Volunteer Computing Model Prospects in Performance Data Gathering for Broadband Policy Formulation (*)

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Abstract: The recent unprecedented growth of telecom facilities has offered the Internet users in most Asian countries a flavour of broadband. Yet, despite rosy promises by telcos, the user experience has often been less than ideal. These challenges can only be overcome by right policy decisions based on evidences. Thus, monitoring the broadband Quality of Service Experience (QoSE) becomes more than an attempt to ensure quality delivery and create a basis for policy formulation.
The first approach to monitoring QoSE, is the regulator reaching deep into the innards of the telecom network to install monitoring equipment and taking remedial actions, specified under the licenses or the governing statute, when the data indicate below-standard performance. Dearth of financial and human resources can be the key challenge in such a direct approach. The second approach is based largely on user activism, where educated users voluntarily contribute their time and computing resources towards building a performance database which in turn will be used in creating the bigger picture. A comprehensive methodology to benchmark Broadband Quality of Service Experience (QoSE), based on the latter approach has been developed jointly by LIRNEasia and TeNet group of Indian Institute of Technology (IIT) Madras. This methodology uses AT-Tester, an a open source based software tool to monitor all crucial QoSE broadband metrics over a longer period, on both week days and week days covering peak as well as off peak traffic. The traffic is also monitored within segments, ISP, local and international. The methodology adapts the concept of Volunteer Computing (or Public Service Computing). The paper analyses how this approach could be used in broadband policy formulation.
Key words: Broadband, quality of service, volunteer computing.

(*) This research has been funded through a grant from the International Development Research Centre (Canada) and the Department for International Development (UK). The authors also acknowledge the contribution of Prof. Timothy Gonsalves (IIT Madras), Mr. R. Thirumurthy (Midas) and Ms. Helani Galpaya (LIRNE*asia*).
The paper was presented at the Experts Workshop; *Beyond Broadband Access: A data based information policy for a new administration*, 22-24 September 2009, Washington DC, organised by the New America Foundation

International Telecommunication Union (ITU) refers to broadband as 1.5 – 2 Mbps (ITU, 2003) while, Organisation for Economic Cooperation and Development (OECD) accepts 256kbps as the threshold (OECD, n.d.). [1] A publication by Partnership for Measuring ICT for Development (2009) defines broadband as an Internet service of at least 256 kbps in one or both directions. The US Federal Communication Commission has specified 768 kbps as the minimum speed for Broadband (KANG, 2009).

It has been noted in the available literature that provision of broadband would enable the diffusion of certain services to the public. Services such as e-gov, e-health (tele-medicine) and distance education require broadband connectivity (RAMIEREZ, 2007). Broadband has also enabled cheaper communication through Voice over Internet Protocol (VoIP). The impact of broadband is now beginning to appear on the economic statistics (KRUGER & GILROY, 2008). According to ARBORE & ORDANINI (2007, p. 83):

> "The importance of broadband in the business sector is related to the higher potential for data interchange and multimedia applications".

According to the latest OECD data, as at Q4 2008, broadband access per 100 inhabitants in OECD countries stood at 22.35 with Denmark being the highest, 37.18. According to an OECD report some countries have already reached 100% coverage, and prices have fallen since 2006. According to the same report:

> "Data on penetration, price, speed and usage of the Internet highlight how member countries have promoted competition, encouraged investment and worked together with the private sector to increase connectivity" (OECD, 2008, p. 8).

In comparison to the OECD, broadband penetration in emerging Asia is low. [2] However, two of the fastest growing markets, Philippines and Vietnam, grew at rates of 68.47% and 60.94%, respectively during the period 2007-2008 (SILVA, 2009). Overall, prices have come down making the service more affordable. A similar pattern is seen in South Asia (India, Pakistan, Bangladesh, Sri Lanka, Nepal, Bhutan, Maldives and Afghanistan). According to the ITU, the total number of fixed broadband subscribers has grown by 68.5% from 2007-2008 and the number of mobile broadband

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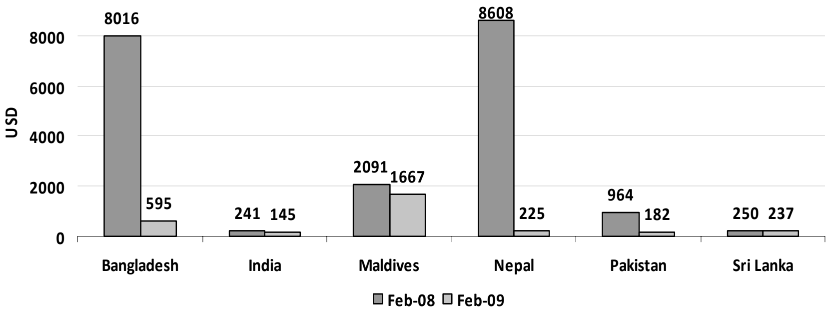
[1] ITU definition for Broadband: Recommendation I.113 of the ITU Standardization Sector: "transmission capacity that is faster than primary rate Integrated Services Digital Network (ISDN) at 1.5 or 2.0 Megabits per second (Mbits)".

[2] This is according to the available data on ITU database, 2008.

connections grew by 218%. In between February 2008-February 2009, the price of a 256kbps fixed broadband connection has reduced in all South Asian countries (LIRNEasia, 2009, 2008). As shown in Figure 1, the biggest change in price was seen in Nepal and Bangladesh.

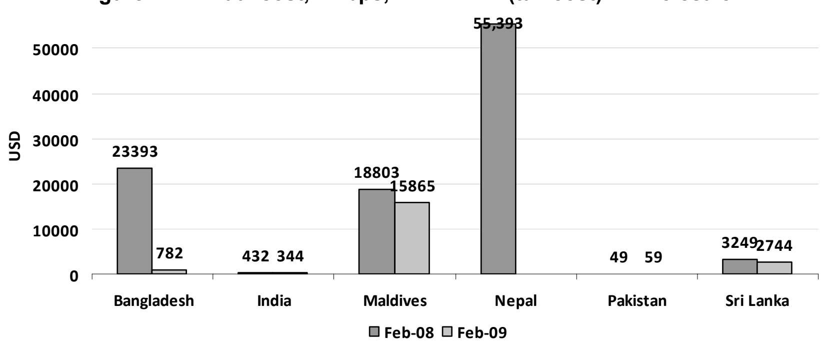
Figure 1 - Annual cost, 256kbps broadband business connection (unlimited download).



Source: LIRNEasia Broadband Benchmarks, February 2008, February 2009

The drop in retail prices in South Asia, as shown in Figure 1, has been made possible, in part, by a drop in wholesale prices though the price drops are not as large as the retail sector. The drop in wholesale prices between February 2008 and February 2009 is shown in Figure 2. Bangladesh exhibited the most significant drop.

Figure 2 - Annual cost, 2Mbps, 2km DPLC (tail cost) – Wholesale



Note: Data for Nepal for February 2009 is not available

Source: LIRNEasia broadband Benchmarks, February 2008, February 2009

The data, as shown above, depicts an increase in demand for broadband, yet increased demand and usage have posed challenges in terms of Quality of Service Experience (QoSE) [3]. Complaints about quality have been voiced in the emerging markets for some time. User complaints are not the only thing driving interest in QoSE – there is increasing recognition that certain QoSE levels need to be maintained in order to enjoy the full economic and social benefits of broadband. As such, policy makers and regulators too have turned their attention to QoSE. Recently, the European Union commissioned a study on the quality of service provided within the region. [4]

The approaches taken by different regulators to monitor or ensure QoSE are quite different. Further in this paper, we examine these approaches and present a particular method that has been developed and tested by LIRNEasia and the Indian Institute of Technology, Madras (India). The paper also proposes a model that helps monitor QoSE with minimal regulatory action.

■ Different approaches of monitoring broadband QoSE

Even without strict regulations, broadband quality monitoring and benchmarking provides the necessary information for the users to make an intelligent choice in a competitive environment.

As noted, approaches to monitoring and regulating QoSE differ from country to country. Some countries use a mix of approaches. Table 1 classifies some of the commonly found modes of regulation.

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[3] Quality of Service Experience (QoSE), used mainly in the field of telecommunications, is the actual measure of user's experience with an operator in terms of delivered quality with or without reference to what is being promised. This is measured technically and not subjectively. So it is different from Quality of Experience, sometimes also known as "Quality of User Experience," which is a subjective measure of a user's experiences with an operator. QoSE also differs from Quality of Service (QoS) which, in the field of computer networking and other packet-switched telecommunication networks, refers to resource reservation control mechanisms rather than the achieved service quality. Quality of service is the ability to provide different priority to different applications, users, or data flows, or to guarantee a certain level of performance to a data flow.

[4] The study has just been commissioned and the call for proposals can be found at the link: http://ec.europa.eu/information_society/newsroom/cf/itemdetail.cfm?item_id=5001&utm_campaign=isp&utm_medium=rss&utm_source=newsroom&utm_content=tpa-3 (accessed August 14 2009).

Table 1 - Different approaches to broadband QoSE monitoring/regulation

	Regulation/Monitoring approaches			
	Self Regulation by operators	Monitoring by regulators	User satisfaction surveys	Demand side (user) testing
Level of Intrusiveness (on the network)	None	High	None	Negligibly Low
Regulator participation	Medium to Low	High	Varies depending upon who conducts the surveys	None
Operator participation	High	High	Varies depending upon who conducts the surveys	None
User participation	None	Low	High	High
Subjectivity of results	Medium to Low	Low	High	Low

Source: Authors

Self regulation by operators

This mode is mostly used when quality is relatively better. The regulator expects self-regulation by operators instead of other stringent measures. Office of Communications of UK (Ofcom) had requested the broadband service providers to follow a voluntary code when promoting broadband speeds (Ofcom, 2008). It published a report in July 2009 on broadband, which compares advertised vs. actual speeds (PARKER, 2009).

Monitoring by regulators

Regulators are placed ideally to monitor broadband QoSE. They can play a key role in specifying the standards for operators and conducting frequent tests to make certain they are followed. Singapore is one of the few Asian countries which regulate broadband QoSE. Infocomm Development Authority (IDA), Telecommunication Regulator in Singapore, has been publishing quarterly data on the identified QoSE measures since 2006. The Telecommunication Regulation Authority of India (TRAI) and Malaysian Communication and Multimedia Commission (MCMC) have followed suit and has since published QoSE standards similar to Singapore.

All three regulators have specified the matrices:
- network availability,
- local network latency,

- international network latency,
- bandwidth utilisation.

The Indian and Malaysian regulators have included packet loss as an indicator. Non-compliance of these regulation leads to fines for the operators. Of the above matrices, network availability, latency and packet loss can be tested at the consumer end. However, bandwidth utilization information has to be provided by the operators. While the Singapore regulator allows operators to use up to 90% of the available bandwidth, the Indian and Malaysian regulators only allow up to 80%. IDA also specifies the permissible Round Trip Time (RTT) within the national segment of network and up to the first entry point in USA. [5] However, not every country has such regulatory arrangements to ensure broadband QoSE. The absence of a stringent regulatory environment in many developing countries makes it easier for telecom operators to use higher contention ratios there by lowering bandwidth than stipulated. Ordinary users, possessing neither the equipment nor the technical knowledge to ascertain this, most of the times have no alternative other than taking the word of the operator. Data for this is gathered from the supply side. Regulatory agencies are required to place necessary monitoring equipment in operators' or service providers' systems. This requires operator interaction and can be a cumbersome process. It can also be too costly in terms of equipments and personnel.

User surveys

User surveys, conducted either by the regulator (usually) or a third party (rarely) does not measure quality *per se*, but user perception. The users rank the operators based on their satisfaction/dissatisfaction of usage experience. [6]

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[5] RTT *per se* is not a measure of the throughput of the link but indicates the bottlenecks in the path. For example, if the packets are pinged from Sri Lanka or India there will be a significant delay from the local exit point to the first international entry point. This is because the key issue these countries face is constraints in international bandwidth.

[6] Quality of Experience (QoE), some times also known as "Quality of User Experience," is a subjective measure of a customer's experiences with a vendor. Used typically by organisations providing services, such as hotels and hospitals.

Demand side (user) testing

Measuring the performance of the broadband service from the consumer end provides an alternative mechanism to quality monitoring by the regulator. No special equipments will be required for this except a software application that can measure the required metrics. The Web provides a gamut of applications that can be used to test the quality of a broadband link. GONSALVES & BHARADWAJ (2009) analyses some of the most popular testers including www.speedtest.net (what is popularly known as Speedtest), Speedtest2, www.speedtest2.com, and internetfrog, www.internetfrog.com. In addition, the report also does an overview of eight relatively less popular online testers.

The applications for testing QoSE of broadband were rated according to technical merit and the convenience of using the application. All three popular testers focus on download, upload and latency or ping. They are the metrics an average user is most familiar with. However, the absence of other parameters like jitter, packet loss and availability makes the testers technically incomplete as the test results give an incomplete picture.[7] Another drawback seen in all three testers is that it averages the data or results, regardless of whether or not the testing was conducted at peak or off peak times. This would undoubtedly give distorted results. In spite of its drawbacks the testers are relatively easy and quick to use and the results of the tests are displayed in graphical manner which makes it easy for a non-expert to understand.

To address some of the common drawbacks in these popular testers for measuring the broadband QoSE, a methodology to measure five metrics was designed by LIRNEasia and IIT-Madras. AT-Tester, a software application downloadable from www.broadbandasia.info is used for the testing.

■ User-centric methodology with AT-tester

The methodology developed by LIRNEasia and IIT-Madras falls into the 'user testing' category. It is an application that is available freely via web which can be downloaded and installed by users on their computers. The

[7] Commercial version of Speedtest measures jitter and packet loss.

AT-Tester software measures a total of five metrics: Throughput (download and upload speeds), Round Trip Time, jitter, packet loss and availability. Each is defined below:

Throughput (kbps)

Throughput is the "actual amount of useful data sent on a transmission" (DODD, 2005, p. 14). Defined by the ITU as "an amount of user information transferred in a period of time" (ITU, 1997, p. 15), more commonly referred to as download or upload speeds.

- Download speed is a key metric advertised in broadband services. It defines how much information a user receives.
- Upload speed defines the rate a user can send information to a server. It plays a significant role in responsiveness and real-time applications like VOIP.

Throughput varies depending on the location of the server that hosts the content. If the location is local, such as an ISP server, the throughput may be higher than it would be for an international server. Therefore the testing has included throughput for both local (ISP) and international servers.

Latency or RTT (ms)

"Latency refers to delays when voice packets transverse the network" (DODD, 2005, p. 60). This is significant in systems that require two-way interactive communication, such as voice telephony, or ACK/NAK [acknowledge/not acknowledge] data systems where the round-trip time directly affects the throughput rate, such as the Transmission Control Protocol (TCP). The ITU definition states that "Latency means transmission delay for FEC (Forwarding Equivalence Class) encoding, decoding, interleaving and de-interleaving" (ITU, 2004a, p. 9).

Jitter (ms)

"Jitter is uneven latency and packet loss" (DODD, 2005, p. 60). It is the variation of end-to-end delay from one packet to the next within the same packet stream/connection/flow. Jitter is more relevant for real-time traffic like VOIP. Ideally, the figure should be low.

Also defined by ITU as "Short-term non-cumulative variations of the significant instants of a digital signal from their ideal positions in time" (ITU, 1993, p. 6).

Packet Loss (%)

The ratio of packets that does not reach the destination to the sent. Degradation can result in noticeable performance loss with streaming technologies, VOIP and video conferencing. ITU states that:

> "In general, IP-based networks do not guarantee delivery of packets. Packets will be dropped under peak loads and during periods of congestion. In case of multimedia services, when a late packet finally arrives, it will be considered lost" (ITU, 2004b, p. 6).

Availability

The number of times the user is able to access the Broadband services. Availability = (1–F/T) x 100

Depending on the application, different combinations of the above metrics become important. Table 2 below gives the degree of importance of each metric with regards to different applications.

Table 2 - Importance of the matrices across applications

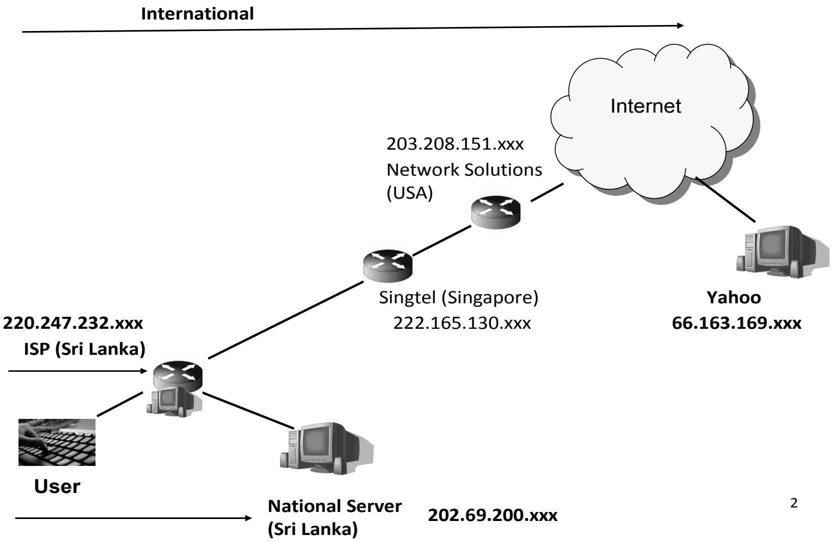
	Throughput		*Delay*		
Service	Download	Upload	RTT	Jitter	Loss
Browse (Text)	++	-	+	-	-
Browse (Media)	+++	-	+	-	-
Download file	+++	-	+	+	+
Upload file	-	+++	-	-	-
Transactions	+	+	++	+	+
Streaming Media	+++	-	+	++	++
VoIP	+	+	+++	+++	+++
Games	++	+	+++	++	++

Note: +++ Highly Relevant ++ very relevant + relevant - not relevant

Source: GONSALVES & THIRUMURTHY, 2008

The above metrics are measured separately for three domains; ISP, national, and international. From the user to the Internet Service Provider (ISP) is the ISP Domain. (aka 'last mile' or 'first mile'). From the user to a website hosted within the geographical boundaries of the user's country is the National Domain. This is an important metric in countries such as Japan where most of the local content is hosted on local servers (i.e. within servers located within the country). Most of the content that a typical Japanese user accesses resides on servers within Japan, and language constraints prevent most Japanese users looking for content elsewhere. For users from India or Bangladesh, this might not be the case given the lack of local content and higher percentage of persons speaking English. The final domain is the International Domain, defined as being from the user to a server or website hosted outside the country of testing. Figure 3 presents this information.

Figure 3 - Three domains of testing



Note: In the above example, the user is situated in Sri Lanka. The two ISPs shown (SLT and Dialog) are shown in Sri Lanka (the user's own ISP is SLT, while Dialog is a competing ISP). International content may be accessed from Singapore or USA (as shown) or any other location outside of Sri Lanka.

Source: LIRNEasia

■ Volunteer computing as a means of data gathering

The LIRNEasia/IIT Madras broadband QoSE monitoring project was largely based on the concept of Volunteer Computing for data gathering purposes.

Volunteer computing is defined as "a form of distributed computing in which the general public volunteers processing and storage resources to computing projects" (ANDERSON, 2009, p. 1). It becomes necessary as computationally intensive research activities require outside resources. It allows researchers to use the resources (such as processing speeds and storage capacity) of computers connected via the internet, that would be otherwise unavailable to them (TOTH & FINKLE, 2007). One of the first projects to benefit from the volunteer computing is 'Great Internet Mersenne Prime Search', (GIMPS) [8], a mathematics project on finding the prime numbers. The project began in 1997. According to ANDERSON & REED (2009) volunteer computing is now used in a wide variety of fields; physics, molecular biology, medicine, chemistry, astronomy, climate dynamics, mathematics, and the study of games. Most typically, volunteer computing is used either in academic or popular public interest projects like climate change and cancer research. CHRISTENSEN *et al*. (2005) details how volunteer computing has aided in the research into climate change. In one of the most popular 'volunteer computing' modes, volunteers are required to download a software application from a project website and install it. From there on the processes are largely automated where the software does the required tasks of computations, communicating with the main server and uploading the results. In the initial stages that involved some human interaction. Now most of the tasks are automated.

Volunteer computing requires a trust between the volunteers and the project managers. Anonymous volunteers will not and cannot be held accountable for incorrect data. In turn, the volunteers trust the project to be within legal standards such as security, privacy and intellectual property laws. In spite of the advances in the relative ease of taking part in a volunteer computing, it has been estimated that only about 1% of world's computers participate in it. As the literature suggests, obtaining volunteers is easier when the project holds public appeal Volunteer computing Projects should be designed to ensure minimum inconvenience to the volunteers. (CHRISTENSEN *et al*., 2005).

■ Volunteer computing in broadband QoSE measurements

Inherent interest of users to know the quality of their broadband links was the foundation for the LIRNEasia/IIT Madras research project. The AT-Tester assumed therefore that the general public would be interested in

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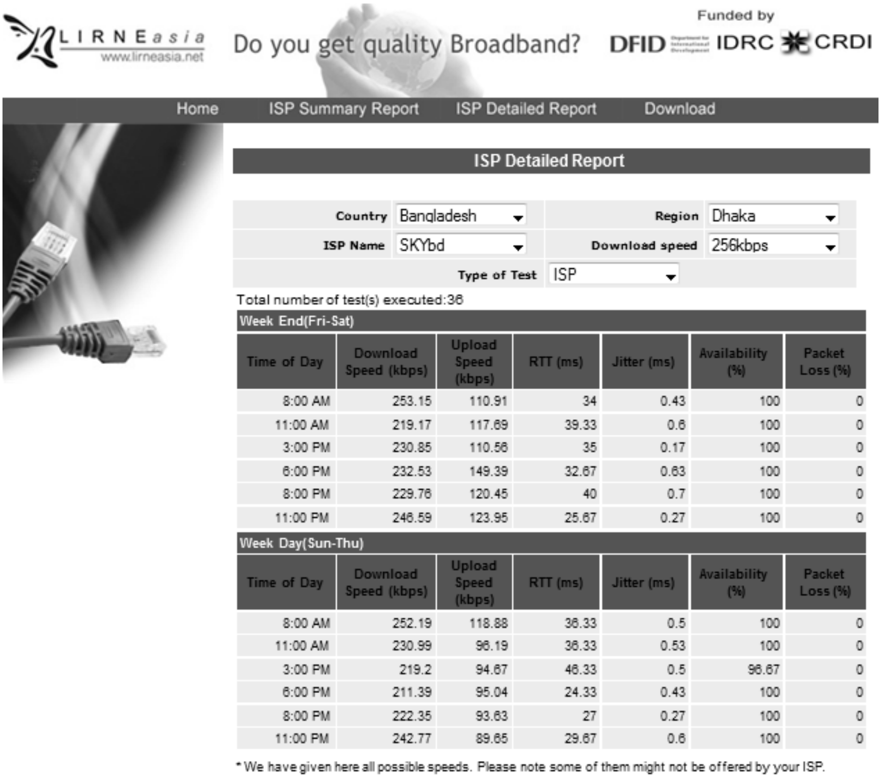
8 More details about the project can be found in their website; http://www.mersenne.org/. Accessed on 2 September 2009.

downloading, installing and running a software that enables them to measure broadband quality. Provided that the process was user-friendly and the application (and provider) was trustworthy.

Figure 4 - Sample test report from broadbandasia.info



Week End(Fri-Sat)

Time of Day	Download Speed (kbps)	Upload Speed (kbps)	RTT (ms)	Jitter (ms)	Availability (%)	Packet Loss (%)
8:00 AM	253.15	110.91	34	0.43	100	0
11:00 AM	219.17	117.69	39.33	0.6	100	0
3:00 PM	230.85	110.56	35	0.17	100	0
6:00 PM	232.53	149.39	32.67	0.63	100	0
8:00 PM	229.76	120.45	40	0.7	100	0
11:00 PM	246.59	123.95	25.67	0.27	100	0

Week Day(Sun-Thu)

Time of Day	Download Speed (kbps)	Upload Speed (kbps)	RTT (ms)	Jitter (ms)	Availability (%)	Packet Loss (%)
8:00 AM	252.19	118.88	36.33	0.5	100	0
11:00 AM	230.99	96.19	36.33	0.53	100	0
3:00 PM	219.2	94.67	46.33	0.5	96.67	0
6:00 PM	211.39	95.04	24.33	0.43	100	0
8:00 PM	222.35	93.63	27	0.27	100	0
11:00 PM	242.77	89.65	29.67	0.6	100	0

* We have given here all possible speeds. Please note some of them might not be offered by your ISP.

Source: www.broadbandasia.info

The value of the tester lies not just in getting a user to test his or her connection quality. Rather to enable the user to compare his/her metrics with a group of other users (or an average).This is facilitated by having the measurement data automatically uploaded to the website (www.broadbandasia.info, the same website from where the user downloads the application from). The user of the software (or anyone else, for that matter) is then able to view the data reported by all other users. Results are available on country and city basis, where applicable. The averaged results of all tests conducted are reported. Figure 4 shows a sample of data from Bangladesh. The key to success of course is in having as many users reporting data as possible.

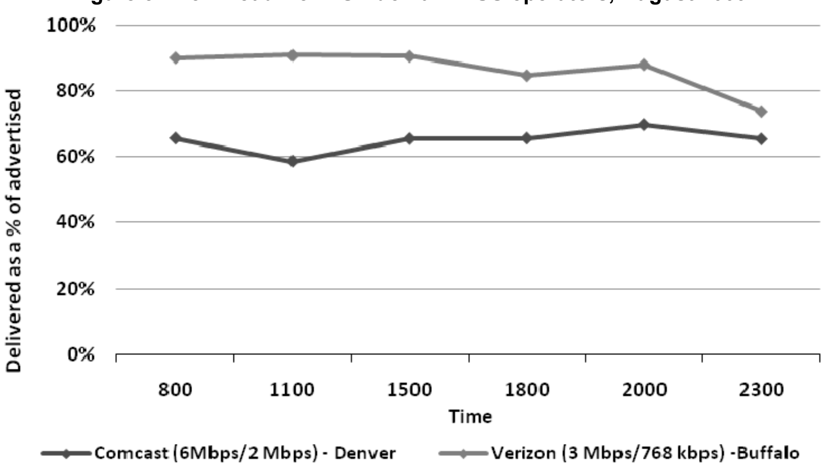
■ Examples of data analysis

The project was initiated in 2008 when the AT-Tester software was first developed and used. The project has been continuing since. QoSE information on broadband packages of several countries has been recorded since then. Given that the project is still in early stages, not all data comes from volunteers. At times the research team from LIRNEasia had to employ testers in order to ensure that data from multiple locations were collected at the same time, in order to facilitate benchmarking. The following are examples of the type of information that can be extracted by analyzing the data gathered and the policy interventions it could lead to.

Results for the USA

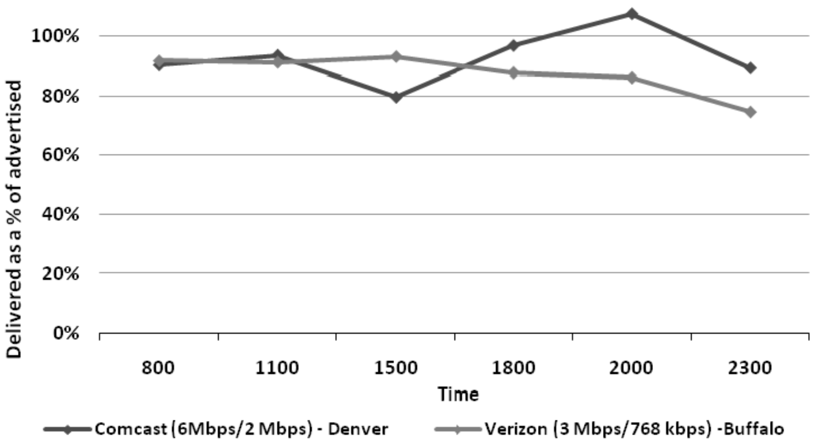
In USA, QoSE results for two unlimited broadband packages, in two cities are available, Verizon and Comcast. Comcast, tested in Denver, has an advertised download speed of 6 Mbps and upload of 2 Mbps and it is priced at USD 59.95 per month. Verizon, tested in Buffalo, New York has an advertised download and upload speeds of 2Mbps and 768 kbps respectively and a monthly cost of the connection is USD 29.99. The tests were conducted in August 2009, 6 times a day in order to capture the peak and off peak times. The download test results (as percentages of advertised speeds) are given in Figures 5, 6 and 7

Figure 5 - Download from ISP domain – US operators, August 2009



Source: LIRNEasia test results, August, 2009

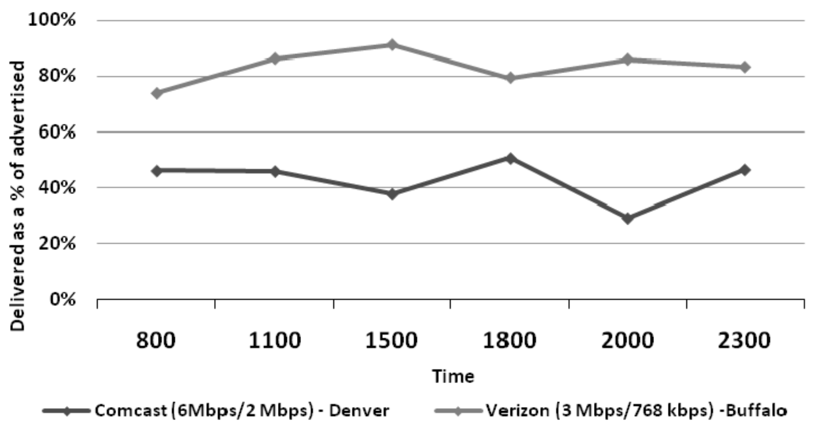
Figure 6 - Download from national domain – US operators, August 2009



Source: LIRNEasia test results, August, 2009

In all three graphs, Figures 5, 6 and 7, the download speed data shows Verizon performs better than Comcast. This is more significant in the international segment. Ideally, the speeds should have been close to 100%, but no serious performance drops are observed.

Figure 7 - Download from international domain – US operators, August 2009

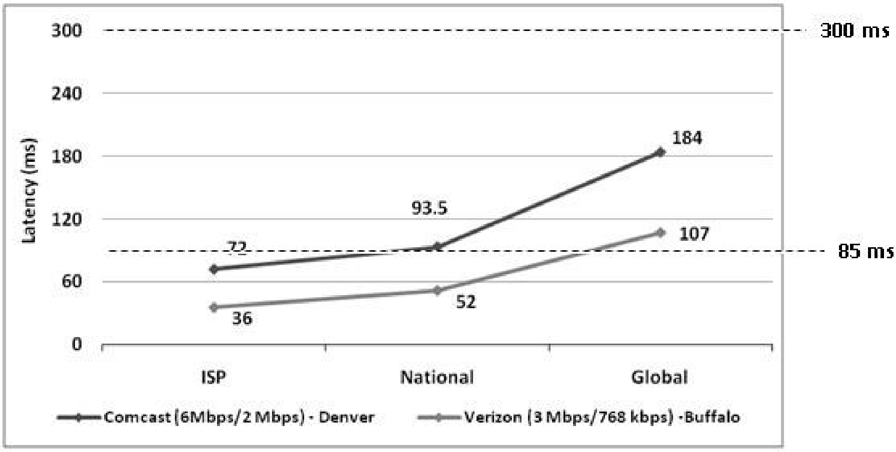


Source: LIRNEasia test results, August, 2009

Performance is seen falling below 75% for Comcast in Figure 7. Its users might experience this drop in quality when accessing an international server.

This indicates possible bottlenecks in the trans-Atlantic link used by Comcast.

Figure 8 - Round trip time to ISP, national and international domains (in ms) US operators, August 2009

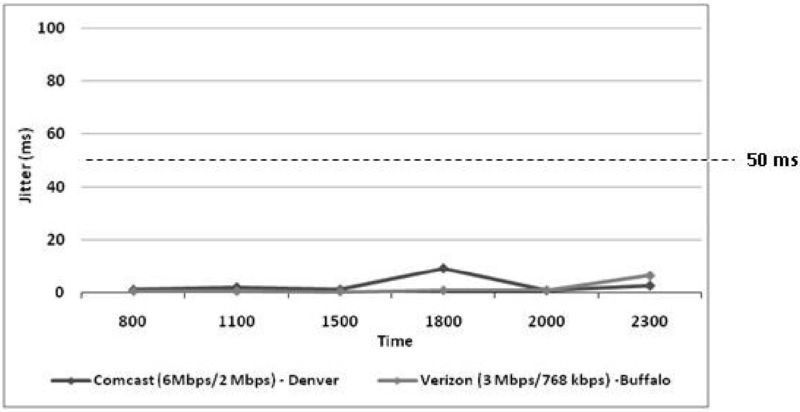


Source: LIRNEasia test results, August, 2009

A typical download speed graph for a package not prone to congestion, shows drops during 'peak' periods, usually around 11 am (business peak) and anytime between 6 pm to 11 pm (residential peak). Absence of such an inverted hump characteristics mean the networks are not overly congested, or right contention ratios are applied. Latency (RTT) plays a major role in the real time or interactive applications. The specified limit for the Singaporean operators by the Infocomm Development Authority (IDA) is 85 ms for local network segment and 300 ms for international segment (until the first entry point to USA from Singapore.) Out of the two US operators, while Broadband Verizon complies with both, Comcast meets the national standard only in certain cases (NB. USA is taken as the 'international' destination for users from most of the countries. For USA and Canada, Germany is taken as the 'international' destination, representing a server in Europe). Neither universal acceptance levels nor national standards exist for jitter and packet loss. The limits depend upon the applications too. Ideal will be 0 ms jitter and 0% packet loss. For practical purposes LIRNEasia has adopted 50ms and 3% as standards. Performances of both operators are within these overall limits.

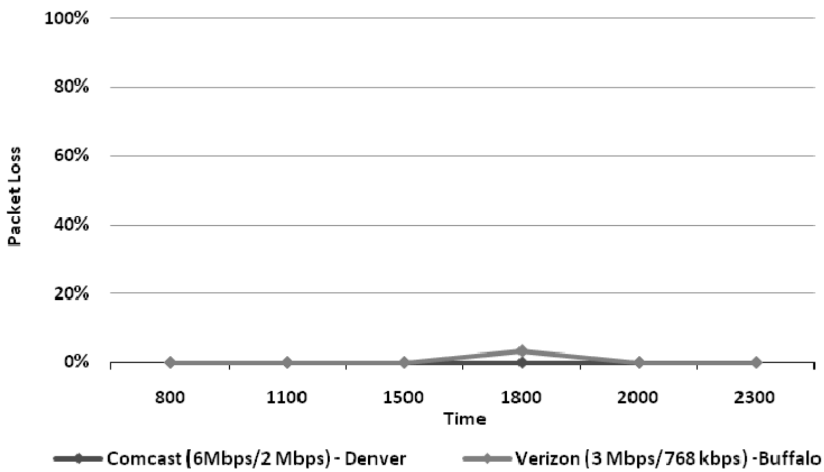
Based on the above results (which are all within reasonable or acceptable range), there is little need to call for policy interventions. The only improvement might be to expand the international link capacity for Comcast in order to obtain better download speeds when accessing content overseas. [9]

Figure 9 - Jitter when pinged to the international domain (in ms)
US operators, August 2009



Source: LIRNEasia test results, August, 2009

Figure 10 - Packet loss when pinged to international domain – US operators, August 2009



Source: LIRNEasia test results, August, 2009

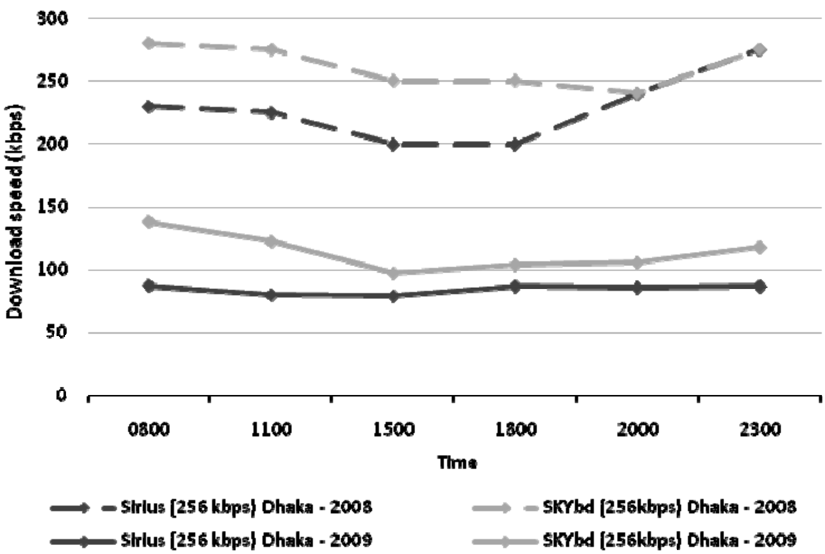
9 However, given the propensity for even international data to be hosted in the US, it is likely that the International Domain is the least accessed by US-based broadband users.

Results from South Asia

The results of testing from South Asia, in contrast, show that there is much to be desired, and therefore point at opportunities for regulatory intervention. Under its Rapid Response program LIRNEasia makes quick responses to specific requests for training/advice by governments/entities in the region on telecom policy and regulatory issues. One form of response is a written submission (e.g., to a public consultation or to media). On several occasions data from broadband QoSE database has been used as the basis of these rapid responses.

Bangladesh: Comparing the tests done in September/2008 to the ones done in February 2009 in Dhaka, Bangladesh showed a marked deterioration in download speed within these 6 months (Figure 11). These results were used in the policy recommendations made by LIRNEasia to Bangladesh Telecommunication Regulatory Commission (BTRC) in August 2009.

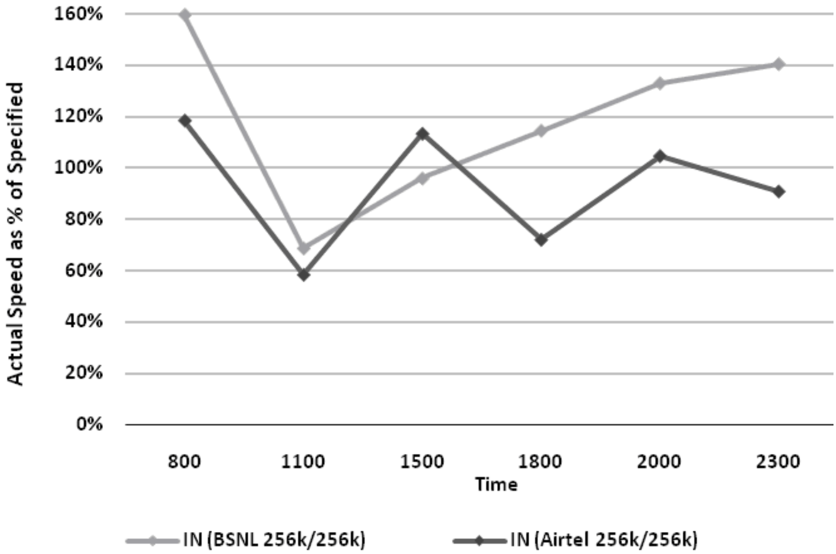
Figure 11 - Download speed in international domain, Bangladesh



Source: LIRNEasia Broadband Test Results, Sept 2008 and Feb 2009

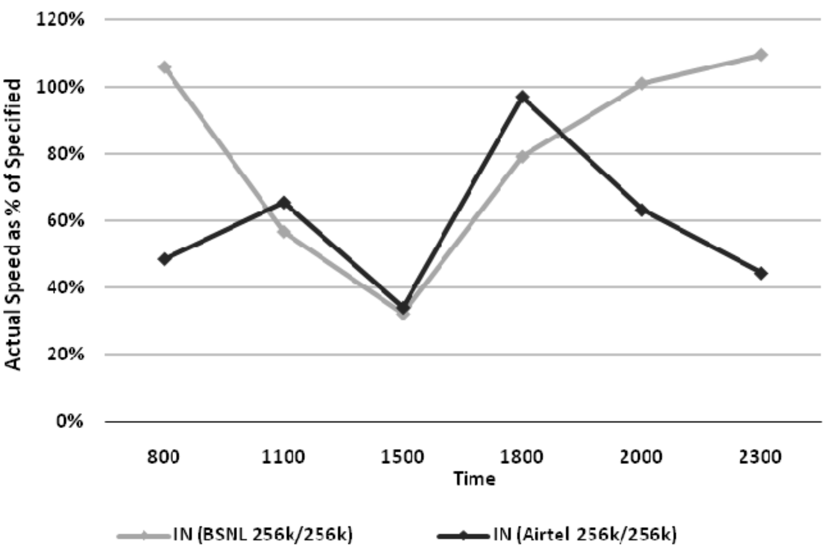
The possible reasoning was the immediate expansion of the broadband user base in Bangladesh, following the rapid drop in prices (Please refer Figure 1), perhaps without allowing the operators to expand their infrastructure. LIRNEasia recommended the approach regulators should take in adopting broadband regulatory measures based on its experiences in QoSE research in South Asia.

Figure 12 - Download speed in ISP domain for Chennai



Source: LIRNEasia test results, Sept 2008

Figure 13 - Download speed from international domain for Chennai



Source: LIRNEasia test results, Sept 2008

India: Recommendations were made to Telecommunication Regulatory Authority in India (TRAI) also based on the erratic patterns observed in download speeds offered by the Indian operators.

Prima facie, this appears a case of over-delivery but only because TRAI has specified the local operators to advertise based on the minimum speeds rather than a range. In spite of the higher percentages, in actual terms the speeds are low and behave in an erratic pattern. This normally happens when there are significant variations in the number of users sharing the same link. LIRNEasia's key recommendation here was to specify the contention ratios, 1:20 for business and 1:50 for residential, for the operators. They have adopted 1:30 (business) and 1:50 (residential).

■ Observations on the use of volunteer computing model

The following are the observations for a period of nearly a year of operation:

- The response rate was not as high as expected. The anticipated level of traffic, based on the presumed broadband user activism in South Asian countries was not seen. The data received now largely appears to be from one-time users. [10]

- The model seems to work better for certain countries than the rest. Response rate is best for Sri Lanka and India.

- The number of requests to register for testing is higher than the number of tests completed [11], as indicated by the site statistics, than the number that completes the process.

- More test results are observed being fed immediately after the awareness creation workshops by LIRNEasia and IIT Madras.

It is too early to deduce the success/failure of the model. The low rate of response can be due to multiple reasons. Perhaps activism *per se* was not adequate to entice users to contribute the anticipated time and effort. It also may be due to less awareness. Some users have commented on the

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[10] Since it is not mandatory for a user to input results to the database, the number of records in the database is not a reflection of the number of tests conducted, which has to be higher.

[11] The application needs pre-registration. The user has to provide the ISP, country and package information.

aspects of user-friendliness of the software application. The need for first time registration discourages many users but it is essential as the ISP information needs to be fed to the system. It cannot be the user's responsibility for two reasons. An ordinary user might not be aware of the technical details of the ISP. Then it is too risky to entirely depend on the data fed by a volunteer with no guarantee about the accuracy.

■ Conclusion

LIRNEasia has used the data gathered through the AT-Tester software application for four rapid responses it made to South Asian regulators for policy intervention purposes. Two of these are shown above. Though not all data gathered was through volunteer computing, this illustrates the potential.

The volunteer model as it is might not be the best for an exercise of this nature. The additional time and effort, compared to other examples that use the same model makes a big difference. Users cannot be expected to make this contribution without any return. They need to be compensated, not necessarily in financial terms, but at least in kind.

The other improvement can be awareness creation. It will not be practical to expect users to spend time doing a test on a site they find on a casual search. A casual user does not fit into the ideal profile of a 'volunteer'. Rather the volunteers need to be carefully nurtured. Awareness creation plays a major role there. Increase in the response rate following awareness creation workshops indicates that would be a good exercise, but other modes too can be tried.

Overall, these trends suggest the need to slightly deviate from the volunteer computing model. Participation requires the broadband users to contribute both his/her time and computer resources to the project.

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