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Peering in Paraguay: Analysis and Recommendations 2012

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In this report we presents findings regarding the current state of network interconnection and Internet traffic exchange in Paraguay and offer policy recommendations to improve their efficiency and competitiveness. We also exhibit an economic outlook of the telecommunication sector and analyze the structure and competition of the Internet market to further our arguments.

This report is the outcome of country consultations carried out by PCH staff Gaël Hernández and Robert Martin-Legène in Asunción, Paraguay, in July and September 2012. During the consultations, we interviewed more than twenty executive managers of Internet service networks operating in Paraguay as well as representatives of the Internet industry association CAPADI and the telecommunications regulator CONATEL.

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1. Internet traffic exchange

The Internet is a global network of thousands of interconnected local networks. The efficiency and possibilities of growth of the Internet are largely dependent on the number of network interconnections; the more densely interconnected a network is, the lower its costs and the higher its quality and reliability.

When more than two Internet service providers (ISPs) decide to interconnect, the most efficient approach both technically and economically is to meet at a common location, generally called an Internet exchange point (IXP). These exchange points are physical locations created to facilitate and streamline interconnection among networks. The cost of building an IXP is largely dependent on the equipment used and the business model. New exchange points typically cost between USD 4,000 and 40,000 to establish.

Dense domestic interconnections between ISPs keep domestic traffic in-country and provide cost and performance benefits. Participating networks exchange traffic between their customers in a value-neutral transaction, an interconnection relationship known as "peering." Unlike transit interconnections, which provide connectivity to the entire Internet at a cost, peering interconnections allow the exchange of traffic in virtually unlimited quantities without significant incremental cost. As illustrated in Figure 1, if Internet service providers A and B do not exchange traffic domestically, they must use their international transit connections to move traffic between Customers A and B, introducing unnecessary costs and delays to what should be a fast and inexpensive domestic transaction (see Appendix A). Besides cost, the inferior performance (latency, jitter, packet loss, and out-of-order delivery) of longer-distance international connections constrains the quality and services that providers can deliver.

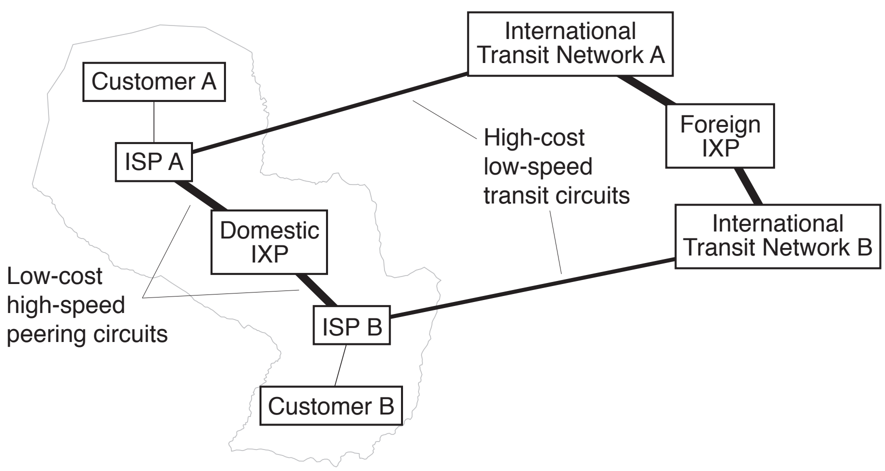

Figure 1: Two ISPs connected through a domestic IXP and via international transit networks

Although more than 350 IXPs exist worldwide,[1] less than half of the countries in the Latin American and Caribbean region enjoy the benefits of an exchange, as shown in Table 1. Among those countries, only Argentina, Brazil, Ecuador, and the Netherlands Antilles have more than a single exchange.

Table 1. Countries with and without IXP in the Latin American and Caribbean region (Source: PCH Global Internet Infrastructure Database, December 2012)

Countries with IXPs (number of IXPs)	
Argentina (10)	Grenada (1)
Brazil (19)	Haiti (1)
British Virgin Islands (1)	Netherlands Antilles (2)
Chile (1)	Nicaragua (1)
Colombia (1)	Panama (1)
Cuba (1)	Paraguay (1)
Dominican Republic (1)	Peru (1)
Ecuador (2)	Puerto Rico (1)
Total: 16 countries	

Countries without IXPs	
Antigua and Barbuda	Honduras
Bahamas	Jamaica
Barbados	Mexico
Belize	Saint Kitts and Nevis
Bolivia	Saint Lucia
Costa Rica	Suriname
Dominica	Trinidad and Tobago
El Salvador	Uruguay
Guatemala	Venezuela
Guyana	Saint Vincent and the Grenadines
Total: 20 countries	

Internet bandwidth is produced in IXPs by interconnection of networks and exchange of traffic among service providers. In most countries, IXPs are built so bandwidth can be produced locally rather than be imported from IXPs in other countries. As with agricultural produce, a country can have its own farms and produce food locally—becoming self-sufficient, independent, and paying less for fresher produce—or import food from elsewhere and lose all those benefits.

A country without well-established and fully functional exchange points must import bandwidth produced at IXPs in other countries. Domestic content such as digital media or bank online services, which could be easily produced and exchanged locally, must instead be imported via another country's IXP, a process that is economically and technically inefficient and yields slow, low-quality bandwidth.

As Table 2 indicates, Paraguay's production of bandwidth at exchange points is poor both in absolute and relative terms compared to neighboring countries. In economic terms, this means that most of the bandwidth consumed in Paraguay is imported at higher costs from other IXPs internationally rather than being locally produced at much lower costs. Needless to say, the capital used to import bandwidth is being used to pay foreign companies owning international submarine and terrestrial cables rather than being invested in Paraguay's economy through growth and profitability of local ISPs.

Table 2. Total IXP bandwidth (Mbps) and per-capita bandwidth (Mbps/1,000 persons)
(Source: PCH Global Internet Infrastructure Database, December 2012)

Country	IXPs	Bandwidth produced	Population	Bandwidth per person
Argentina	10	12,000	40,117,096	299
Brazil	19	123,896	193,946,886	639
British Virgin Islands	1	0	106,405	0
Chile	1	1,420	16,572,475	86
Colombia	1	11,700	46,741,000	250
Cuba	1	50	11,247,925	4
Dominican Republic	1	0	9,445,281	0
Ecuador	2	2,800	14,483,499	193
Grenada	1	1	110,821	9
Haiti	1	0.098	10,085,214	0
Netherlands Antilles	2	2,126	304,759	6,976
Nicaragua	1	82	6,071,045	14
Panama	1	0	3,405,813	0
Paraguay	1	150	6,337,127	24
Peru	1	2,015	30,135,875	67
Puerto Rico	1	0	3,706,690	0
Germany	14	2,320,000	81,946,000	28,311
Netherlands	5	2,290,000	16,778,806	136,482
Russia	16	1,590,000	143,369,806	11,090
United Kingdom	12	1,570,000	63,181,775	24,849

In the long run, a well-accepted aspiration for all countries is to become at least self-sufficient in the generation of bandwidth, hence developing their Internet-based economy with e-commerce, e-government, and other Internet-based services for the interest of both companies and the general public.

2. The Internet in Paraguay

The Internet arrived in Paraguay through its two main universities in the mid-1990s. As with most landlocked countries, Internet access in Paraguay was provided through expensive satellite connections to the USA and was affordable only by a few corporations and government institutions.

In 1996, Network Information Center Paraguay (NIC.PY) was created to coordinate the growth of the domain name system (DNS) in Paraguay. On year later, private-sector ISPs formed the industry association Cámara Paraguaya de Internet (CAPADI) in order to protect their interests, primarily relative to the national telecommunications operator ANTELCO.

In September 2000, CAPADI facilitated the interconnection of fifteen ISPs at a common neutral exchange point known as the Paraguayan Network Access Point, or NAP-PY (Figure 2). The goal was to exchange domestic traffic locally in Paraguay rather than use expensive satellite transit connections to exchange data in other locations, principally the NAP of the Americas in Miami. In its first years of operation, the exchange point routed 30-40% of the total Internet traffic of Paraguay, increased the performance of service providers, and accelerated the uptake of Internet users through the decrease in consumer price. Today the NAP-PY produces an average of 250 Mbps, annually worth USD 450,000.[2]

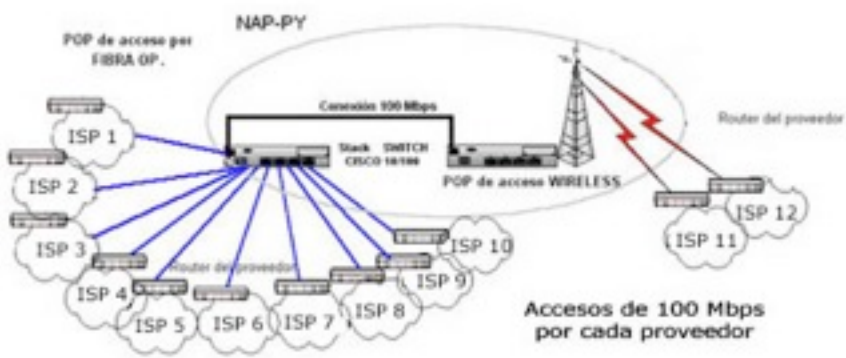

Figure 2. NAP-PY, CAPADI's IXP (source: CAPADI)

The NAP-PY was built in a space controlled by international cell phone provider Tigo (Millicon International Cellular) in Asunción. Although IXPs are rarely located within the facilities of one of their participants, because it precludes true neutrality, in this case it was deemed appropriate due to the concentration of traffic and the presence of the largest ISPs. The equipment used to interconnect the networks in the Tigo facility was a 100 Mbps switch, augmented later with a second 100 Mbps switch hosted in the facility of another provider, Consultronic, which also provided the 100 Mbps fiber link connecting the two switches. Service providers from Encarnación and Ciudad del Este (365 km southeast and 327 km east of Asunción, respectively) also connect to the NAP-PY, covering their own transport costs to Asunción.

In 2002, COPACO inherited the infrastructure owned by ANTELCO and continued the local, national, and long-distance telephone operations, adding dial-up Internet service. COPACO did not, however, connect its network to the rest of the local ISPs through the NAP-PY, undermining its original purpose and confirming industry suspicions of unfair monopolistic practices. Instead, COPACO selected a few providers seen as competitors to share traffic with and considered the rest of the smaller ISPs solely as potential transit customers.

With the objective of reducing its cost of international interconnection, in 2005 COPACO granted rights to build a fiber optic cable between Paraguay and Argentina to Telecom Argentina. Later the same year, the telecommunications regulator CONATEL forced ISPs to buy international capacity exclusively from COPACO, imposing a monopoly on international connectivity supply and thereby affecting access and pricing to the rest of the providers. As a result, nearly 90% of the domestic traffic was then being routed through COPACO's network, which was still not connected to the NAP-PY.

In the following years, mobile operators Tigo and Personal consolidated their positions in the wireless market. In November 2006, Personal launched its WiMAX service in Asunción and, in May 2007, Tigo expanded its wireless broadband infrastructure to metropolitan Asunción. By 2009 the fixed broadband market was divided as follows: Tigo (67% market share), COPACO

(17%), Personal (12%), and Cablevisión/Multicanal (3%). This concentrated more than 95% of the market in a small oligopoly, leaving little room for growth among small providers and new entrants in the residential market.

Between 2007 and 2008, mobile operators Tigo, Personal, and Claro launched mobile broadband services with great success. Mobile broadband technology and its inexpensive customer equipment introduced volume-based data plans in the market, accelerating the uptake and growth of Internet users (as example, the number of mobile broadband subscribers reached the number of fixed broadband subscribers in one and a half years). The major beneficiary of the launch of mobile Internet was Tigo, which continued to increase its market share in Internet service provision.

In May 2009, telecommunications regulator CONATEL made major changes to Internet regulation, intended to promote competition among ISPs and end COPACO's monopoly on international connectivity. CAPADI proposed additional policies to ensure competition, such as a single licensing scheme for ISPs, access to the right of way, and liberalization of access to unused network infrastructure owned by the State, but these recommendations were not included in the final law.

According to sources within CAPADI, the intended liberalization backfired, with significant negative unintended consequences. For larger companies with national infrastructure, such as Tigo, COPACO, and Personal, the liberalization of the international connectivity allowed them to negotiate lower prices for their larger volumes of traffic and further reinforce their market positions. For small providers, mostly serving the corporate market, there were very limited alternatives and opportunities to compete within the new regulation and market structure.

Currently, CONATEL is paying close attention to interconnection at the NAP-PY and its effects on market competition. Since 2011, CONATEL has been actively advocating voluntary interconnection of providers at the exchange point without success. According to information disclosed by a CONATEL representative in January 2013, the existing mechanisms to enhance traffic exchange among ISPs are not effective because of a lack of transparency at the NAP-PY and failed leadership by CAPADI. In his view, the ISP industry needs to reform CAPADI as a representative body so that the current anomalies of network interconnection and Internet traffic exchange can be resolved through an agreed roadmap between the ISP industry and CONATEL.

3. Properties of the IXP in the Paraguay context

The success of the Internet model of traffic exchange is founded upon the low cost and rich interconnection that IXPs enable. This platform makes exponential economic growth possible, in the form of Internet-enabled commerce. In this section we examine four economic and technical properties of IXPs and their advantages in the Paraguayan context.[3]

3.1. Costs savings by substitution of low-cost peering for high-cost transit

By reducing networks' reliance on costly international data transit, domestic IXPs reduce networks' cost of bandwidth.

From the perspective of an individual network, savings result from the substitution of low-cost peering for high-cost transit—letting networks exchange data with their domestic peers without paying high transit costs, and reducing networks' average per-bit delivery costs. From the perspective of the system as a whole, savings come from the increased efficiency of local IXPs—reducing the need for the indirect routing imposed by transit and distant IXPs.

In Paraguay, the use of the NAP-PY by service providers has been a source of economic efficiency that results in lower prices for consumers and larger profits for providers. As an example, a small-size corporate ISP with a customer portfolio of 200 clients routing 20% of its traffic to domestic destinations via the IXP is saving USD 32,400 each year in connectivity costs.[4] A complete example including calculations can be found in Appendix A.

This economic property of exchange points also enables a competitive market by giving new market entrants and smaller competitors access to the same “wholesale” low-cost, high-volume bandwidth as their larger, more established competitors. Simple access to cheap domestic bandwidth in large quantities creates an important incentive for creation of value-added services and more competition with other providers.

3.2. Increased bandwidth available to Internet users

By providing more high-speed interconnections, IXPs increase total bandwidth production, thereby increasing the amount of bandwidth available to each end user. This mitigates networks’ bandwidth shortages and reduces their incentives to impose user-frustrating bandwidth throttling and usage limits (caps).

This property has two different though related effects. First, high-speed 1 or 10 Gbps links to the IXP create additional capacity for domestic traffic. Second, routing data through the IXP frees up capacity on slower and more expensive transit links, allowing for additional traffic growth on those transit links before incurring new costs associated with upgrades.

In economic effects terms, by lowering networks’ average data transmission costs, IXPs allay networks’ concerns about bandwidth usage and allow them to offer users increased capacity. Meanwhile, increased use of local IXPs yields cost savings that increase the funds available for investment in last-mile improvements.

In Paraguay, bandwidth limits result in part from the high transit costs networks face in transporting users’ data to and from desired destinations. Using IXPs to lower the networks’ average per-bit delivery cost via dramatic efficiencies for data that networks can deliver through peering allows networks to offer users increased capacity.

A method broadly used by ISPs for cost optimization is to establish the costs per unit delivered in every possible link and work toward minimizing each of those costs. This method, based on the calculation of the average per-bit delivery cost (APBDC), illustrates very clearly the efficiencies offered by IXPs (for elaboration, see Appendix B).

3.3. Shortening routes to reduce network latency and improve performance

By creating shorter and more direct routes, IXPs reduce network latency, improving the performance of latency-sensitive services such as VoIP, videoconferencing, cloud-based web applications, and video games.

Several forms of delay result when Internet traffic takes a longer and more complex route. These delays include retransmission delay (dropped packets), systematic delay (increased latency due to distance and processing), unpredictable delay (jitter), and differential delay (out-of-order delivery). These delays particularly disrupt voice, video, and other types of streaming and time-sensitive communications.

In the case of Paraguay, a simple time and route analysis of the path followed by data packets can illustrate the benefits of exchanging traffic locally. As illustrated by traceroute samples, data packets take six to eight hops and between 5 to 20 ms to reach a destination available through local connection to the exchange point hosted in Paraguay. By comparison, domestic traffic exchanged at other IXPs such as the NAP of the Americas in Miami may require as many as thirty hops and 320 ms of delay. Illustrative packet samples can be found in Appendix C.

3.4. Increasing reliability and resilience of Internet access

By increasing the peering and transit connections between networks, additional IXPs increase the reliability and resilience of Internet access.

Without IXPs, networks typically find it cost-effective to rely on just one or two links to key transit providers. In this sparsely interconnected network architecture, if one of a network's links fails, the network often suffers severely degraded performance. In contrast, a robust web of interconnected networks, with substantial local peering at IXPs, gives networks many ways to reach each other. Thus, if one link fails—whether through operator error, equipment malfunction, maintenance downtime, sabotage, or natural disaster—communications continue unimpeded. IXPs make it easy and cost-effective for a network to have substantial excess capacity—capacity that is easily and automatically invoked as needed.

Most of the time, IXP facilities become central marketplaces for transit interconnections among providers as well as for the peering interconnections they are initially created to facilitate. Besides increasing the peering interconnections, the possibility of having several transit providers at the IXP increases the opportunities for ISPs to combine and choose among multiple providers with different commercial terms. Further, because the local loop to the IXP is owned and maintained by the ISPs themselves, the fluidity with which they can switch between transit providers is far greater than if they have to order a new crosstown circuit and tear down an old one each time they change. This decreased cost of switching leads to more competitive behavior among transit providers.

In Paraguay, where a large number of ISPs are using a single transit provider (COPACO) to reach the Internet, connections to one or several IXPs would create a transit and peering marketplace for ISPs, increasing the number of interconnections with other networks. More interconnections would substantially increase the reliability and resilience of Internet access for the ISP and its users.

4. Analysis and key findings of the Internet ecosystem in Paraguay

In this section we examine key findings regarding the Internet ecosystem in Paraguay in terms of interconnection and infrastructure, economic outlook and market trends, and market structure and competition.

4.1. Interconnection and infrastructure

COPACO has never connected to the NAP-PY and is selective in its peering, excluding new market entrants.

The state-owned national incumbent operator COPACO, second-largest residential provider with 60,000 ADSL subscribers, has never been connected to the NAP-PY due to ongoing disputes with CAPADI about entry and peering conditions. As a result, COPACO has established direct circuit interconnection with several other large operators, bypassing the NAP-PY and excluding smaller providers. Since COPACO does not offer peering for domestic destinations, small ISPs are forced to maintain expensive international transit links to reach COPACO's domestic customers.

This peering policy adopted by COPACO is a decision with economic and quality effects on small providers and new market entrants. The total network capacity of small ISPs is degraded since they have a single link carrying both domestic and international data paid to COPACO at international costs. As the capacity in the link increases, which can generally include negative effects such as traffic congestion, both domestic and international traffic quality indicators are equally affected. Most of the time these network issues—generated by COPACO and beyond the influence of the provider—affect the latter's service and credibility.

From an economic perspective, COPACO's peering policy is directly increasing the costs of domestic bandwidth with artificially high per-bit delivery costs (see example in Appendix B), blocking competition among service providers.

The NAP-PY facility is not suitable for the growth of traffic exchange.

CAPADI's IXP structure consists of a twelve-year-old 100 Mbps Ethernet switch located in a space donated by one of the service providers at one of its operational centers in Asunción. In addition to the primary switch, three other providers are connected through a fiber optic cable to an additional 100 Mbps switch on the premises of another ISP, also in Asunción.

Since the beginning of its operation in 2000, the network equipment has not been upgraded to support faster speeds or more participants. Furthermore, the donated facilities in which the network equipment is currently operating do not offer additional space and power to other possible participants, limiting the scalability and growth of the exchange point in members and therefore traffic.

Finally, the IXP lacks the basic traffic monitoring tools and services necessary for efficient and reliable operation. Quality-related traffic measurements such as link capacity and usage, latency, and packet loss and basic services such as a looking glass have not been implemented.

The current scenario requires more collaboration to create bandwidth locally.

In September 2000, Internet providers under the industry association CAPADI shared a common objective when they jointly established the NAP-PY: reduce their costs of exchanging local traffic and increase connection quality and availability to the Internet community. With the arrival of terrestrial fiber from Argentina first and the liberalization of international connectivity later, prices for international bandwidth have dropped from thousands to hundreds of dollars per megabit per second per month, reducing the resolve of the original collaborators.

Nevertheless, the current market scenario of Paraguay (high prices for end users and low fixed broadband penetration) needs more collaboration among providers to create bandwidth locally instead of buying it internationally. More intense collaboration, which will produce additional bandwidth, will also increase the level of competition, offering customers higher speeds at the same or lower costs.

Interconnection efforts need renewed institutional leadership.

According to most service providers consulted, the industry association CAPADI is not able to provide the institutional leadership needed to overcome the challenges faced by its members. ISPs are divided, and they lack an institutional forum for dialogue, even informally. As a result, the success of the NAP-PY as an interconnection platform is compromised by CAPADI's current difficulties, and individual companies prefer to negotiate individual agreements. This situation is indirectly reducing the possibility of a common agenda among providers regarding technical implementation of newer Internet standards such as DNSSEC and IPv6, which will inhibit further growth and modernization.

The mobile operator Claro is bypassing the NAP-PY.

Claro is not peering at the NAP-PY and is most likely routing its domestic and international traffic through its larger networks in Argentina and Uruguay, leaving small providers in Paraguay to use international capacity to interconnect with its network. This situation could change if regulatory measures are set in place by CONATEL.

4.2. Economic outlook and market trends

In the following points, we present the key indicators published by the regulator CONATEL, which can be found in Appendix D.

Mobile telephony is driving the telecommunication sector.

The telecommunications market size in revenue for telephony, Internet, and cable TV services was estimated at USD 920 million in 2011. Based on the latest available data from the regulatory agency CONATEL, the average monthly revenue increased 11.25% between December 2010 and December 2011. Mobile telephony accounts for nearly three-quarters of the total market volume, with fixed telephony, fixed and mobile broadband, and cable TV dividing the remaining quarter relatively evenly (Figure 3).

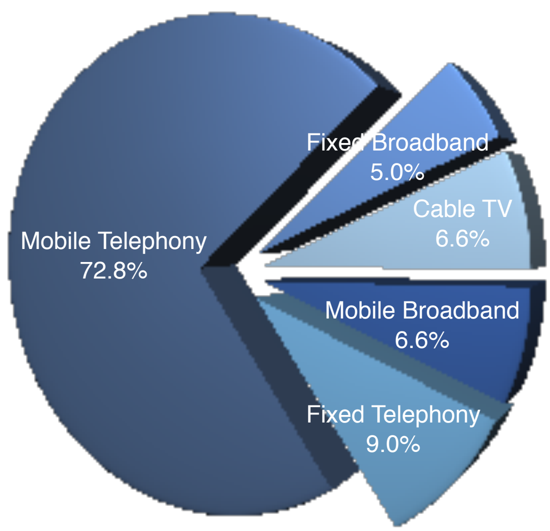

Figure 3. Telecommunication market volume by service (Source: CONATEL, September 2012)

Cable TV subscriptions increased 126% in 2011.

A subscriber analysis per service shows continuous growth of this sector in 2011, notably in cable TV and mobile broadband services, with 126% and 32% increases, respectively. Fixed broadband subscriptions increased on average 14%, whereas fixed and mobile telephony grew 10.8% and 10.27%, respectively (Figure 4).

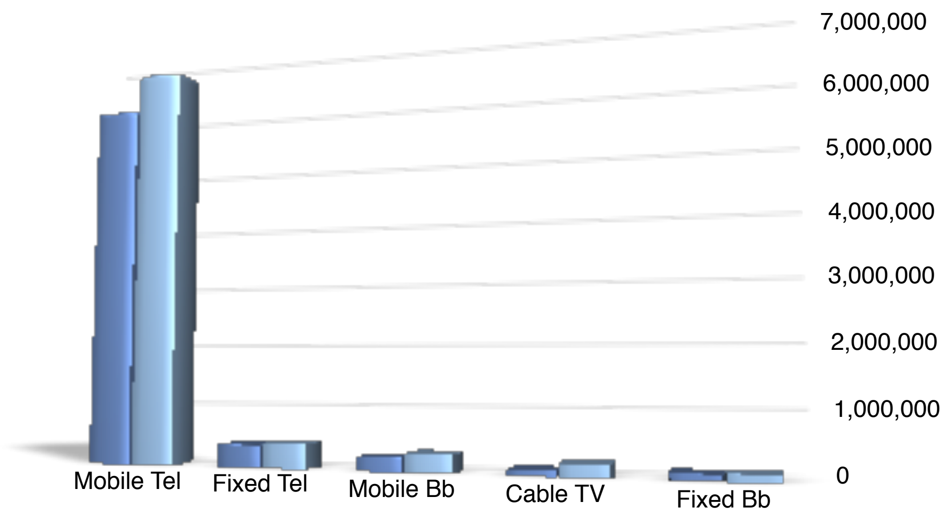

Figure 4. Subscriptions per service, year-over-year change, 2010-2011 (Source: CONATEL)

Internet growth is driven by mobile broadband.

In the Latin American region, individual citizens and households are becoming increasingly connected through mobile broadband subscriptions, web browsing, online social networks, and video streaming. In Paraguay, the total number of mobile broadband subscriptions in 2011 increased 32%, reaching 288,000. During the same period, fixed broadband subscriptions increased 14%, reaching 120,000.

Fixed broadband subscribers demand higher capacity for their traffic.

In 2011, fixed broadband subscribers demanded connections with higher bandwidth, as shown in Figure 5. The number of 512 Kbps-2 Mbps subscriptions increased 278%, the number of 2 Mbps-10 Mbps subscriptions increased 323%, and the subscriptions of 10 Mbps or more increased 681% by the end of the year.

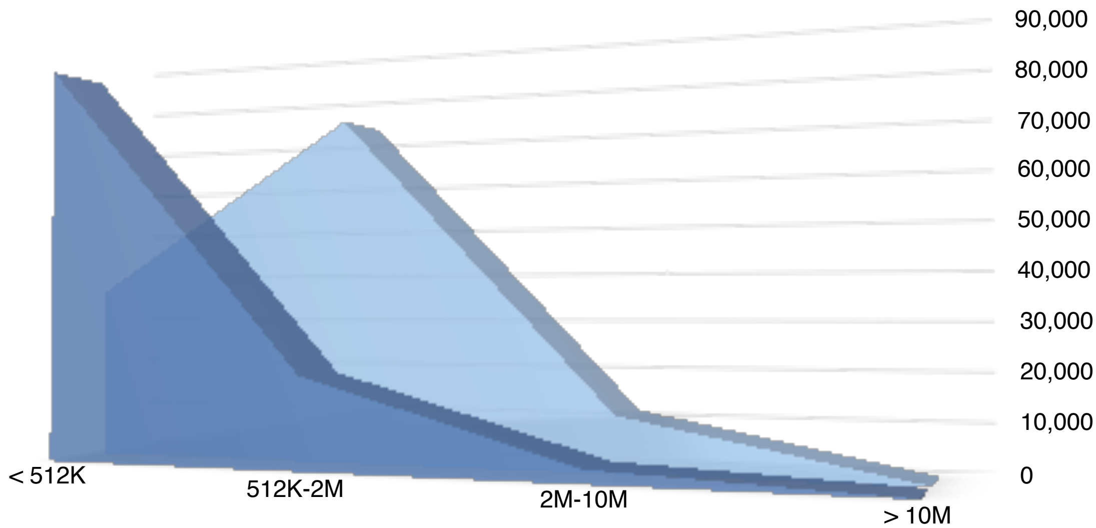

Figure 5. Fixed broadband subscriptions by speed, increasing from 2010 to 2011 (Source: CONATEL)

4.3. Market structure and competition

Tigo is reaching a monopolistic position as infrastructure and service provider.

The current Internet market in Paraguay is divided among one state-owned provider (COPACO), three large multinational corporations (Tigo, Personal, and Claro), two medium-sized transport and Internet providers (Consultronic and TEISA), and several smaller providers based in the metropolitan areas of Asunción, Encarnación, and Ciudad del Este such as Netvision, Rieder Internet, Planet SA, ITACOM, Chaconet, an Get Line.

The multinational group Tigo has the largest share of the fixed Internet market (67% based on the latest available data, 2009). No data are available regarding its market share of mobile broadband (3G or HSPDA) service, but Tigo has 58% of the mobile voice market, which is a strong indicator of dominance in mobile data as well.

With the recently approved acquisition of the cable TV operator Cablevisión, Tigo also gained a de facto monopoly in cable TV in Asunción and the associated share of residential fixed broadband customers, extending its market dominance to paid TV as well.

Analysis of the current number of IP addresses originated by service providers in Paraguay carried out in September 2012 confirms that nearly 80% of Paraguayan IP addresses are served by Tigo (Figure 6).

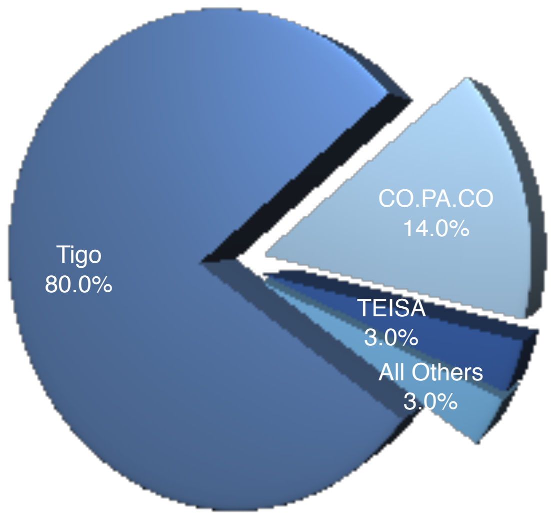

Figure 6. Share of IP addresses advertised (Source: CONATEL, September 2012)

Tigo operates its own HSPA+ mobile access network with more than 1,000 radio base stations, a WiMAX access network in Asunción, and a fiber backbone network with national coverage and three main nodes in Asunción, Encarnación, and Ciudad del Este. Tigo also has projects underway to increase its transit capacity.

In addition to network infrastructure, Tigo provides hosting services to content publishers in its data center in Asunción and has more data centers under construction.

Complementing the triple-play services Tigo will be soon able to launch in the wake of its Cablevisión aquisition, it recently launched the Tigo Money platform, which unifies several financial services and makes them accesible through mobile phone, creating additional high-value low-bandwidth services for its customers.

The number of ISPs is shrinking.

Tigo and Personal are large and modern multinational companies providing access to the Internet in addition to their mobile voice service. In line with their strategic objectives, both companies invested in core and access IP infrastructure nationwide, increasing their network capacity to sustain growth and profitability. Further, strong communication and branding campaigns have enlarged their fixed broadband and mobile Internet customers, reaching a combined share of 80% of the total market.

The strategies used by COPACO have differed, primarily because of its unique position as the sole supplier of international bandwidth between 2005 and 2009. During this time and despite efforts to modernize its network and services, COPACO was unable to compete with Tigo and Personal directly or develop strategic partnerships with smaller ISPs. In a way, COPACO's fight to maintain the status quo in Paraguay led to control of pricing and strict peering policies, which benefited only Tigo and Personal. The liberalization of the Internet market in 2009 allowed Tigo and Personal to negotiate commercial pricing for transit purchases and benefit from large volumes and multinational agreements. COPACO provides international transit mainly to smaller ISPs in Asunción, Encarnación, and Ciudad del Este.

Smaller ISPs are cherrypicking high-revenue customers and delivering Internet connectivity with value-added features like monitoring and support in order to survive. Some ISPs have left the Internet transit market to focus on overlay services such as software application development, corporate VoIP PBX, and IP-based camera surveillance systems.

Real competition in international transit is limited.

As a land-locked country, Paraguay does not have direct access to submarine cable systems, which limits the number of available transit providers and therefore competition in pricing (Figure 7).

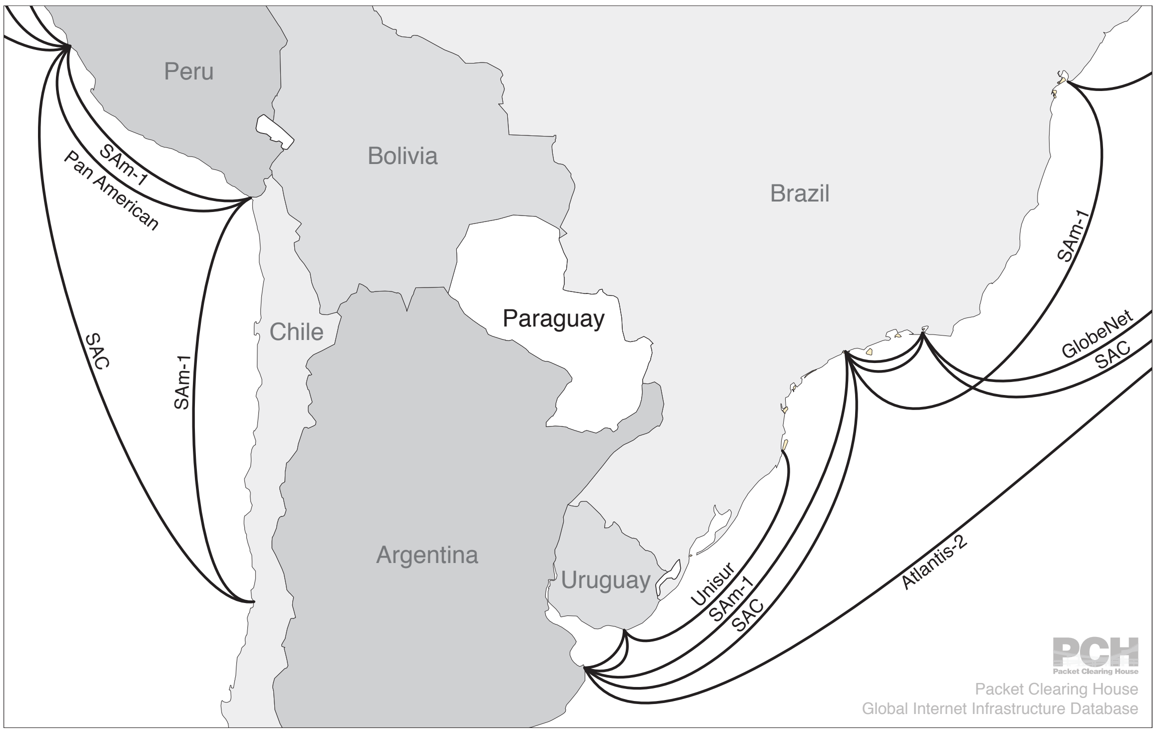

Figure 7. Access to submarine cables in central South America

According to information provided by network operators, a terrestrial fiber cable was laid from Argentina to Paraguay by Telecom Argentina in 2005 and is operated jointly by Telecom Argentina and Telefónica (indicated by the solid line in figure 8). The cable is owned by COPACO and crosses the border between Argentina and Paraguay at two locations: Asunción and Encarnación. Future projects include a terrestrial connection to Brazil through Ciudad del Este and a joint project between COPACO and Bolivian Entel to reach Peru through Bolivia (dotted lines). All three cable systems follow existing roadways.

Figure 8. Current and projected terrestrial cables in Paraguay

This infrastructural environment imposes different challenges for large and small providers in Paraguay. For larger providers such as Tigo or COPACO, the lack of additional providers at different locations has a direct effect on costs, with moderate incentives to increase competition in pricing. For smaller providers without physical infrastructure to reach the border at the transit locations, the situation is even worse, because their only choice is to use transit services from the larger providers, creating a wholesale/retail model not beneficial to competition or the public's interest in decreasing prices over time. Having additional IXPs in Paraguay would create an incentive for transit providers to offer their services at the IXP facility, limiting the negative effects of the two-level model, which increases costs passed on to the end user.

Transit prices are dropping but remain uncompetitive.

International transit prices paid by ISPs in Paraguay vary from USD 90 to 150 per Mbps/month, depending on volume and number of years of the contract. Although this is still two orders of magnitude higher than prices paid in major markets in the United States and Europe, prices in Paraguay have fallen gradually over time (Figure 9). Prices dropped from USD 1,200 per Mbps/month before 2005 with satellite connections to USD 400 per Mbps/month with the introduction of the fiber cable, and they were further reduced by the introduction of competition to the current USD 150 per Mbps/month.

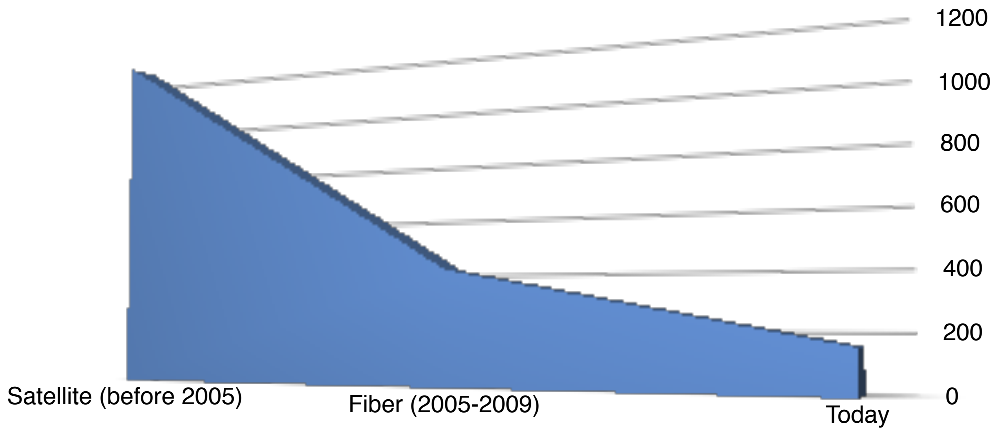

Figure 9. Costs of transit connection in Paraguay over time

Despite this positive trend over the years, the same connectivity bought in Buenos Aires costs an average of USD 30, four to five times cheaper than in Paraguay. In Brasil, international bandwidth is still cheaper, around USD 10 per Mbps/month in São Paulo, but the path from Paraguay to the large exchange in São Paulo traverses two to four providers, each of which add expense (Figure 10).

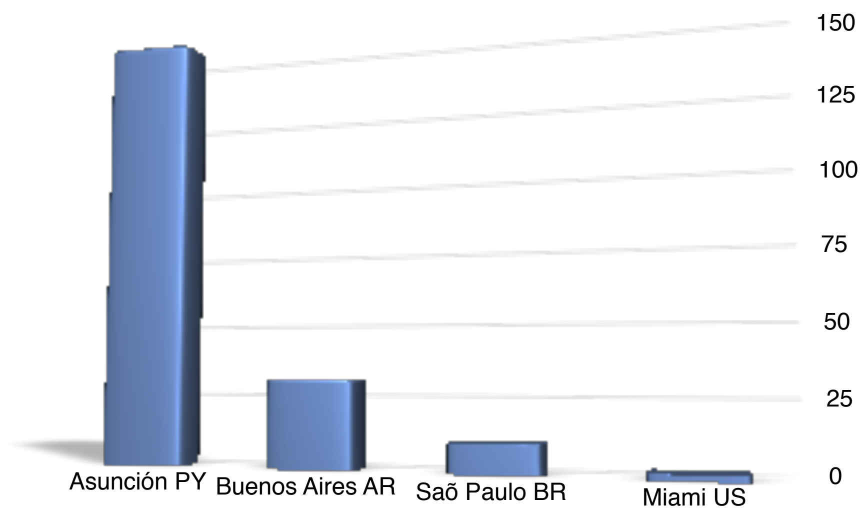

Figure 10. Costs of transit connection in Paraguay, Argentina, Brazil, and USA

Fixed broadband competition for the residential market in metropolitan areas is limited.

Currently, fixed broadband competition for the residential market in the three major metropolitan areas of Paraguay is limited because of lack of providers. In metropolitan Asunción, the largest urban concentration in Paraguay with 2.5 million people and 38% of the country's total population, consumers have access to only three ISPs—Tigo, COPACO, and Consultronic.

In metropolitan Ciudad del Este, the second-largest area with 12% of the population (835,000 people), on the border with Brazil, competition among service providers is limited to Get Line, Tigo, and Personal. Competition in metropolitan Encarnación (118,000 people) is similar, with ITACOM the main local provider and Tigo and Personal as competitive options.

A strategy to increase competition in both Encarnación and Ciudad del Este is to establish additional traffic exchange points in both cities. Replicating the same economic and technical model built in Asunción would decrease the cost of accessing local bandwidth in both metropolitan areas.

5. Conclusions and recommendations

The economic benefits that normally follow the establishment of an exchange point have not been fully realized in Paraguay because of a combination of regulatory decisions and abuse of market power by the dominant Internet service providers. The findings of our study are as follows:

- **The state-owned national incumbent operator COPACO, second-largest residential provider of Paraguay, has never been connected to the NAP-PY.** Instead, COPACO has established bilateral circuit interconnections with most of the larger operators and excluded smaller providers. Since COPACO does not offer peering routes to domestic destinations, smaller ISPs are forced to either maintain expensive international transit links or purchase transit from COPACO, their competitor, in order to reach COPACO's domestic customers. This peering policy has significant economic and network effects on small providers, new market entrants, and the market as a whole. The total network capacity of small ISPs is degraded since they have a single link carrying both domestic and transit data paid to COPACO at international costs. As utilization of the link increases, which generally includes negative effects such as traffic congestion, both domestic and international traffic quality are affected. Most of the time, these network issues—generated by COPACO and beyond the influence of the provider—affect its service and credibility.

- **As a land-locked country, Paraguay does not have direct access to submarine cable systems, which reduces the number of potential connection partners and therefore the degree of competition in pricing.** This situation imposes different challenges for large and small providers in Paraguay. For larger providers, such as Tigo or COPACO, the lack of additional providers at different locations directly affects costs with moderate incentives to increase competition in pricing. For smaller providers without physical infrastructure to reach the border at the transit locations, the only choice is to use transit services from the larger providers, creating a wholesale/retail model not beneficial to the public interest. Overall, this creates a bottleneck for competition and a wholesale/retail model that benefits only the backhaul international cable multinationals.

- **Domestic bandwidth production is low, which maintains dependence on expensive international transit connections to import bandwidth generated at IXPs in other countries.** Without an increase in the amount of bandwidth produced locally, Internet access for a large majority of the Paraguayan population will remain expensive or unaffordable.

- **The facility used by the NAP-PY does not provide the minimal conditions of space and power needed to install additional network equipment and is limiting the growth of the exchange point in membership and bandwidth production**. In addition, the governance structure of the NAP-PY requires its members to be ISPs, excluding other potential players such as content providers, reducing the overall value of the exchange point to its members and the public. Google servers, for instance, are housed at the premises of service providers rather than at the IXP, limiting access to the customers of those service providers and excluding access to new market entrants.

- **Regulatory measures for the Internet sector inhibited its growth, particularly during the period of monopoly by COPACO between 2005 and 2009.** During this period the number of residential ISPs decreased dramatically; by the end of 2009, nearly 95% of the consumer and corporate market was concentrated in Tigo, Personal, and COPACO. In May 2009 major Internet regulation reform was enacted, ending COPACO's Internet monopoly and promoting competition among service providers. After this reform, larger providers such as Tigo, Personal, and TEISA connected their networks to international transit providers at the border, becoming direct competitors with COPACO in the provision of transit services. The situation for small-size providers, however, has not improved after the reform.

- **Fixed broadband networks are able to provide better performance and quality of service than mobile 3G or HSPA+ networks because radio frequency is a shared physical transmission medium, unlike dedicated fiber or copper circuits.** Highly interactive services sensitive to network performance, such as VoIP and video streaming, particularly demonstrate the benefits of locally exchanged Internet traffic to end users. Generally, this condition also encourages competition among service providers, driving last-mile investment. Since 2009, however, the increase of Internet traffic has been driven by mobile broadband, whose typical usage (email or social networking) does not provide insight on network performance and keeps the importance of locally exchanged traffic invisible to end users.

We make the following recommendations:

- **Define a policy and regulatory framework for Internet carrier interconnection to increase competition.** Considering the connection limitations caused by Paraguay's geographic position in the region, collaboration among ISPs to reach optimal network interconnection is even more critical than for other countries. Using regulatory requirements to ensure interconnection of service providers for the exchange of domestic traffic would reduce the cost of bandwidth, improve network performance, and enable new market entrants.

- **Build additional Internet exchange infrastructure to increase the domestic production of bandwidth.** Increasing the production of domestic bandwidth would gradually strengthen the Internet economy in Paraguay, decreasing dependence on expensive international transit connections. The current NAP-PY could be expanded using neutral data centers as interconnection facilities. In addition, a change in the admission policy to welcome entities such as content providers and another institutions would increase the value of the exchange point and transform it into a marketplace for information-economy goods and services. More professional services at the IXP, such as a 24/7 network operation center or instrumentation servers, would also attract larger regional players to Paraguay's Internet market.

- **Create a beneficial feedback loop between Internet regulatory measures and market conditions, with the goal of establishing a regulatory environment hospitable to competition, innovation, and new market entrants.** The regulatory agency CONATEL could evaluate the actual effects of Internet reform in the market and establish whether further regulation is necessary. To increase competition and encourage innovation in the last mile, further regulations could be assessed, such as the disaggregation of the public telephony network or measures aimed at utilizing existing but unused infrastructure.

Appendix A: Internet exchange point economics

In this appendix we present an example of the basic economic properties of an IXP used to route domestic traffic directly among service providers. In the example, we use numbers as provided by ISPs in Paraguay to represent real scenarios rather than estimations or suppositions. We examine the economics of a small Paraguayan service provider business unit selling to the corporate market with the following customer portfolio and traffic profile:

Number of customers	200 x 5 Mbps DSL
Peak aggregate utilization	200 Mbps
Transit cost	150 USD/Mbps/month
Revenue per customer	250 USD/month

In the case that no IXP is used to route domestic traffic (Figure A1), all traffic is routed through the transit connection, which is billed by maximum capacity in bits per second per month. In the particular case that the traffic is addressed from an ISP in Paraguay to another ISP in Paraguay, the traffic returns after being exchanged at an exchange point in another country, typically Argentina or the United States. In this situation, called “tromboning,” both ISPs have to pay for expensive international transactions instead of performing a local exchange virtually free of charge.

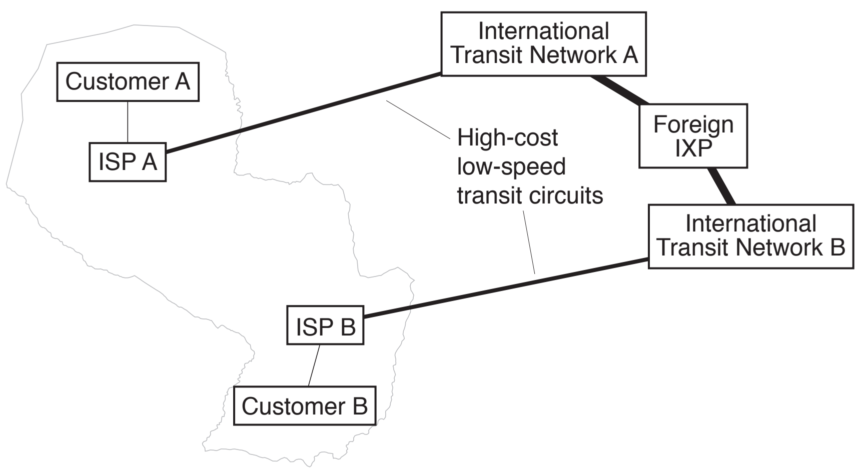

Figure A1. Domestic traffic routed through international transit and a foreign IXP

In this somewhat simplified example, the ISP pays 200 Mbps x USD 150/Mbps/month = USD 30,000 per month for operational connectivity costs, or 60% of its gross revenue—a figure which, although unfortunately high, is characteristic of stagnant markets.

Introducing an IXP to the country offloads domestic traffic from the international transit links, producing economic savings and improving the performance of the domestic traffic by decreasing the number of hops (Figure A2). Peering costs at the IXP include at least the cost of the infrastructure to connect to the IXP, as well as any membership fee at the IXP if applicable.

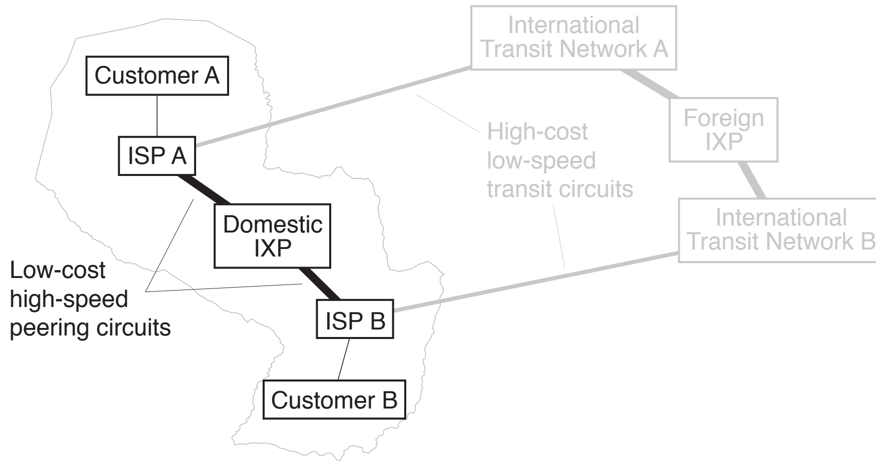

Figure A2. Domestic traffic routed through a domestic IXP

In our example, we assume that the ISP is going to lay a fiber optic cable from its premises to the building hosting the IXP and connect to the IXP at 1 Gbps. One-time (“non-recurring costs,” “capital expenditures”) costs include these:

License fees	USD 5,000
Fiber optic costs	USD 2.5/foot for 15,000 feet = USD 37,500
One 1 Gb router port	USD 2,500
1 Gbps LR optics	USD 200

The one-time cost of connecting to the IXP is thus USD 45,200. With an average life expectancy for the fiber cable of 20 years and a 6% interest rate, the monthly costs of the investment are USD 324, assuming that the costs and benefits are not being shared among multiple investors in the cable, a highly recommended practice.

Recurring costs include insurance or amortized cost of early damage to the cable, management overhead, and peering coordination, all of which might come to an additional USD 150 per month.

ISPs in Paraguay report that 25% of their traffic has domestic destinations today, and we find that over time, when domestic content and hosting are incentivized, this portion generally climbs to 50%.

When the ISP connects to the IXP, its cost of bandwidth increases from USD 30,000 to USD 30,474, and its nominal bandwidth available to sell increases from 200 Mbps to 1.2 Gbps. One-fourth of the traffic shifts from transit to the IXP, leaving the 200 Mbps transit connection at 150 Mbps peak utilization and the 1 Gbps IXP peering connection at 50 Mbps peak utilization. This allows 67 new customers to be added without purchasing additional transit capacity, adding USD 16,667/month, or 33%, to gross receipts, of which USD 16,193/month goes to gross margin, increasing it 81%. (Alternatively, one could recoup USD 7,026/month in savings by reducing the size of the transit connection to 150Mbps, but doing so would be counterproductive, since it would not contribute to growth.)

As the peering mesh at the IXP becomes denser and more content and destinations can be accessed through this peering, the 25% domestic figure might reasonably be expected to double to 50%. This would allow the ISP to support 400 customers on 200 Mbps of transit and 1 Gbps of peering, bringing gross receipts to USD 100,000/month and the gross margin up from USD 20,000 (40% of USD 50,000) to USD 60,526 (61% of USD 100,000).

In an industry that typically features net profit margins of less than 5%, these dramatic reductions in external costs spell the difference between stagnation or bankruptcy on the one hand and profitability, reinvestment, and growth on the other.

Appendix B: Average per-bit delivery costs

This example is based on the APBDC calculation tutorial available online, [5] but using market prices from Paraguay. It showcases how to use the method to optimize the ISP costs associated with connectivity.

Step 1. Calculation of APBDC for each link

First, let's calculate the average per-bit delivery cost of a 100 Mbps transit connection running at 75% of its capacity, that is, 100 Mbps of potential capacity but 75 Mbps of actual utilization.

```
 75 Mbps
= 4,500 Mbits/minute
= 270 Gbits/hour
= 6480 Gbits/day
= 197.64 Tbits/month
```

If the ISP is spending USD 16,000 per month for that link, the first interpretation of that price is USD 160 Mbps/month. But that figure does not take utilization into account, which is why the APBDC method provides a more accurate overview of the cost:

APBDC for 197.64 terabits at USD 16,000 is

$$\frac{\$16,000}{197.64} = \frac{\$80.95}{1}$$

or USD 80.95 per terabit.

In addition to the transit link, the ISP has a second 100 Mbps connection to an IXP, with only 12% of utilization, for which it is spending USD 4,000.

```
12 Mbps
= 720 Mbits/minute
= 43.2 Gbits/hour
= 1,063.8 Gbits/day
= 32.445 Tbits/month
```

Again, a simplistic analysis would give the peering connection cost as USD 40 per Mbps/month. However, using the APBDC method we find that APBDC for 12 Mbps at USD 4,000 is USD 123.30 per terabit.

$$\frac{\$4,000}{32.44} = \frac{\$123.30}{1}$$

Step 2: Aggregation of APBDC and analysis of results

If the ISP uses only these two links to deliver packets, then it is delivering a total of 87 Mbps and spending USD 20,000:

```
$16,000  +  $4,000   =  $20,000

75 Mbps   +  12 Mbps  =  87 Mbps
```

```
87 Mbps  *  2,635,200 seconds/month  =  229.262 Tbits/month

$20,000     $87.23
_______  =  _____
229.262       1
```

So the overall APBDC for the ISP is USD 87.23 per terabit. There are two cost factors contributing: transit at USD 80.95 and peering at USD 123.30. If you are buying two products and reselling them at the same price, you try to buy as much of the less expensive one and as little of the more expensive one as possible.

In our example, the analysis shows that the peering connection is increasing the costs of the overall ISP's APBDC, which is contrary to the economic advantages of peering described earlier in this report. In this example, where figures have been taken from a real ISP in Paraguay, there are two reasons behind the high APBDC. First, the ISP does not own the link to the IXP, so we can consider it a leased line, which is generally more expensive than an amortized investment. Second, the link is heavily underutilized as compared to the transit link, so the resulting APBDC is closer to an underutilized leased line, which makes it even more expensive than the transit link.

For a more typical case, please read the aforementioned tutorial maintained at Packet Clearing House website.

Step 3: Improving APBDC

First option: Shifting traffic to the peering link

An effective way of improving the overall APBDC is shifting traffic from high-cost APBDC transit links to low-cost APBDC peering links. In our example, if the ISP were able to shift 10 Mbps (11.5% of the total) from transit to peering, that would reduce the transit from 75 Mbps to 65 Mbps and increase peering from 12 Mbps to 22 Mbps.

Recalculating on those terms, we have

```
APBDC for 65 Mbps at USD 16,000 = USD 93.41 per terabit

APBDC for 22 Mbps at USD 4,000 = USD 68.99 per terabit
```

The overall APBDC does not change, since neither costs or utilization have changed.

If, instead, we hypothesize an exceptional increase in domestic traffic and the ISP is able to shift 25 Mbps to peering, and we assume that costs of the transit link drop to USD 12,000, then the calculations show that

```
APBDC for 50 Mbps at USD 12,000 = USD 91.07 per terabit

APBDC for 37 Mbps at USD 4,000 = USD 41.02 per gigabit
```

which gives a combined APBDC of USD 69.78. Thus, the USD 4,000 savings in transit are reflected in a change from USD 87.23 per terabit to USD 69.78.

Second option: Investing in your own link to the IXP

The peering link at USD 4,000 per month is probably not owned by the ISP, which makes it expensive and not scalable in the long run. If we assume that laying down fiber cable from the

ISP operational center to the IXP costs USD 45,000 and is amortized in 10 years, the cost of the new link is USD 375 per month.

Considering that the initial 12 Mbps now costs USD 375 per month, the new APBDC becomes USD 11.85 per terabit as opposed to USD 123.30—one order of magnitude less. Since the individual APBDC has decreased, the overall APBDC also decreases. Calculating the overall APBDC for 87 Mbps at USD 16,375 give us USD 71.42 per terabit, as opposed to the initial USD 87.23.

Appendix C: Traceroute samples

This appendix includes traceroute samples obtained in Paraguay to map traffic routing and measure delays.

A) Traffic routed nationally, through local interconnections

```
traceroute to itau.com.py (200.12.146.21), 64 hops max, 52 byte packets
 1  cnc-gw.cnc.una.py (200.10.228.126)  3.667 ms  1.036 ms  6.771 ms
 2  br-una2.cnc.una.py (200.10.228.136)  2.194 ms  4.680 ms  7.383 ms
 3  10.255.10.2 (10.255.10.2)  18.649 ms  20.958 ms  23.980 ms
 4  10.1.2.20 (10.1.2.20)  27.040 ms  18.528 ms  15.937 ms
 5  200.85.47.9 (200.85.47.9)  20.183 ms  3.253 ms  3.629 ms
 6  200.85.47.194 (200.85.47.194)  3.838 ms  3.790 ms  5.692 ms
```

```
traceroute to juegosonline.com.py (190.211.243.238), 64 hops max, 52 byte packets
 1  cnc-gw.cnc.una.py (200.10.228.126)  4.333 ms  14.131 ms  2.922 ms
 2  br-una2.cnc.una.py (200.10.228.136)  2.101 ms  2.565 ms  5.881 ms
 3  10.255.10.2 (10.255.10.2)  5.337 ms  4.118 ms  6.290 ms
 4  10.1.2.25 (10.1.2.25)  6.405 ms  12.511 ms  5.860 ms
 5  10.20.40.11 (10.20.40.11)  4.744 ms  5.260 ms  12.838 ms
 6  host242.teisa.com.py (190.211.241.242)  7.736 ms  9.886 ms  13.962 ms
```

```
traceroute to abc.com.py (201.217.5.252), 64 hops max, 52 byte packets
 1  cnc-gw.cnc.una.py (200.10.228.126)  4.697 ms  3.713 ms  2.081 ms
 2  cnc-gw3.cnc.una.py (200.10.228.140)  4.798 ms  3.741 ms  4.159 ms
 3  201.217.5.45 (201.217.5.45)  7.328 ms  2.876 ms  4.222 ms
 4  201.217.63.10 (201.217.63.10)  5.991 ms  3.082 ms  3.451 ms
 5  201.217.63.2 (201.217.63.2)  2.980 ms  6.830 ms  6.364 ms
 6  201.217.62.113 (201.217.62.113)  5.793 ms  3.492 ms  5.050 ms
```

```
traceroute to www.ultimahora.com (190.128.131.250), 64 hops max, 52 byte packets
 1  cnc-gw.cnc.una.py (200.10.228.126)  2.037 ms  2.249 ms  1.187 ms
 2  br-una2.cnc.una.py (200.10.228.136)  2.484 ms  1.400 ms  2.117 ms
 3  10.255.10.2 (10.255.10.2)  23.028 ms  22.039 ms  23.103 ms
 4  10.1.2.20 (10.1.2.20)  21.697 ms  20.847 ms  23.676 ms
 5  200.85.47.85 (200.85.47.85)  20.807 ms  21.899 ms  30.008 ms
 6  200.85.47.3 (200.85.47.3)  17.793 ms  20.106 ms  15.460 ms
 7  172.16.250.252 (172.16.250.252)  18.435 ms  20.909 ms  11.388 ms
 8  172.16.248.14 (172.16.248.14)  16.902 ms  19.008 ms  22.730 ms
```

B) Traffic routed internationally

```
traceroute to bancoatlas.com.py (200.58.117.52), 64 hops max, 52 byte packets
 1  cnc-gw.cnc.una.py (200.10.228.126)  44.759 ms
 2  cnc-gw3.cnc.una.py (200.10.228.140)  26.242 ms  11.601 ms  5.169 ms
 3  201.217.5.45 (201.217.5.45)  4.411 ms  7.139 ms  11.295 ms
 4  201.217.63.10 (201.217.63.10)  49.093 ms  7.358 ms  4.895 ms
 5  201.217.63.14 (201.217.63.14)  4.372 ms  5.686 ms  3.893 ms
 6  201.217.62.12 (201.217.62.12)  3.812 ms  40.650 ms  2.595 ms
 7  201.217.0.66 (201.217.0.66)  3.925 ms  3.401 ms
    201.217.0.74 (201.217.0.74)  4.014 ms
 8  201.217.0.73 (201.217.0.73)  7.354 ms  4.907 ms  10.457 ms
 9  201.217.0.26 (201.217.0.26)  5.445 ms  2.955 ms
10  host57.181-15-41.telecom.net.ar (181.15.41.57)  163.798 ms  165.188 ms  159.551 ms
11  host246.200-3-32.telecom.net.ar (200.3.32.246)  170.115 ms  168.738 ms  161.208 ms
12  host57.200-117-127.telecom.net.ar (200.117.127.57)  143.812 ms  148.358 ms
13  201-234-128-38.static.impsat.net.ar (201.234.128.38)  169.865 ms  173.280 ms
14  dattamax.com (200.58.117.52)  213.481 ms  289.754 ms
```

```
traceroute to google.com.py (74.125.229.184), 64 hops max, 52 byte packets
 1  cnc-gw.cnc.una.py (200.10.228.126)  3.327 ms  4.503 ms  3.807 ms
 2  cnc-gw3.cnc.una.py (200.10.228.140)  14.236 ms  3.797 ms  3.879 ms
 3  201.217.5.45 (201.217.5.45)  4.354 ms  14.902 ms  6.666 ms
 4  201.217.63.10 (201.217.63.10)  3.804 ms  6.302 ms  3.842 ms
 5  201.217.63.2 (201.217.63.2)  3.304 ms  3.721 ms  3.566 ms
 6  201.217.62.24 (201.217.62.24)  5.331 ms  6.544 ms  4.921 ms
 7  201.217.0.70 (201.217.0.70)  3.091 ms
    201.217.0.78 (201.217.0.78)  10.880 ms
    201.217.0.70 (201.217.0.70)  4.982 ms
 8  201.217.0.77 (201.217.0.77)  19.022 ms  4.537 ms  4.248 ms
 9  201.217.0.27 (201.217.0.27)  4.138 ms  8.806 ms  4.679 ms
10  so1-3-2-0-grabueba3.red.telefonica-wholesale.net (84.16.8.229)  23.790 ms  23.553 ms
11  xe5-0-5-0-grtbueba1.red.telefonica-wholesale.net (94.142.119.110)  336.800 ms
12  xe4-1-2-0-grtvapem1.red.telefonica-wholesale.net (94.142.124.41)  56.247 ms
    xe-0-0-2-0-grtvapem2.red.telefonica-wholesale.net (94.142.121.241)  67.203 ms
13  xe6-1-1-0-grtmiabr8.red.telefonica-wholesale.net (94.142.124.30)  173.356 ms
    xe6-1-0-0-grtmiabr7.red.telefonica-wholesale.net (94.142.124.14)  146.527 ms
    xe4-1-0-0-grtmiabr7.red.telefonica-wholesale.net (94.142.121.182)  171.949 ms
14  xe6-0-3-0-grtmiana3.red.telefonica-wholesale.net (94.142.123.5)  142.480 ms
    xe-2-0-0-0-grtmiana3.red.telefonica-wholesale.net (94.142.125.166)  142.704 ms
15  google-xe-7-1-0-0-grtmiana3.red.telefonica-wholesale.net (84.16.6.114)  171.242 ms
16  209.85.253.74 (209.85.253.74)  173.010 ms  170.985 ms  189.640 ms
17  209.85.248.8 (209.85.248.8)  166.093 ms *  168.950 ms
18  mia04s04-in-f24.1e100.net (74.125.229.184)  178.265 ms  166.287 ms  165.344 ms
```

Appendix D: CONATEL development indicators

The regulatory agency CONATEL compiles and publishes biannual telecommunication development indicators on its website.[6] The development indicator matrix is reproduced here. “Total International capacity” is not part of the original matrix and has been obtained fom the Manual Plan Nacional 2010–2015 document.[7] Paraguayan guaraní have been converted to US dollars as a reference point, noting that the exchange rate has floated since 1985, and was 4848.4:1, 4160.17:1, and 4537.5:1 on the three dates in the table. The differing exchange rate over time accounts for the corresponding difference in percentage of annual increase.

	01/12/10	**01/06/11**	**01/12/11**	**Annual increase**
Fixed telephony				
Subscriptions	362,939	364,557	402,136	10.80%
Average monthly income (PYG)	45,707,818,840	28,287,016,108	31,551,624,218	-30.97%
Average monthly income (USD)	9,427,400	6,799,490	6,953,530	-26.24%
Mobile telephony				
Subscriptions	5,920,858	6,219,563	6,529,053	10.27%
Average monthly income (PYG)	247,739,661,226	194,513,328,726	254,178,369,126	2.60%
Average monthly income (USD)	51,097,185	46,756,131	56,017,304	9.63%
Mobile broadband				
Less than 512 Kbps	66,994	47,754	0	-100.00%
Between 512 Kbps and 2 Mbps	150,729	205,587	287,229	90.56%
Between 2 Mbps and 10 Mbps	0	0	0	NA
More than 10 Mbps	0	0	0	NA
Total subscriptions	217,723	253,341	287,229	31.92%
Average monthly income (PYG)	17,522,784,049	20,833,617,968	22,977,040,976	31.13%
Average monthly income (USD)	3,614,136	5,007,880	5,063,814	40.11%
Paid TV				
Subscriptions	87,248	169,648	197,327	126.17%
Average monthly income (PYG)	8,253,895,793	20,300,282,550	22,982,324,683	178.44%
Average monthly income (USD)	1,702,395	4,879,679	5,064,978	197.52%
Fixed broadband				
Less than 512 Kbps	82,617	58,990	35,914	-56.53%
Between 512 Kbps and 2 Mbps	18,937	37,520	71,570	277.94%
Between 2 Mbps and 10 Mbps	2,683	4,008	11,348	322.96%
More than 10 Mbps	16	108	125	681.25%
Subscriptions	104,253	100,626	118,957	14.10%
Average monthly income (PYG)	16,062,557,075	14,605,716,298	17,399,913,506	8.33%
Average monthly income (USD)	3,312,959	3,510,848	3,834,694	15.75%
Total monthly expenditure (USD)	69,154,076	66,954,029	76,934,319	11.25%
Total international capacity (Gbps)	10.61	14.585	14.885	40.29%

Notes

[1] A comprehensive list of Internet exchange points is available at the IXP directory maintained by Packet Clearing House, http://www.pch.net/ixpdir.

[2] Figure calculated from data obtained from six Internet service providers during in-person consultation in September 2012.

[3] This section adapted from Woodcock and Edelman, "Toward Efficiencies in Canadian Internet Traffic Exchange," September 2012. http://www.scribd.com/doc/105832435/Toward-Efficiencies-in-Canadian-Internet-Traffic-Exchange.

[4] Based on actual figures gathered through in-person consultation with service providers.

[5] See http://www.pch.net/resources/tutorials/average-per-bit-delivery-cost/APBDC-Tutorial-v09.txt.

[6] From http://www.conatel.gov.py/documentos/Matriz%20de%20Indicadores%20de%20Desarrollo%20a%2012_2011%20actualizado%20agosto%202012.pdf.

[7] From http://www.conatel.gov.py/documentos/MANUAL%20PLAN%20NACIONAL.pdf.