

# South Asian Broadband service quality: diagnosing the bottlenecks<sup>1</sup>

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## 1 Abstract

The developing countries have lately experienced a surge in mobile phone adoption. New investment into the telecom sector has enabled network roll-out, and increasingly innovative business models have driven down network operation costs and customer acquisition & retention costs, enabling pricing to be lowered significantly (Samrajiva, 2009). The result is that people who, just a few years ago were unable to afford any form of telephone are now purchasing mobile phones and SIM cards and using them to make calls and send SMS. Given the dearth of fixed access networks, developing nations, especially those in South Asia, depend on mobile phones to take their citizens online. All these new consumers are naturally creating increased demand for Internet capacity. At the same time, the demand for Internet access capacity is increasing because many South Asian countries (particularly India, and to a less extent others such as Sri Lanka) have been at the forefront of attracting a significant share of the booming market for business process outsourcing.

While new consumer numbers are growing, tests performed by LIRNEasia in India, Bangladesh and Sri Lanka show that users get low value for money from their broadband connections when compared to North American counterparts.

Using only data publically available, we could hypothesize that the poor performance of South Asian broadband in terms of throughput (upload speed, download speed), jitter, latency and other measurable dimensions is due to the lack of international capacity (as opposed to the local access network capacity or in-country backhaul capacity). For example, we know that while the region has surging demand, the supply of international connectivity has not caught up to the demand (Telegeography, 2010). Therefore South Asian internet service providers end up paying significantly higher fees for international connectivity when compared even to their East Asian peers (Telegeography, 2009).

We test our hypothesis using a broadband quality of service testing methodology developed jointly by LIRNEasia and the Indian Institute of Technology, Madras. The results confirm that international connectivity is indeed a significant choke point when accessing the Internet and negatively impacts the service quality of broadband.

Individual countries or individual ISPs cannot do much in the immediate or near term to increase international leased line capacity and prices (due to relatively long lead times required to actually lay the cable, and the seemingly longer time some countries require to agree on the rules related to the consortia that participate in the cable). However, our testing provides data on a second choke point, one that is very much within the control of the ISPs. The points where two or more ISPs exchange traffic (network access points/NAPs, or Internet exchanges/IXPs) turn out to be choking points also. While ISPs in smaller/developing countries may not have control over international NAPs/peering points, the local NAPs and IXPs are very much within their control. Real-world examples show that when a country sets up at least one IXP, it is able to achieve a significant rationalization of demand for international capacity because local traffic is kept local, instead of being exchanged internationally. The resulting lower cost and higher quality of the connectivity justifies the relatively small investment required to set up an IXP. However due to a host of issues, it is possible to have an IXP and not get the benefits – we show

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quality testing data from India (which has a network of IXPs) that confirms this. Therefore while we push strongly for the establishment of IXPs, we will caution about getting the technical models and business incentives aligned towards its proper functioning.

## 2 Broadband in South Asia: delayed start, but steady growth in adoption

Access to ICTs is increasingly a large part of the development agenda, due to the proven micro and macro level positive impacts of ICTs (see among others Waverman, Meschi and Fuss, 2005; Souter et al., 2005; Jensen, R., 2007; Akers, J.C., 2008; Goyal, A., 2008). Initiatives to increase the access to and use of the Internet has taken prominence among activities of many governments and civil society organizations, and increasingly it's considered a basic human right.

However, Figure 1 shows that South Asia (and indeed other developing regions of the world) has a long way to go to achieve acceptable levels of Internet access and use, compared to the developed world.

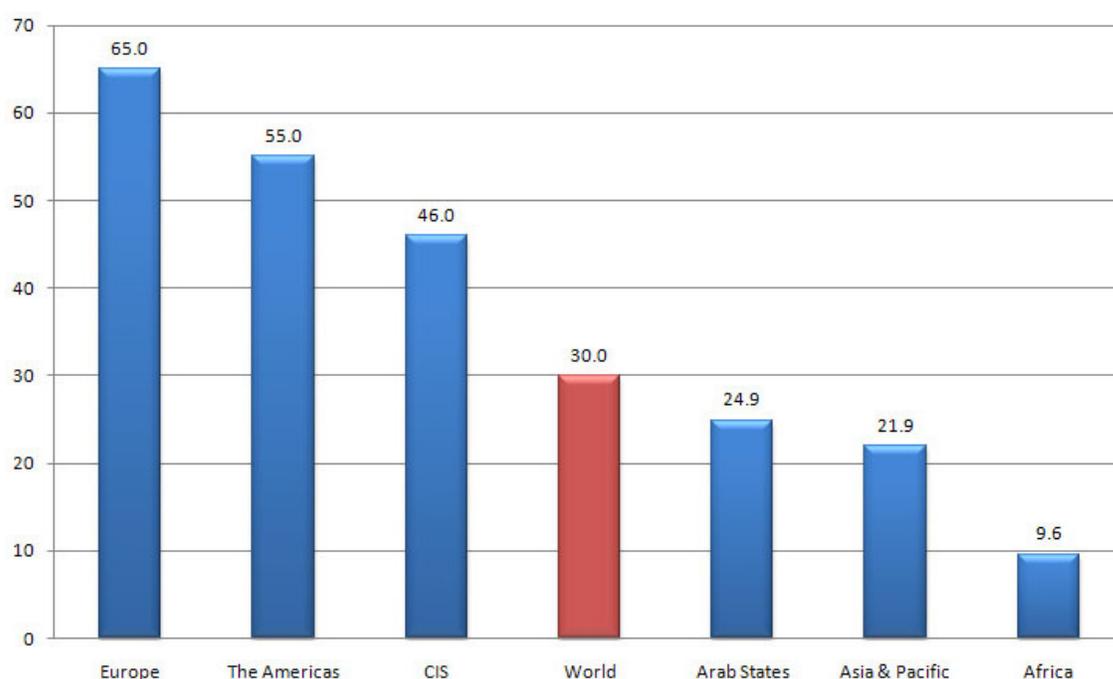
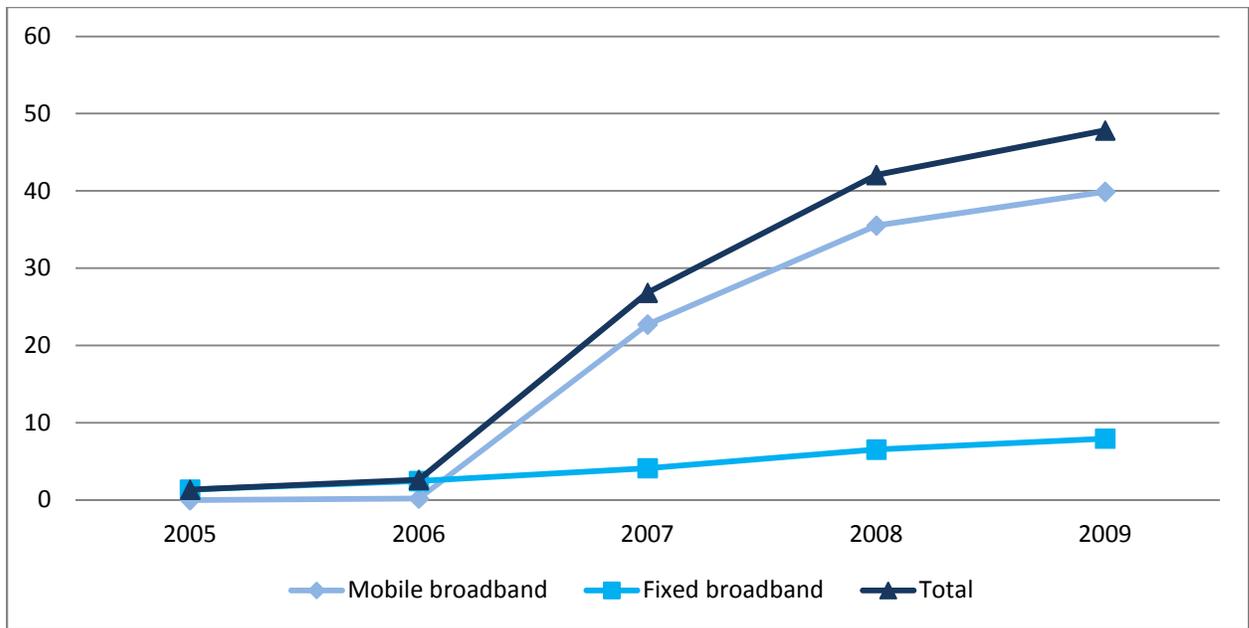


Figure 1: Internet users per 100 population. (ITU, 2010). See footnote<sup>4</sup>

However, evidence is increasingly showing that the developing countries, particularly the South Asian region will be able to bridge the gap – the significant growth of mobile broadband even in the absence of widespread fixed copper or fiber access networks is evident (Figure 2). Indeed literature shows that developing nations will come online via predominantly wireless technologies (Badmino, Anna, 2005) skipping the fixed altogether.

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<sup>4</sup> Note: Estimating the number of internet users is challenging due a number of reasons as acknowledged even by the ITU. Supply-side data is used in these estimates, and it's difficult to avoid over- or under-counting users (one user may have mobile and fixed internet connections, one connection may be used by multiple users, and so on). Counting mobile internet users is even more complicated because operators still only count users who subscribe to a data plan or have purchased a data dongle, leaving out users who access internet through their mobile phones on a pre-paid basis. However, the above graph is indicative of the usage gap/disparity in the regions.



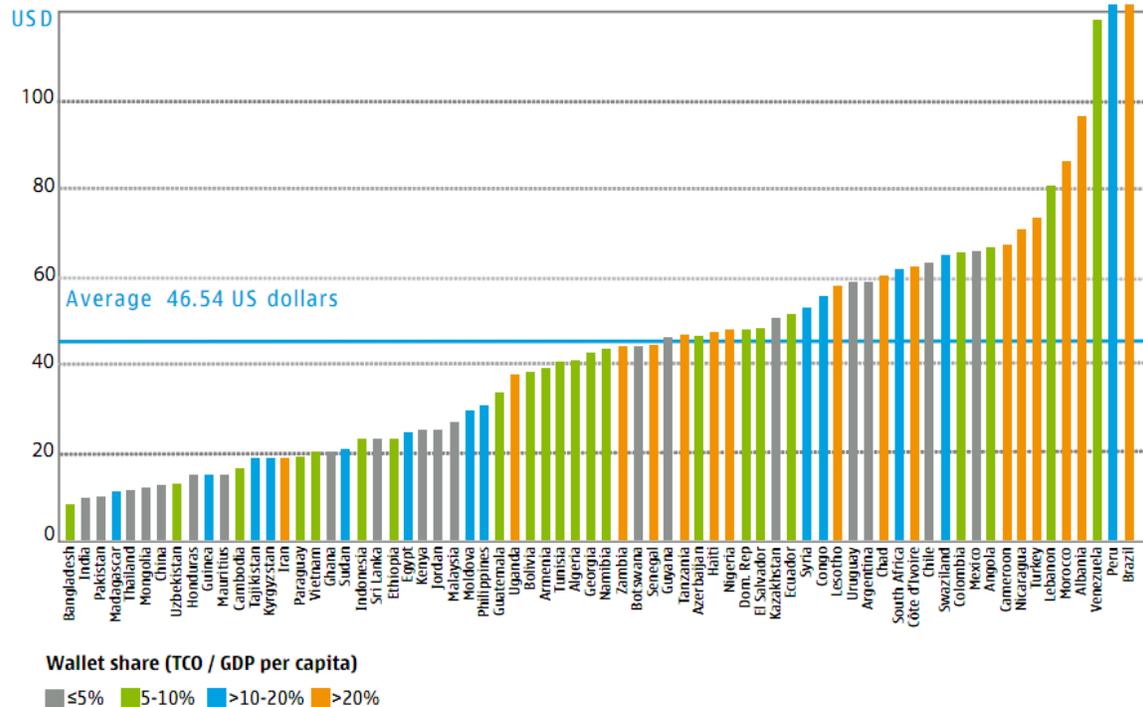
**Figure 2: Broadband users per 100 population (ITU Statistics, Dynamic Reports<sup>5</sup>)**

Given that a large portion of the world's poor live in South Asia, affordability is going to play a key role in determining adoption. As Nokia (Expanding Horizons, 2009) shows, many of the South Asian countries offer low prices as measured by total cost of ownership for basket of Internet and voice use typical for a lower income user<sup>6</sup> and these prices are affordable. For example Figure 3 shows that prices in India, Pakistan, Bangladesh and Sri Lanka are considerably lower than the average of USD 46.54. Further, India, Pakistan and Sri Lanka offer a total cost of ownership (TCO) that is less than 5% of their GDP while Bangladesh offers a TCO for under 10% of its GDP and enjoys the lowest TCO (among countries studied) of USD 8. This implies the South Asia offers some of the most affordable prices (handsets as well as service tariffs) that make access to Internet services via mobile phones viable for those at the bottom of the economic pyramid<sup>7</sup>.

<sup>5</sup> Dynamic report generated on-demand and available at: [http://www.itu.int/ITU-D/ict/eye/Reporting/ShowReportFrame.aspx?ReportName=/BDT/DynamicReportPublic&ReportFormat=HTML4.0&RP\\_intLanguageID=1&RP\\_strCodeIDs=422,5114&RP\\_intClassID=0&RP\\_strCountryIDs=6,34,44,113,149,171,182,54&RP\\_bitLatest=False&RP\\_intYearFrom=2005&RP\\_intYearTo=2009&RP\\_strGrouping=rbTrendCty\\_rCod\\_rYer\\_c](http://www.itu.int/ITU-D/ict/eye/Reporting/ShowReportFrame.aspx?ReportName=/BDT/DynamicReportPublic&ReportFormat=HTML4.0&RP_intLanguageID=1&RP_strCodeIDs=422,5114&RP_intClassID=0&RP_strCountryIDs=6,34,44,113,149,171,182,54&RP_bitLatest=False&RP_intYearFrom=2005&RP_intYearTo=2009&RP_strGrouping=rbTrendCty_rCod_rYer_c)

<sup>6</sup> Calculated as handset cost + service cost + tax/charges. Handset cost is 1/36 of the lowest cost of handset in the country (assuming an average hand-set is used for 3 years, the cost is one-thirty sixth for a month). The taxes and charges include taxes on both handset and service, including value added, sales tax, custom duties and/or specific telecommunications tax. The service charge is calculated based on a "typical middle-income emerging market mobile data subscriber" and includes 165 voice minutes, 174 SMSs, 1 MMS, 2.1 MB of other data traffic, 1 ring-back download and 3.7 premium SMSs.

<sup>7</sup> Getting data on percentage of broadband enabled mobile phones is not straightforward in Asia due to the high number of "black market" phones that enter the market and therefore are not countable in supply side data. While nearly all handsets are internet enabled, various online sources claim that the majority of handsets are still not broadband/3G/3.5G enabled. But we know this situation is changing, with cheap, broadband ready handsets manufactured in China or India now flooding the South Asian Market and driving prices down. And while operators have seen margins squeezed with the global economic downturn, they are now beginning to re-invest in infrastructure in the region, and the investment is going towards upgrading network speeds (moving to LTE, for example)



**Figure 3: Total Cost of Ownership for mobile voice and data (Nokia, 2009)**

However lower prices often come at a cost, or in other words, higher quality often comes at a higher price. In the next section we present broadband performance data from South Asia to explore this angle.

### 3 Low quality = low prices in Asian Broadband?

We saw above that South Asian consumers can experience reasonably affordable voice and broadband, and that is one of the factors helping its adoption. However, price is just one side of two a sided coin – the other side is quality. The relationship between price and quality is often an inverse one – higher quality services are pricier and lower quality services are cheaper, at least in sufficiently competitive markets.

Samarajiva (2009) and Nokia (2009) showed that in voice markets, indeed the tradeoff between quality and price exist: South Asian consumers enjoyed some of the lowest voice calling prices in the world, thanks to innovative business models that were developed by the operators, but network quality was compromised in connecting large numbers of consumers at very low prices.

A testing methodology designed by LIRNEasia and Indian Institute of Technology (Madras) provides insight into the broadband/data service quality experienced in South Asia. The methodology depends on a crowd-sourcing model where volunteers download a software that then runs at regular intervals each day to measure broadband quality along various dimensions (such as download speed, upload speed, round trip time, jitter, packet loss and availability). This enables benchmarking across countries and packages offered by various operators from chosen locations/cities. Because each indicator is measured multiple times (six time slots a day, multiple days per week and weekends and so on) and outliers are taken out, the averages that are reported are a good measure of actual performance. See Gonsalves, T.A & Bharadwaj, A., 2009 for the details on the methodology and software.

Figure 4 shows the results from a rounding of tests run in September 2009, plotted based on a price of the broadband connection. It shows that for each dollar spent, South Asian consumers receive lower performance (as measured by download speed in Kbps per USD) than their North American counterparts.

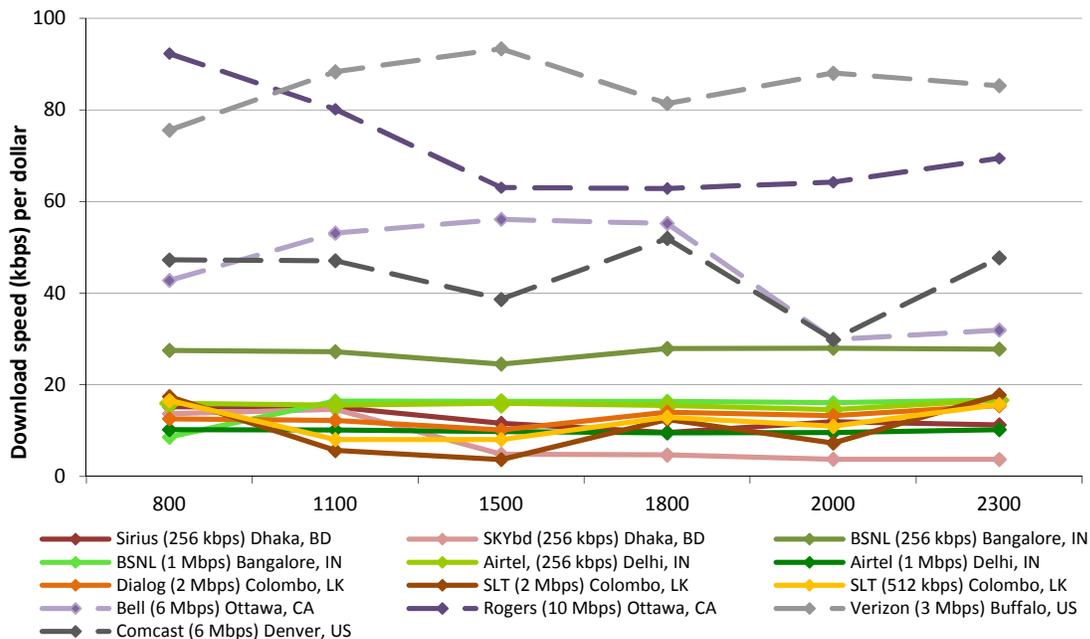


Figure 4: Value for money of broadband packages in South Asia and North America (LIRNEasia, 2009)

With the relative low-performance of South Asian broadband thus established, we can now explore possible reasons for poor performance.

## 4 Identifying the bottlenecks

### 4.1 International Connectivity

The broadband quality of service experience (QoSE) testing methodology that provides the data for this paper is capable of testing performance in different parts of the network. For example, it can measure quality indicators for downloading data hosted on the user's own ISP, for downloading data hosted on a competing ISP's server in the user's country or for downloading data hosted in a server at some pre-specified international location. It can measure not just download speeds from these locations, but also upload speed, round-trip time, jitter and other relevant quality indicators.

Such fine-tuned testing enables us to identify the first possible bottleneck in the Internet user experience for South Asian users.

The graphs laid side by side in Figure 5 show that download speeds deteriorates significantly as users in four cities in India (New Delhi, Bangalore, Chennai and Mumbai) attempt to access a data hosted on a server within his/her own ISP and then attempt to access data hosted on an international server (in the US, in this case).

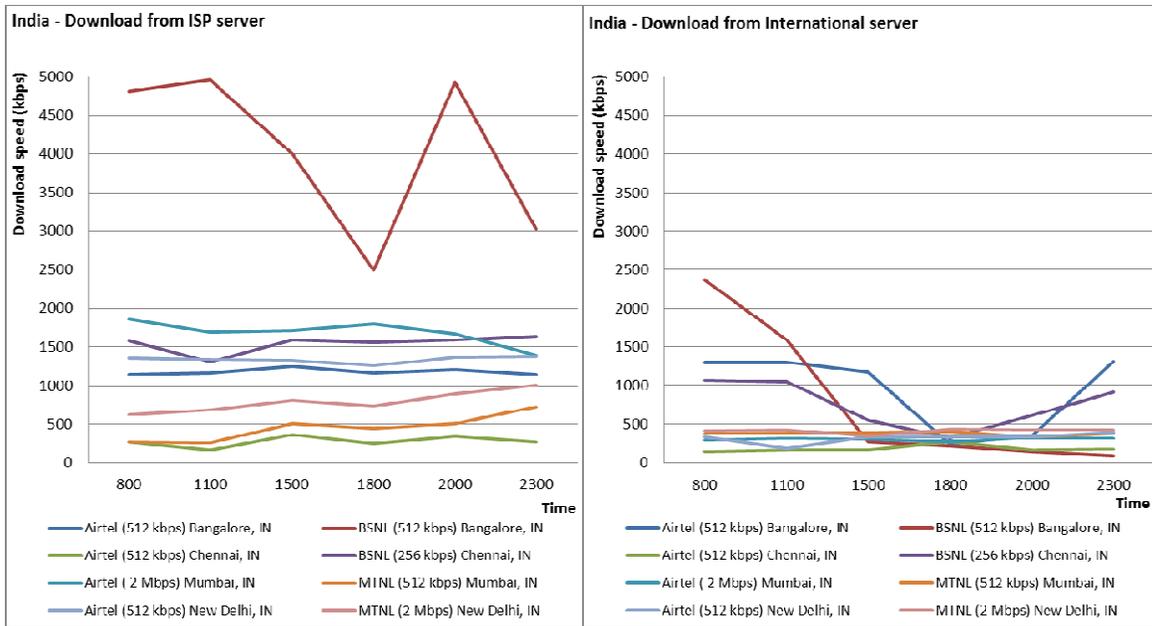


Figure 5: Download speeds from ISP vs. international server when tested from multiple cities in India (LIRNEasia, 2010)

Similar deterioration of performance is experienced from Sri Lanka as well, as demonstrated by the results when testing from Colombo, Sri Lanka (Figure 6).

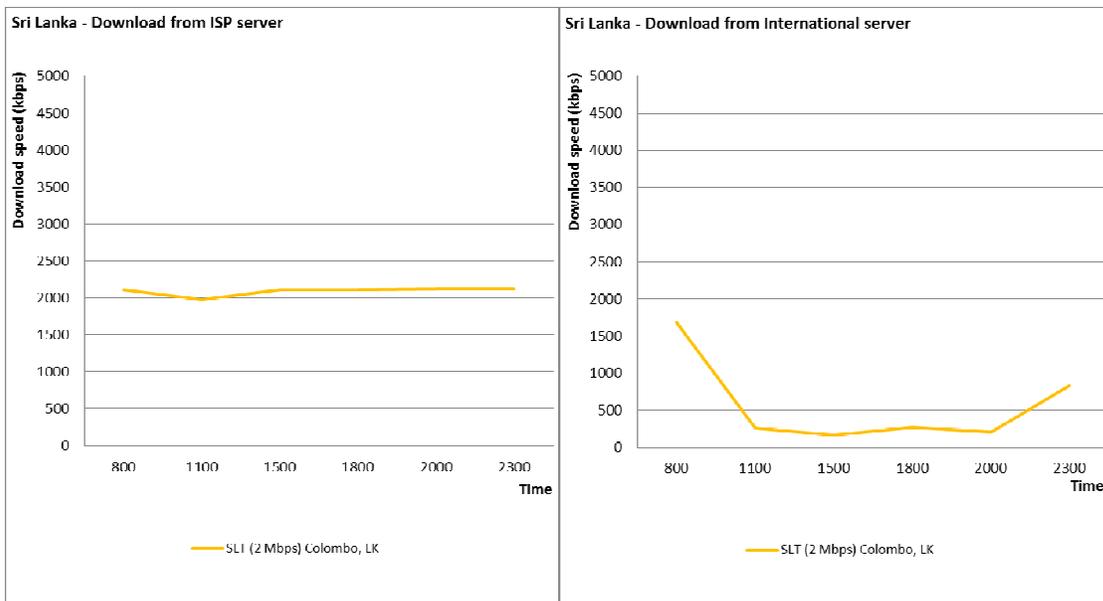


Figure 6: Download speeds from own ISP, local (in-country) ISP and international server when tested from Colombo, Sri Lanka (LIRNEasia, 2010)

Similarly, round-trip time deteriorates when the user accesses international data, as opposed nationally<sup>8</sup> hosted data (Figure 7)

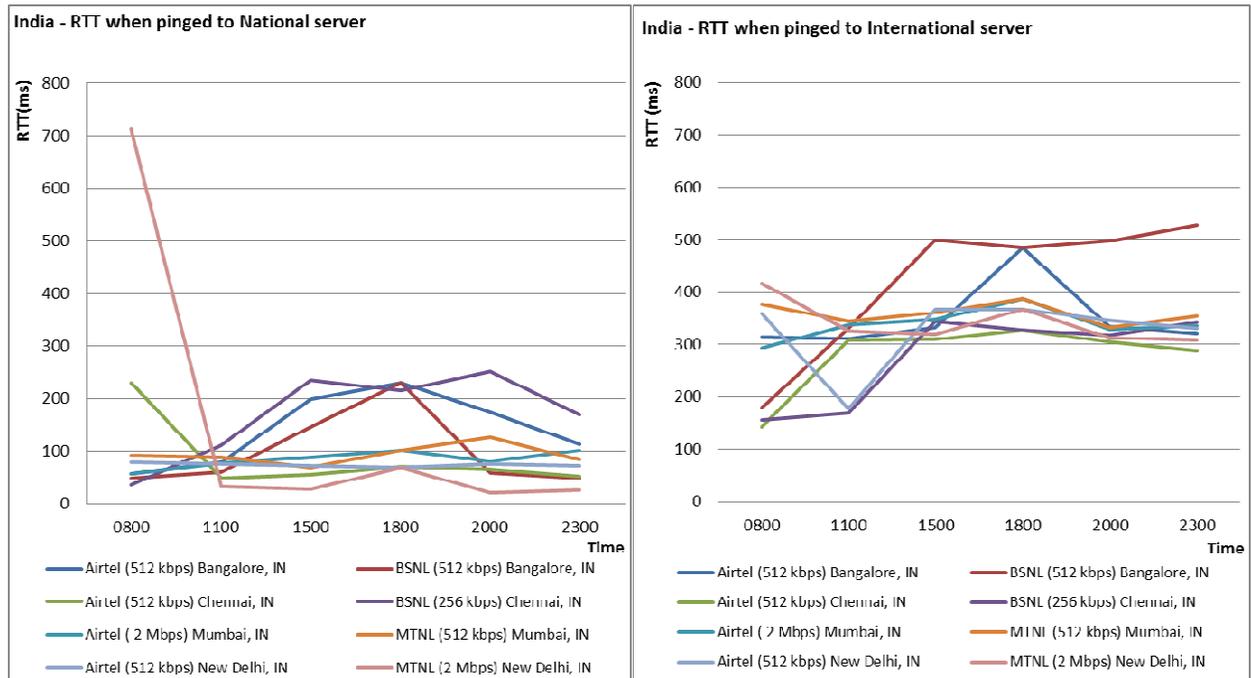


Figure 7: Round trip time to in-country server vs. international server (LIRNEasia 2010)

All of the above point to international connectivity as a significant bottleneck in the quality of broadband as experienced by the users of the countries tested.

Figure 8 shows the installed and planned undersea cables across the world, with the capacity represented by the thickness of the lines. We see that the majority of the cables lie in the Pacific and Atlantic Oceans, connecting Europe to the North American East Coast and East Asia to North American West Coast. The low international connectivity capacity South Asian countries experience is coupled with growing demand for the Internet by its citizenry.

<sup>8</sup> "Nationally hosted" means the data is hosted on a competing ISPs server but inside the geographic limits of the country under discussion/being tested.



Figure 8: Global undersea cable capacity, installed and planned up to 2011 (Telegeography, 2010)

While international capacity is low, countries in South Asia are experiencing high growth in Internet activity because more and more citizens are coming online (predominantly through mobile technologies, but also through other means). A booming Business Process Outsourcing and/or IT enabled services market are increasing the demand for international bandwidth. Majority of the content accessed by South Asian users are hosted overseas, further increasing the international traffic. For example, Table 1 shows the top 10 websites accessed by users in India, Bangladesh, Pakistan and Sri Lanka in April 2011. Majority of sites accessed are “foreign” sites where the content is hosted overseas (and perhaps even generated overseas). Even for sites where the content generation is local (for example, ElaKiri.com is an online community for Sri Lankan users who engage in discussion forums and upload music videos and photos), the site is hosted overseas. Further, it may be possible to have sites with a local top-level-domain name (i.e. those ending with .lk, .in, .pk or .bd, such as orkut.co.in) immediately re-direct to an overseas server, thereby eliminating the need to host the data in-country.

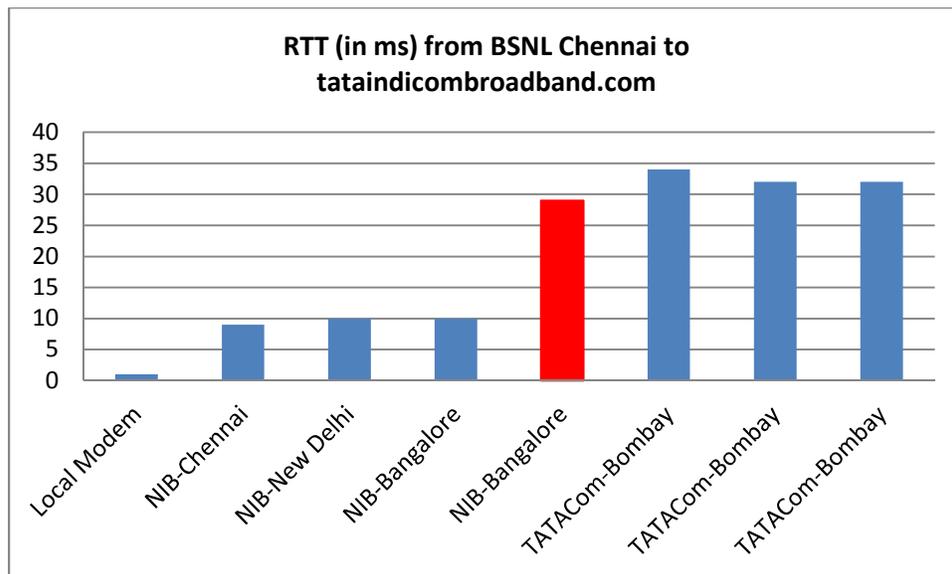
Rank	Sri Lanka	India	Pakistan	Bangladesh
1	Google (google.lk)	Google India (google.co.in)	Google (google.com.pk)	Google (google.com)
2	Facebook (facebook.com)	Google (google.com)	Google (google.com)	Facebook (facebook.com)
3	Google (google.com)	Facebook (facebook.com)	Facebook (facebook.com)	Yahoo! (yahoo.com)
4	YouTube (youtube.com)	Yahoo! (yahoo.com)	YouTube (youtube.com)	Blogger.com (blogspot.com)
5	Yahoo! (yahoo.com)	YouTube (youtube.com)	Yahoo! (yahoo.com)	YouTube (youtube.com)
6	Blogger.com (blogspot.com)	Blogger.com (blogspot.com)	Blogger.com (blogspot.com)	Google (google.com.bd)
7	Espncriinfo.com	Wikipedia (Wikipedia.org)	Windows Live (live.com)	Espncriinfo.com
8	Wikipedia (Wikipedia.com)	Twitter (twitter.com)	Wikipedia (Wikipedia.com)	oDesk (odesk.com)
9	Gossip Lanka News (gossiplankanews.com)	Rediff.com India Ltd. (rediff.com)	Twitter (twitter.com)	Prothom Alo (prothom-alo.com)
10	ElaKiri.com	Orkut.co.in	Espncriinfo.com	Wikipedia (Wikipedia.com)

**Table 1: Top 10 sites accessed by users in April 2011 by country (Source: [www.alexa.com](http://www.alexa.com)).**

The result of this high demand for and low supply of international bandwidth is that South Asian countries pay a premium for such connectivity. For example, Telegeography (2009) finds international connectivity prices for Asia to be three times higher than those in the West<sup>9</sup>. This is despite increased competition that has reduced backhaul costs at certain major Asian hubs such as Hong Kong and Singapore.

#### 4.2: Network Access Points/Internet Exchanges

Using the same quality of service testing methodology, we examine the route taken by a packet of data (again, multiple trace-routes performed multiple times of the day by multiple users etc.). The example in Figure 9 below shows the round-trip times for all the “hops” (servers traversed through for the packet to move from source to destination) in reaching an in-country server of a competing ISP. We see that going from one ISPs network (NIB’s network in this case) to another (TATACom’s network) imposes significant delays.



**Figure 9: Round trip time (RTT) to access in-country server (Gonsalves, T.A, 2009)**

Figure 10 also shows similar results for the deterioration in speed when moving from the Airtel Network to TATACom.

<sup>9</sup> Global Internet Geography Pricing, *TeleGeography* 2009.

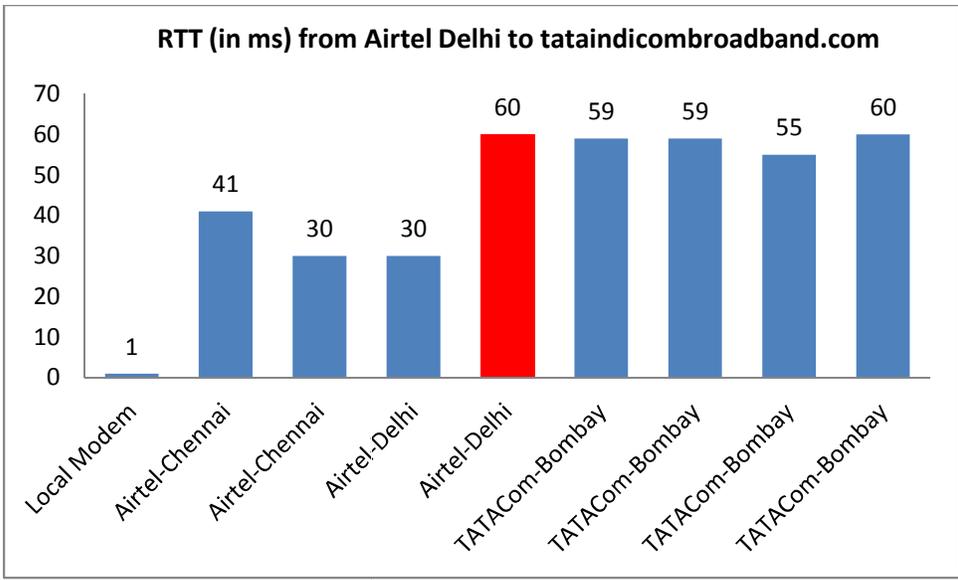


Figure 10: Round trip time to access in-country server (Gonsalves, T.A, 2009).

Another indicator, download speed, also deteriorates depending on whether the data is hosted within the user's own ISP or on a competing ISP's networks within the same country, as shown in Figure 11 and 12 for India and Sri Lanka, respectively.

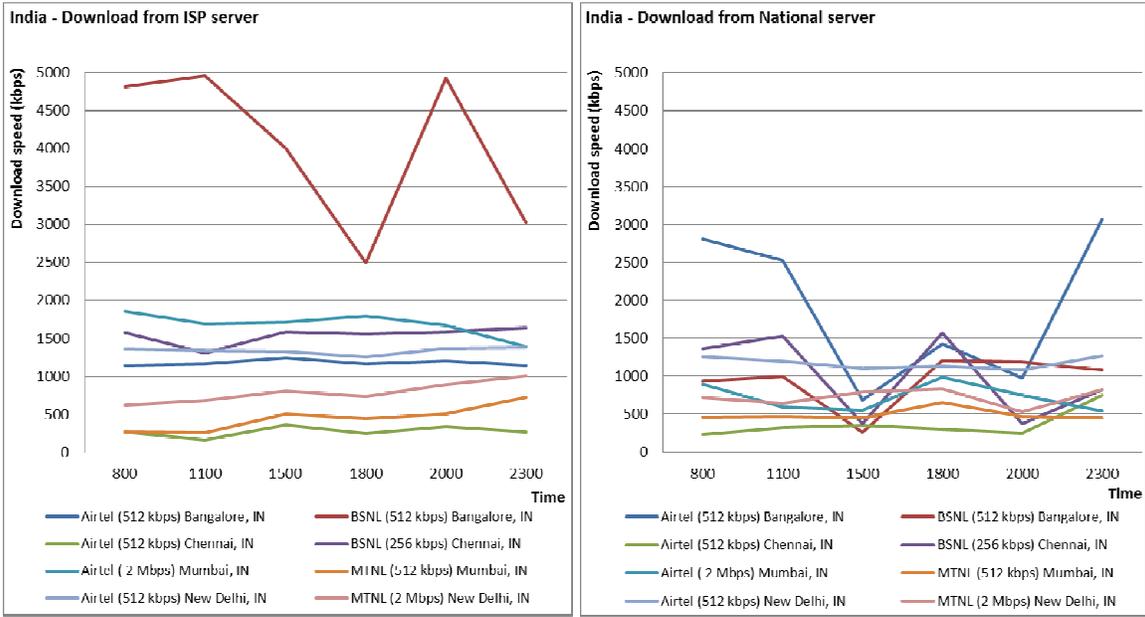
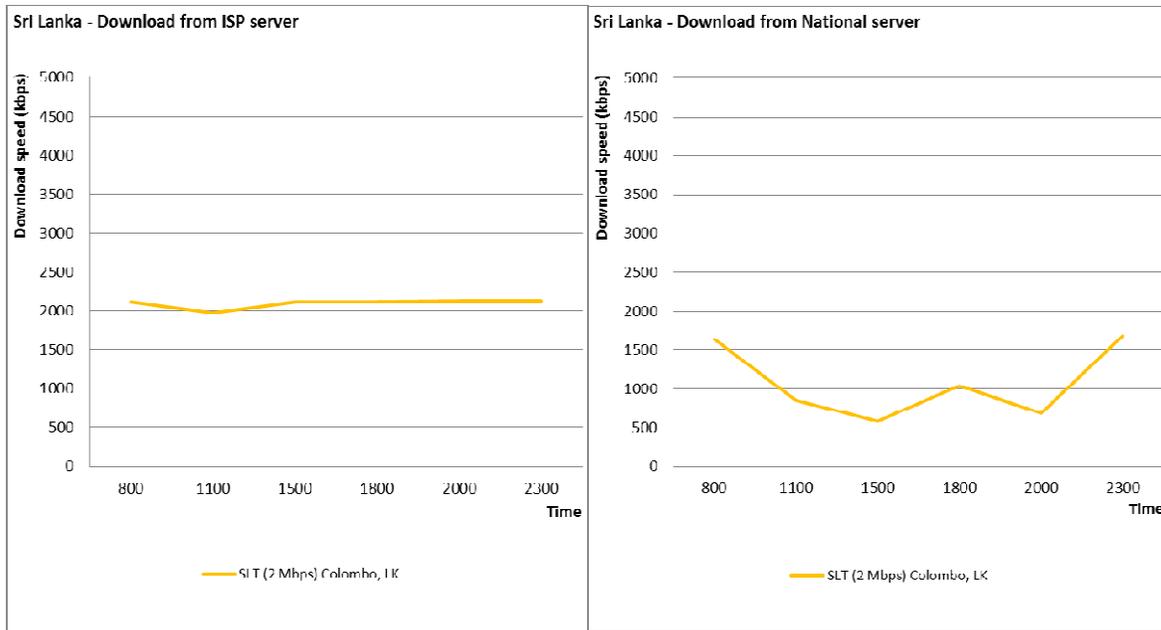


Figure 11: Download speed from multiple cities in India when accessing a server on the user's own ISPs vs. a server on a competing ISP's server located in India (LIRNEasia, 2010)



**Figure 12: Download speed from Colombo, Sri Lanka when accessing a server on the user's own ISP vs. a server on a competing ISP's server located within Sri Lanka (LIRNEasia, 2010)**

Therefore, the second bottleneck we can identify through this testing is the gateway to other ISPs. While two networks may connect to each other directly to exchange traffic, when more than two networks need to exchange traffic among each other it becomes more efficient to install a switch, or an Internet Exchange Point (IXP, for short) to which all networks can connect. India has about seven IXPs, therefore the bottle-necks identified above in Figures 11 and 12 hint at problems with the IXPs. Lower-than-optimal capacity to/at the IXP is a significant problem that needs to be addressed to ensure IXPs don't choke traffic. In Sri Lanka, low port capacity of the ISPs at the IXP meant (that at least in the recent past) most operators bypassed it and went directly to the Internet cloud, even for in-country traffic.

When done right with sufficient capacity, an IXP helps reduce the demand on international bandwidth by keeping in-country traffic within the country. In the absence of an IXP, every time two ISPs in a country need to exchange traffic, the data needs to be sent to the Internet cloud (outside of the country), until a peering point is found. Further, instead of each operator paying separately for an international leased line, the IXP can purchase and send/receive traffic through the leased line on behalf of all operators, saving significant money. Further, because the IXP aggregates all international traffic, the possibly higher volume may enable the IXP to negotiate better terms in purchasing transit or peering with other international ISPs. Jensen (2008) provides a theoretical discussion on this topic and provides examples of cost savings achieved due to the establishment of IXPs in various countries.

While the advantages of IXPs are high, not all countries have managed to establish them. By February 2011, only 89 countries in the world had one or more IXP while 158 did not. In South Asia, Nepal, Bhutan, Maldives had not established an IXP (PCH, 2011). Even when an IXP does exist, as in India, we see from the test results presented in Figures 9 - 11 that the IXPs act as a bottleneck when passing traffic from one exchange to another. There are several possibilities for bottlenecks at the IXP; a lower bandwidth allocated at the peering routers is one. For instance the National Internet Exchange of India (NIXI) offers five different tariff plans<sup>10</sup> for the varying port capacities. As such, it is likely that some traffic may flow from a link of higher capacity to one with lower capacity thereby creating an inherent block. This potential issue is not confined to IXPs only. The

<sup>10</sup> <http://nixi.in/en/routing-and-tarrif-policy>

capacity at the peering points or the lack of it rather, is cause for concern even in cases of bilateral peering. In the case of smaller service providers joining an IXP it is likely (bearing costs in mind) that the cheapest / lowest capacity leased line connections are obtained, which presents a further bottleneck.

In addition, IXPs require co-operation between competing ISPs, often third party intervention (by an independent consultant or the government) is used in negotiating the terms and conditions, and a third party (often non-for-profit) company is set up for the IXP. This process may not be smooth. Even if it is, perverse incentives to not participate fully in the IXP process exist. For example, the dominant operator may often have an incentive to choke the connection to the IXP, so that users from other ISPs are “forced” to the dominant ISP in order avoid the deterioration in quality.

## 5 Conclusions and Next Steps

In this paper, we used data from a broadband performance testing methodology (and software) to assess overall quality of the Internet as experienced by users in South Asia. We have demonstrated through data that the value for money received by the users in these countries is lower when compared to those in North America.

We then used more data from the same methodology/software to identify choke-points (bottle-necks) in the internet pipe. The data clearly points to international connectivity and Internet exchanges as bottlenecks.

International connectivity suffers from a classic case of (lack of) competition – the supply is low at present (though new undersea cables are planned for in the near future) while the demand is growing almost exponentially due to more and more users coming online, a booming business process outsourcing business, lack of locally hosted content and the lack of IXPs causing even local traffic to be sent out of the country before being exchanged. Clearly one of the solutions is to install (or purchase, if capacity exists) more international capacity. However, installing undersea cable is costly - in terms of actual cost and also co-ordination costs because a consortium of operators is usually needed to finance it.

The second solutions would be to establish one or more IXPs. However even in a country such as India which has a network of network peering points, the exchange itself is shown to be a bottleneck as per the quality testing data we provide. Clearly then, simply having an IXP is not sufficient – dimensioning the IXP appropriately, removing incentives for a dominant ISP to participate but severely under-provisioning the link to the IXP (thereby forcing users to switch) are issues that need to be dealt with in order achieve the benefits of IXPs<sup>11</sup>. However, many countries have yet to overcome these issues. Therefore, while waiting for more international cable capacity to be installed, developing nations can achieve immediate reductions in costs in improvements in quality by installing well designed IXPs.

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<sup>11</sup> While these are issues that regulators can monitor/regulate, successful IXPs have been set up by third parties who have managed to bring the operators together and find common ground without regulatory involvement. What works in each country will differ.

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