quite high, but not yet to the level where Mexico can be considered a leader in innovation for Internet usage. Currently, Mexico is ranked at a level three under the GDI criteria. This level is the transforming use level. At this level, new uses are developed within a nation for the Internet, but, most commonly, these new uses do not expand on the technology cluster's capabilities. Table 20 provides a description of the criteria for this dimension and shows Mexico's current ranking.

There are uses currently, such as ITESM's virtual university, which are cutting edge uses of the Internet. ITESM's virtual university is one of the leading and most innovative distance learning programs in the world. Still, although many uses of the Internet in Mexico can be considered advanced, few are distinctly innovative. For example, the development of Internet2 in Mexico enhances the use of the Internet for research by scholars in Mexico but it is an extension of Internet2 in the United States. Further discussion of ITESM's virtual university and Internet2 is provided at the end of this section.

There are many uses for the Internet that show that Mexico currently should have a ranking above level two in addition to ITESM's virtual university and Internet2. Many companies, especially companies with global presences, have elaborate EDI relationships with other divisions, suppliers and customers. Virtual private networks have recently become fairly common.

There are several Spanish language portals and search engines, such as Yupi, T1MSN and Yahoo Mexico. These are similar to sites in other countries. Many have been localized from English language source sites. Interactive sites in Mexico are becoming more common.

Table 20. Ranking Sophistication of Use of the Internet in Mexico – Early 2002

Level 0	**None:** The Internet is not used, except by a very small fraction of the population that logs into foreign services.
Level 1	**Minimal:** The user community struggles to employ the Internet in conventional, mainstream applications.
Level 2	**Conventional:** The user community changes established practices somewhat in response to or in order to accommodate the technology, but few established processes are changed dramatically. The Internet is used as a substitute or straightforward enhancement for an existing process (e.g., e-mail vs. post). This is the first level at which we can say that the Internet has "taken hold" in a country.
Level 3	**Transforming:** The use of the Internet by certain segments of users results in new applications, or significant changes in existing processes and practices, although these innovations may not necessarily stretch the boundaries of the technology's capabilities.
Level 4	**Innovating:** Segments of the user community are discrimination and highly demanding. These segments are regularly applying, or seeking to apply, the Internet in innovative ways that push the capabilities of the technology. They play a significant role in driving the state-of-the-art and have a mutually beneficial and synergistic relationship with developers.

The Historical Development of the Sophistication of Use of the Internet in Mexico

Until recent years, academia has been the primary driving force for the development of sophistication of use of the Internet in Mexico. Although academia still remains as one of the driving forces behind advancing sophistication of use, other sectors have been increasingly demanding more sophisticated applications.

Before 1989, there were no direct links to the Internet, so Mexico had a level zero ranking for sophistication of use. Between 1989 and 1994, Mexico had a level one ranking. During this period, academia drove the development of the Internet. ITESM established the first direct international link. Regional networks were established. These networks connected over twenty universities in Mexico into five regional networks, but the regional networks were not interconnected. These regional networks did allow universities to share resources and reduce costs, though.

The need for academia to connect its regional networks and the need for commercial applications of the Internet led to the development of the first national backbone in 1995. With the creation of a national backbone, the nation became able to adopt the Internet for basic services and began to do so. At this point, Mexico's sophistication of use ranking increased to level two. Mexico stayed at this level from 1995 through 1999.

Advanced uses of the Internet in Mexico have only recently taken hold. Mexico did not reach the third level until 2000. Some sectors have advanced more quickly. Academia still leads the way. ITESM's virtual university and the advent of Internet2 are examples. Also, ITESM was among the first organizations to establish a virtual private network for its campuses. In the past few years, commercial applications have become increasingly complex. Governmental and private uses have become more complex too, but all these are relatively recent developments. During the time this paper was being researched, the sophistication of source web sites increased dramatically. Many began using multimedia applications, began providing significantly more material, and began updating information more frequently.

Table 21, which follows, provides a summary of rankings for sophistication of use for Mexico over time.

Table 21. Sophistication of Use Rankings For Mexico Over Time

Year	Before 1989	1989	1990	1991	1992	1993	1994	1995
Ranking	0	1	1	1	1	1	1	2
Year	1996	1997	1998	1999	2000	2001	2002 (Projected)	
Ranking	2	2	2	2	3	3	3	

ITESM's Virtual University

El Instituto Tecnologico y de Estudios Superiores de Monterrey (ITESM) has been at the forefront of the development of the Internet in Mexico since the Internet's beginnings in the nation. The first direct connection to the Internet was established by ITESM in 1989. ITESM was a driving force in the development of the nation's first national backbone. The university is the home of the organization that registers and allocates domain names in Mexico, NIC Mexico. ITESM provides RJ-45 and wireless connections throughout all of their campuses so that students can conveniently access the Internet with their laptops. The school's campuses are connected in a virtual private network. ITESM is also one of the leading providers of distance learning in the world.

The Virtual University at ITESM provides this distance learning. The virtual school is commonly known as UV, which is short for Universidad Virtual del Tec de Monterrey. In 2000, 80,882 students "attended" UV. Although many of UV's students are also students at one of ITESMs 30 campuses throughout Mexico, many are not. Many live in areas in Mexico that do

not have campuses. Also, students come from ten other Latin American countries, Canada, the United States, Spain and France.

UV uses three different methods of instruction; instructor led study, self-study and collaborative learning. The school uses several media to convey learning materials. The Internet is used, as well as video conferencing, multimedia and digital libraries.

Internet2 in Mexico

The need for the Internet in academia has become more specialized. Within the United States, this has led to the development of Internet2. Internet2 is a specially designed, high-speed, high-bandwidth network. It is designed for advanced applications and networking for education and research. The quality of multimedia applications through Internet2 is advanced, but Internet2 does not include the extraneous Internet sites that are available through the standard Internet.

Internet2 connects more than 180 universities in the United States. Forty of the universities in the United States that use the network are located in California. In the United States, Internet2 uses the Abilene network as its backbone. The California segment of Internet2 is called CENIC. CENIC manages the network used for Internet2 in California. The California network is called CalREN-2.

Mexican universities had an interest in connecting to Internet2. In 1997, CONACYT and the University of California system signed an agreement, which called for more cooperation and collaboration between universities in California and universities in Mexico. Plans were made to develop infrastructure in Mexico that could handle the bandwidth required for Internet2 and to create links that would connect Internet2 to a network in Mexico.

The Corporacion Universitaria para el Desarrollo de Internet (CUDI) was given the responsibility of creating the network and connecting it to CalREN-2 in California. CUDI contracted Telmex to provide the backbone. A network with high-bandwidth capabilities was created. Across Mexico, 30 universities were connected to this network. The San Diego Supercomputer Center and a point in Tijuana were selected as connecting points for the Californian and Mexican portions of the network. The connection between the two networks became fully operational in November of 2000.[44] A topological map of the backbone of Internet2 is provided in Appendix 5.[45]

Conclusions

The use and diffusion of the Internet in Mexico has increased dramatically, especially in recent years. Internet access and Mexico's Internet connectivity infrastructure have grown tremendously. The costs of services have decreased and the breadth and quality of services offered have increased. Currently, Mexico is one of the Internet leaders of Latin America. In 2001, approximately 3.7% on Mexico's population had Internet access. This growth has occurred over a relatively short period of time. The Internet has been diffused in Mexico in four distinct phases: the introductory phase, the developmental phase, the duopoly phase and the competitive phase.

In the introductory phase, academia was the driving force behind Internet diffusion. During this phase, the number of users in the academic sector was greater than in any other sector. Academia saw the need for creating the first international Internet connections and regional networks. Academia developed and implemented plans to make these connections and networks a reality. This phase lasted from early 1989 through 1993.

In the developmental phase, government, industry and academia realized that developing a national network would reduce duplication of efforts between regional networks and create a platform for commercial use of the Internet. The government chose to invest in developing a national backbone and the RTN. The RTN was created to provide commercial applications of the backbone. The national Internet backbone linked the five academic regional networks. Telmex provided part of the infrastructure for the national backbone and developed its own network. This phase lasted from early 1994 through 1995. Plans for the first national backbone were developed and set in motion in 1994 and the first backbone became operational in early 1995.

During the developmental phase, the number of users of the Internet in Mexico grew to 94,000. The number of commercial users grew to 47,000, which was half of all the Internet users in the nation. For the first time, the number of commercial users was greater than the number of academic users. Still, the total number of Internet users at the end of 1995 had barely grown to one tenth of one percent of the population. Although pervasiveness of the Internet in Mexico was not high at the end of this phase, the changes that were made during this period provided the connectivity infrastructure that enabled future growth.

During the duopoly phase, Telmex and the RTN dominated both the IP and ISP provider market. This phase lasted from 1996 through 1998. Telmex had certain legal protections from competition until early 1997. Telmex saw this as an opportunity to become Mexico's Internet leader. The company invested heavily on developing the first private national network. Even after competition became legal, Telmex and the RTN controlled the established international Internet connections and domestic backbones.

Even without effective market competition, the number of Internet users increased by 1300% between the end of 1995 and the end of 1998 to 1,222,000 users. Although this growth was tremendous, the total number of users at the end of 1998 still only represented 1.28 percent of the population of Mexico.

The competitive phase began in early 1999. Mexico is still in this phase. By the beginning of the competitive phase, competitors such as Avantel and Alestra had established their own international links and domestic backbones. Although the backbones only allowed service to Mexico's largest markets and the international links did not have a high capacity, they did allow competition to start to take hold in the nation. As this period has progressed, Avantel's and Alestra's infrastructure has grown to the point where the companies can serve all major

metropolitan areas in the nation and provide comparable or better bandwidth than that provided by Telmex to their customers. Also, several smaller competitors have developed their own backbones and international links. A reduction in government regulation and foreign investment helped spark this growth.

The introduction of competition during this phase has lead to a highly competitive IP provider market in the urban and industrial areas of the nation, although rural access is lagging behind urban access. Many independent national backbones exist. International links are common and have high bandwidth. Multiple exchange points exist. Leased lines and high speed Internet connections, such as cable and DSL access, are available. In the short term, growth of each of these segments of Mexico's infrastructure and of Internet access in Mexico overall are expected to continue.

Pervasiveness of the Internet has increased dramatically during this period. Between the end of 1998 through the end of 2001, the number of users of the Internet has increased from 1,222,000 to 3,636,000. The total number of users in the nation almost tripled during these three years. This growth has occurred across all sectors, but the greatest growth has been in the home user and government user sectors.

Table 22 provides an overview of the current state of Internet diffusion in Mexico by GDI dimension. Table 23 shows changes in the level of each dimension of diffusion over time. Each year reported shows end of year estimates. The estimates for 2002 are projected, end of year estimates. Figure 11 provides a graphical version of the state of the dimensions of Internet diffusion in Mexico in early 2002. Figure 12 shows how the dimensions have changed over time for selected years. Figure 13 shows how the state of the dimensions has progressed by year since the introduction of the Internet in Mexico.

Table 22. The State of the Dimensions of Internet Diffusion In Mexico – Early 2002

Dimension	Level	Description of the State of the Dimension
Pervasiveness	**3**	**Established:** The ratio of Internet users per capita is on the order of magnitude of at least one in a hundred (1% or greater).
Sectoral Absorption	**3**	**Common:** The Internet is well established in all sectors, but is not yet approaching becoming ubiquitous.
Connectivity Infrastructure	**3**	**Broad:** Several high capacity domestic backbones exist. All major competitors have broadband international links. Internet exchanges exist and high-speed access methods are available, if not yet common. The ranking for this dimension is rapidly approaching level four.
Geographic Dispersion	**3**	**Highly Dispersed:** Internet points of presence are located in at least 50% of the first-tier political subdivisions of the country. Rural access is limited.
Organizational Infrastructure	**4**	**Robust:** There is a rich service provision infrastructure. There are many ISPs and low barriers to entry. International links and domestic infrastructure are open to competition. There are collaborative organizations and arrangements such as public exchanges, industry associations and emergency response teams.
Sophistication of Use	**3**	**Transforming:** The use of the Internet by certain segments of users results in new applications, or significant changes in existing processes and practices, although these innovations may not necessarily stretch the boundaries of the technology's capabilities.

Table 23. The State of the Dimensions of Internet Diffusion in Mexico Over Time

	Year							
Dimension	**Before 1989**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Pervasiveness	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**2**
Sectoral Absorption	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**2**
Connectivity Infrastructure	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Geographic Dispersion	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**3**
Organizational Infrastructure	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**2**
Sophistication of Use	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**2**
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002 (Projected)**	
Pervasiveness	**2**	**2**	**3**	**3**	**3**	**3**	**3**	
Sectoral Absorption	**2**	**3**	**3**	**3**	**3**	**3**	**3**	
Connectivity Infrastructure	**2**	**2**	**3**	**3**	**3**	**3**	**4**	
Geographic Dispersion	**3**	**3**	**3**	**3**	**3**	**3**	**3**	
Organizational Infrastructure	**2**	**2**	**3**	**3**	**4**	**4**	**4**	
Sophistication of Use	**2**	**2**	**2**	**2**	**3**	**3**	**3**	

Figure 11. The Dimensions of Internet Diffusion for Mexico - Early 2002

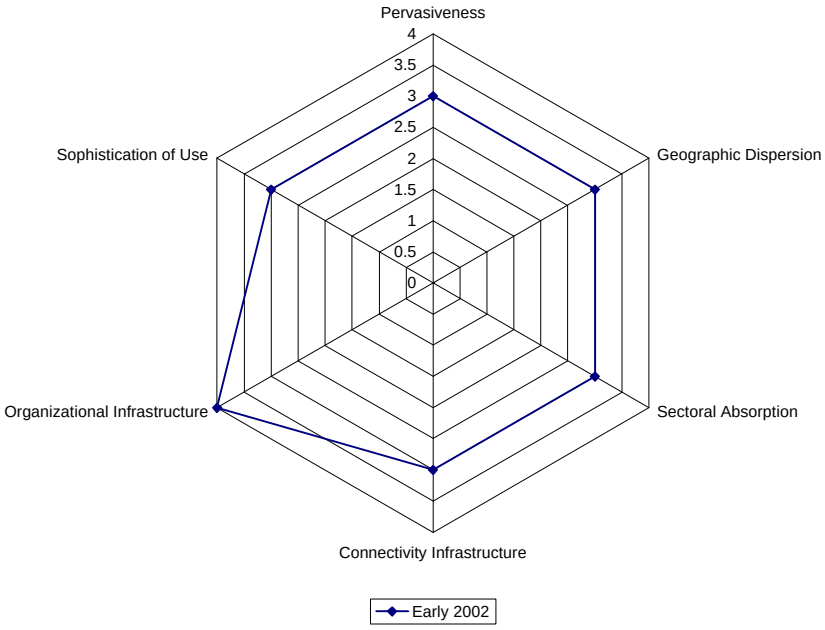


Figure 12. The Dimensions of Internet Diffusion for Mexico - Selected Years

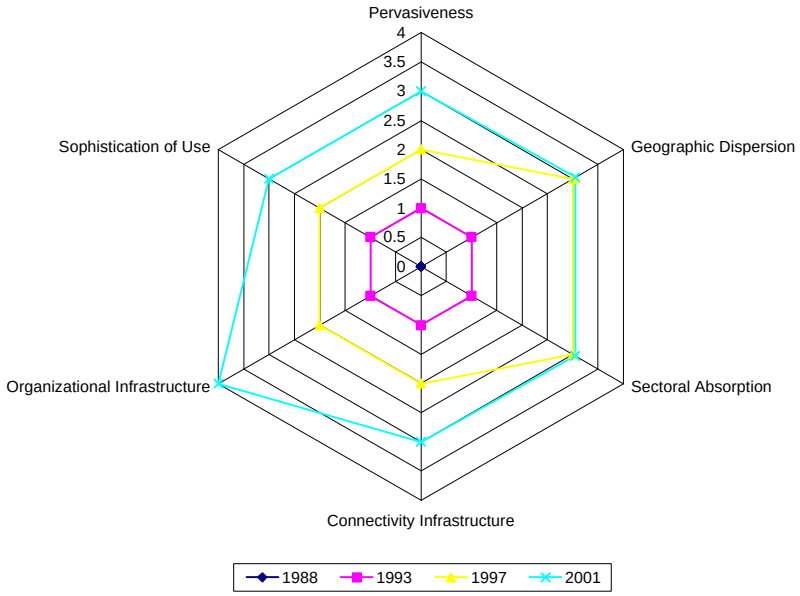
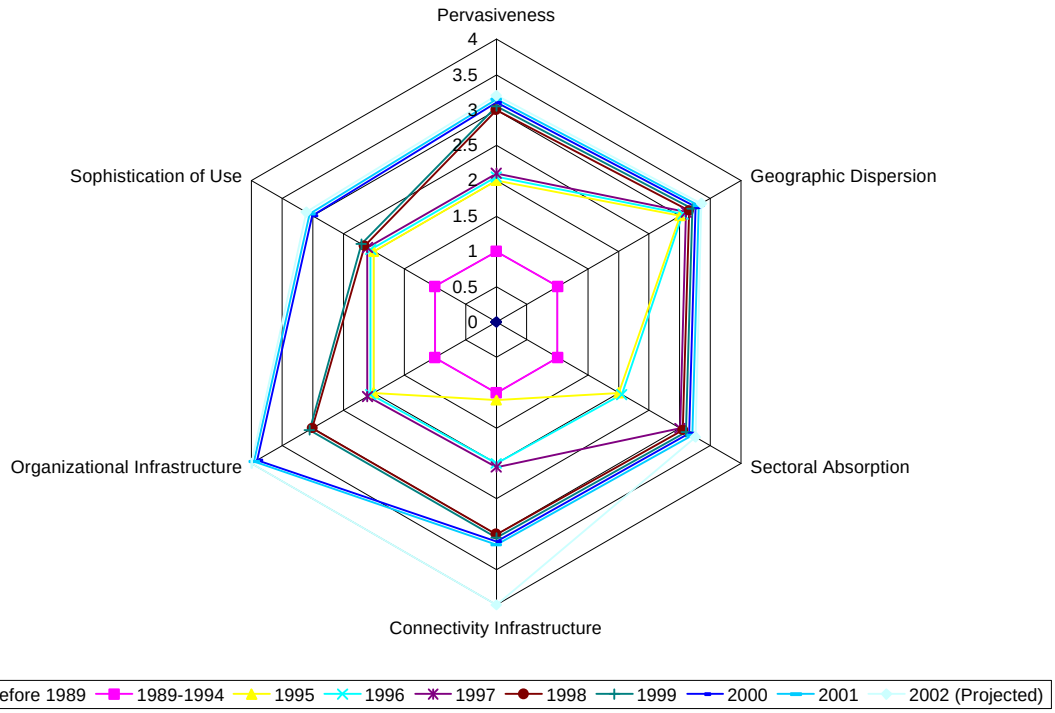


Figure 13. The Dimensions of Internet Diffusion for Mexico - All Years



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Larry Press is a professor of computer information systems at California State University – Dominguez Hills. Dr. Press is also actively involved with the GDI project and has published several papers analyzing the diffusion of the Internet in many nations. Dr. Press has written a large number of published works in other areas of computer science and has extensive consulting experience as well. Dr. Press received his Ph.D. from UCLA in information processing.

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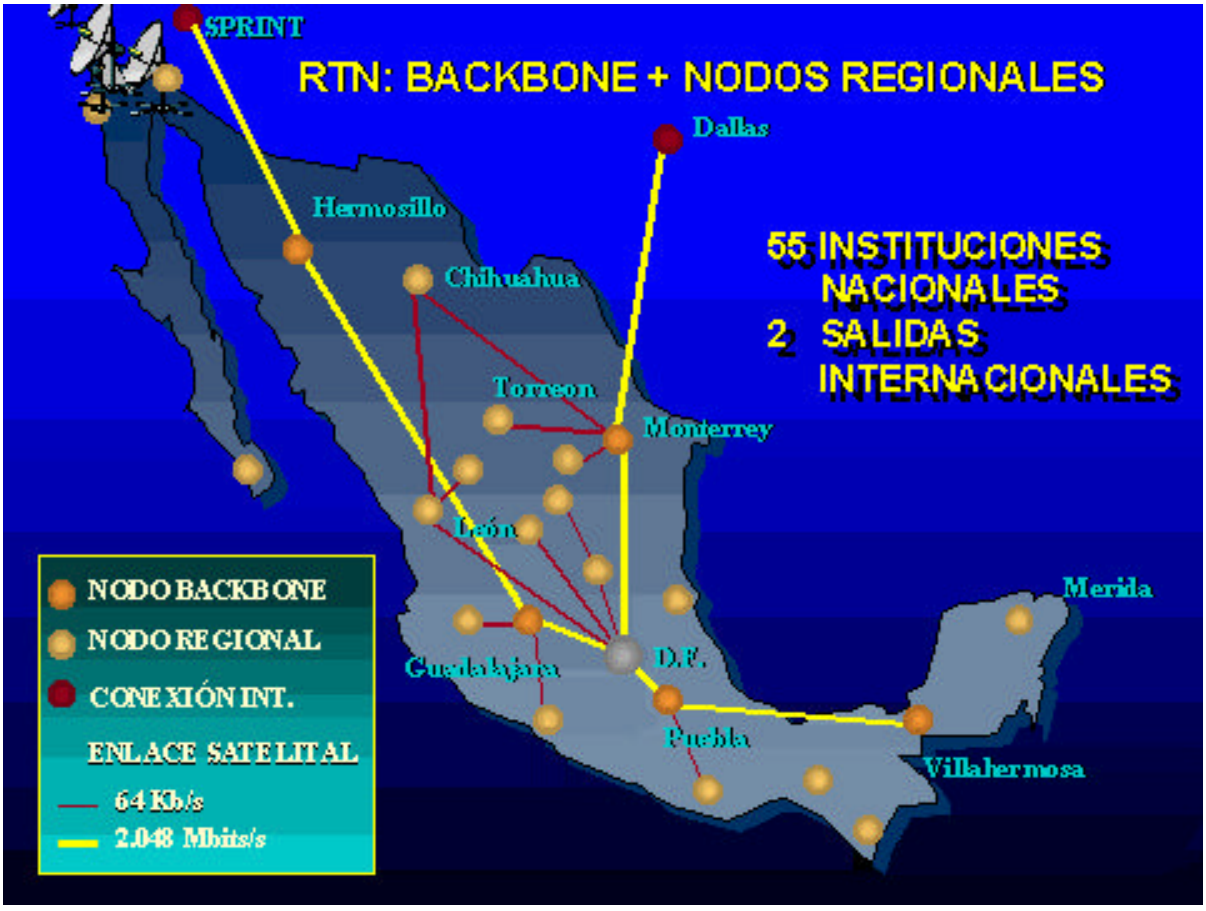
Appendix 1

The Bestel Backbone

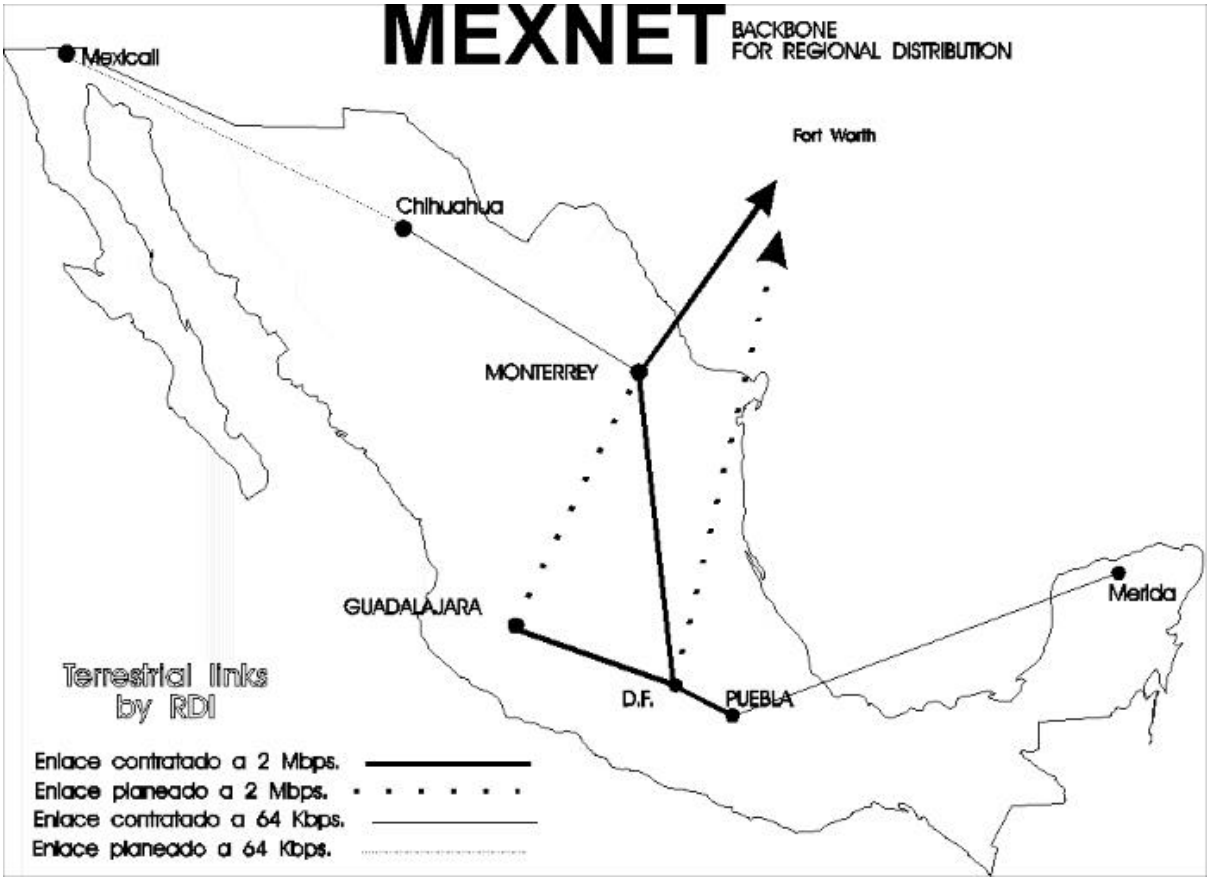
Appendix 2

The RTN Backbone



Appendix 3

The Initial MEXNET Backbone



Appendix 4

Monthly Telmex (Uninet) Rates as of

March 8, 2002 for a Private Virtual Network

(Rates are in Pesos.)

	Calidades de Servicio		
Capacidad (Kbps)	Datos	Datos Críticos	Voz/Video
16	$400	$500	$640
32	$764	$955	$1,222
48	$1,120	$1,400	$1,792
64	$1,459	$1,824	$2,334
96	$2,140	$2,675	$3,424
128	$2,787	$3,484	$4,459
192	$4,087	$5,109	$6,539
256	$5,323	$6,654	$ 8,517
384	$7,806	$9,758	$12,490
512	$10,168	$12,710	$16,269
768	$14,909	$18,636	$23,854
1024	$19,420	$24,275	$31,072
1536	$28,475	$35,594	$45,560
2048	$37,093	$46,366	$59,349
2 E 1	$70,848	$88,560	$113,510
4 E 1	$135,319	$169,149	$216,510
8 E 1	$258,460	$323,075	$413,536
E 3	$493,659	$ 617,074	$789,854

Appendix 5

The Internet2 Backbone

Glossary of Spanish Terms

Used in Appendices

1. Calidades de Servicio – Quality or type of service.
2. Capacidad – Capacity.
3. Conectividad – Connectivity.
4. Conexion int. – International connection.
5. Contratado a – Contracted at.
6. Datos – Data.
7. Datos criticales – Critical data.
8. Enlace – Link.
9. Enlace satelital – Satellite link.
10. Faso – Phase.
11. Hacia – Towards.
12. Instituciones nationales – National institutions.
13. Nodo – Node, connection.
14. Nodo backbone – Backbone node.
15. Nodos de acceso – Access nodes.
16. Nodo regional – Regional node.
17. Planeado a – Planned at.
18. Red – Net, network.
19. Red actual – Current network.
20. Salidas international – International connections.
21. Topologia – Topology.
22. Voz/video – Voice/video.

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