Measuring Broadband Performance: Lessons Learnt, Challenges Faced

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1 Abstract

Multiple studies have associated socio-economic benefits with access to the Internet, broadband in particular (Qiang, C.Z, et al., 2009). This correlation is of national interest and therefore governments in general have a vested interest in the reach and quality of service provided to users.

Regulators have a mandate of acting in the best interests of the consumers. This includes ensuring that certain minimum quality standards are provided and services are reasonably priced, thereby warranting value for money (Epitiro, 2011). International organizations too have highlighted the need to measure and publish broadband performance with recommendations made at the likes of the World Telecom/ICT Indicator's Meeting (WTIM) organized by the International Telecommunication Union (ITU) (ITU, 2012).

Regulatory agencies have been engaging more in the measurements and monitoring of broadband quality, especially on fixed networks. As mobile networks gain popularity regulators must also focus on the performance of mobile broadband networks. Some regulatory bodies are at the forefront of defining and testing mobile broadband performance; however, the very nature of the mobile network poses added challenges and call for a different methodology from what is typically used in fixed network performance measures.

This paper discusses the various approaches of measuring broadband performance and its challenges with select examples of regulatory interventions to ensure the same. It also highlights the complexities associated with measuring the quality of mobile broadband

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networks. Further, after having carried out diagnostics for four years, the authors attempt to answer the questions, how can broadband quality of service studies be introduced in the policy discussion and process, and what concrete steps have researchers taken, particularly in the Philippines, to initiate and sustain these as part of the better internet advocacy?

Key words: Broadband, Performance, Policy

1. Introduction

The quality of a broadband service as experienced by a user becomes increasingly important as the proliferation of Internet services increases, namely the cloud. The International Telecommunication Union (ITU) says that access to broadband is a basic right (ITU News) and thus has been on the top of regulator's agendas.

The number of broadband users has been steadily increasing, as reported by the ITU (Figure 1). This means that more people are getting connected and there is an increase in demand of network resources. Operators, therefore, have a task at hand to ensure that services of an acceptable quality are provided in order for users to access the Internet. Acceptable quality or rather the quality of service experience (QoSE) differs in definition from user to user. It also differs based on the type of service accessed. At minimum, operators are expected to deliver service standards that have been communicated to users. In some cases, regulatory agencies hold operators responsible for below par service delivery that may lead to monitory penalties.

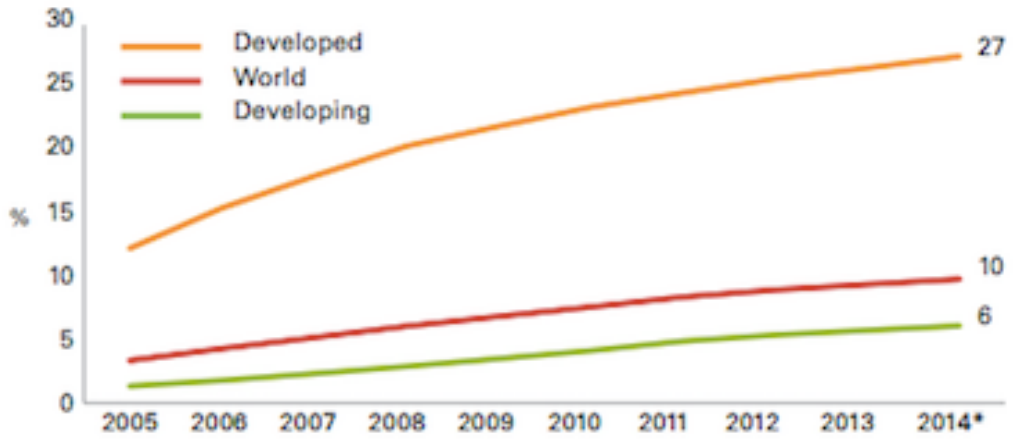

Figure 1: Fixed broadband subscriptions per 100 inhabitants (ITU World Telecommunication / ICT Indicators Database, 2005-20143)

As with the implementation and introduction of most services, access is given higher priority than quality. The performance of broadband services has been gaining more importance with national regulatory agencies (NRAs) issuing performance indicators, outsourcing quality of service (QoS) and quality of experience (QoE) studies to consultants, and some self implementations where diagnostics are conducted, results are published, and operators are held accountable for delivering poor quality. Such measures are also used as marketing tools by the better performing operators. Unlike with other telecom services (e.g., voice services), broadband commands special attention from its users as there are many tools that are promoted to test the performance of the network. However, there can be issues with user-driven performance diagnostics; for example, Wi-Fi networks, operating systems, and viruses on the user's device can distort results. From a user perspective, measuring broadband performance seems to have value because results can be used to challenge the operator's under-delivered services and are often used as ammunition when raising complaints about the performance of broadband.

There is great value in formally measuring performance for all stakeholders involved. However, a distinction in measuring the quality of the service offered and the quality experienced by the user must be made. The operator is often focused on the former (i.e., the capabilities of the network) while the user is

[3] Note: * indicates ITU estimate

more interested in the latter (i.e., actual service received). A good example is LIRNEasia's[4] analysis on the actual download speed as a percentage of the advertised speed (

Figure 2). Instead of reporting raw download speed that often makes an unfair comparison (because it can be heavily dependent on the methodology adopted), these types of analyses provide a better comprehension of the service level differentiation between operators. The comparison in Figure 2 can also be used to promote "truth in advertising."

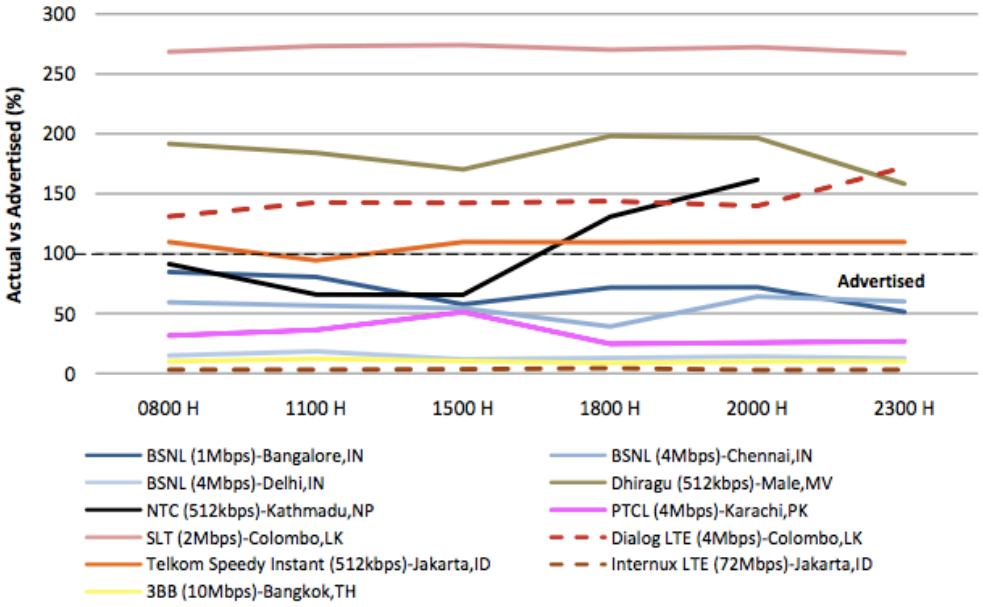

Figure 2: Actual vs. Advertised download speed (LIRNEasia, 2014)

There are many tools and approaches of measuring the performance of broadband connections. However, for results to be comparable, there has to be some form of uniformity in the methodology adopted.

In the Philippines, the QoSE study has provided invaluable evidence of poor broadband service as experienced by the users. In the absence of an official diagnostic tool or set of service performance standards, the QoSE study offered a good argument for the need to investigate "truth in advertising" as practiced by the ISPs and "value for money" of the consumers. The Philippine presents a case for how QoSE research made its way to the

[4] LIRNEasia is a think tank active across Asia and the Pacific. Part of their work has been benchmarking broadband quality of service, as experienced by the user in the region.

policy process, and how key challenges along the way can be overcome, to a certain extent.

2 Factors that affect broadband performance measures

Download speed is often the foremost characteristic cited when illustrating the quality of broadband services. Speed is vital, but it is not the only thing that matters. Different types of applications demand different performance measures in order to function within acceptable standards. Other measures, such as upload speeds, latency, jitter and packet loss (Gonsalves, T.A., & Bharadwaj, A., 2009) are therefore important aspects to consider when measuring a user's broadband experience. For instance, while throughput is vital for downloading media, round trip time (RTT or latency) is more important for networked games (Figure 3). Therefore, when considering the overall quality of a link, it is imperative to consider all dimensions. A user's perception of quality, therefore, also depends on the user's profile. For example, a heavy gamer may perceive a broadband connection to be of poor quality even though it performs well in terms of achieving the advertised download speed.

Service	**Speed**		**Delay**		**Packet Loss (%)**
	Download (Kbps)	Upload (Kbps)	RTT (ms)	Jitter (ms)	
Browse (Text)	++	-	++	-	-
Browse (Media)	+++	-	++	+	+
Download file	+++	-	-	-	-
Transactions	-	-	++	+	-
Streaming Media	+++	-	++	++	++
VOIP	+	+	+++	+++	+++
Games	+	+	+++	++	++

Note: +++ Highly relevant; ++ Very relevant; + Relevant; - Irrelevant

Figure 3: Relevance of metrics to various Internet services (Gonsalves, T. A. & Bharadwaj, A., 2009)

2.1 The Physical Medium

The copper network is perhaps still the most widely spread telecommunications network. Over the past years, technologies have been brought in to cater to subscriber demands and deliver services such as broadband over copper. Instead of replacing the public switched telephone network (PSTN), these new overlay networks have been running in parallel specifically to carry data traffic. However, as the network has been expanding, the network architectures have not necessarily been optimized with regard to the efficient use of current technologies. For instance, copper networks have been designed primarily for plain old telephone service (POTS), whereas a considerable share of traffic is now based on IP (Internet Protocol). In other words, the initial network designed for 4 KHz voice services has been 'upgraded' over time by using different technologies (e.g., xDSL) to provision services that require higher bandwidths. Although the existing network has served well for this purpose, it is unlikely to sustain the predicted future demands.

The physical medium used for signal transmission signifies the capabilities, and thereby, the types of service and quality of service that can be offered. Attenuation over distance, for instance, is high in copper wires as opposed to fiber, thereby requiring more repeaters to amplify the signal in order to transmit over long distances. Nonetheless, copper has served immensely well for broadband services enabling users with much higher data rates than what was originally designed.

Traditionally, cable networks were used as programming services to deliver entertainment by satellite to a cabling television system that redistributes network programs through a wire-line network to individual residences. Motivated by competition and the increase in popularity and use of the internet, Hybrid Fiber Coaxial (HFC) networks have become an attractive alternative for cable companies to remain competitive and diversify in to the telephony market (IEC, 2013). The similarities in architecture of the existing network played a part in strategically positioning the cable companies well within the diverse communications industry. The use of efficient data modulation schemes such as Quadrature Amplitude Modulation (QAM) enables the HFC access network to support a 1-GHz spectrum for integrated broadband services (digital video services, signaling for interactive services) and both upstream and downstream telephony (Perry, E. & Ramanathan, S., 1998).

Due to its advantages over electrical transmission systems, fiber-optic communications have played a revolutionary role in the telecommunications industry. In fact, most operators around the world, especially in developed countries have already or are in the process of replacing the core copper network with optical fiber, especially within the backbone. Comparatively low attenuation, susceptibility to electrical interference, and high data rates are some of the reasons that made the use of optical fiber an attractive option.

Most telecommunications and cable providers, especially in developing countries, have not been able to reach certain rural areas due to the high capital and operational costs associated with laying an access network. This has therefore created broadband 'blackout' spots with limited or no telephony and broadband coverage. Wireless technologies have been developing over the past to reach many users without the additional costs that wire-line networks demand. Wireless technologies are two-fold: fixed wireless that can only be accessed within the range of a wireless adapter or access point offering limited motion, and mobile wireless which is analogous to the cellular network. The increase in mobile subscriptions, ease of access, and low costs makes a viable case for mobile broadband. Measuring performance in mobile broadband networks, however, poses added complications.[5]

In fixed networks, the physical limitations of the medium, such as capacity and attenuation, have bearing on the performance of service delivered. With wireless and cellular networks however, attributes of signal propagation, in addition to other variable parameters, such as weather and location of the base station, affects the quality of service offered. The load of a network can also fluctuate without any prior warning as opposed to fixed networks that operate on predetermined contention ratios. As a result, the quality of the signal can vary rapidly. The volatile nature of the mobile network increases the complexity associated with network performance measurements.

[5] Nokia's Total Cost of Ownership (TCO) study compares the total costs of using an identical basket of services over a mobile phone in selected emerging economies. The 2011 study states that in 12 economies the TCO is less than USD 5, with the average TCO (among 50 economies) at USD 11.47.

2.2 Contention Ratios

Although ideal, the cost makes dedicated lines impractical. Therefore, all service providers define a contention ratio that determines the number of users sharing the infrastructure of the access network. Theoretically, if all lines were to be utilized with heavy traffic flows on each, the performance, and therefore user experience, could decrease drastically. In reality, since usage patterns differ and because contention ratios can be reconfigured if required, this is not considered a major issue.

2.3 Distance from Exchange/Base Transceiver Station (BTS)

Signal degradation occurs over long distances, which reduces the maximum speed achievable based on the distance from the exchange in wire-line networks. In addition, the terrain and quality of wiring can also have an effect on the quality of the connection. In mobile networks, signal propagation characteristics, such as reflection, refraction and diffraction, can cause quality issues. A phenomenon known as cell breathing causes the cell to dynamically resize when it is heavily loaded, which in-turn may cause service disruption.

2.4 Time of Day

Peak and off-peak hours published by service providers indicate the increase and decrease of users based on the time of day. The load on servers when data traffic peaks also contributes to the quality variations experienced.

3 Approaches for Performance Monitoring

3.1 Router-based vs. Application-based Approach

SamKnows is an example of a router-based / hardware approach that has gained popularity in Europe, the United States of America (USA), and Singapore. It is a free resource to the end user; however, there is a significant cost to be borne by the implementers of this approach. The router used for these diagnostics has got in-built intelligent software that makes it possible for a series of network performance tests to be run in the background (Sam Knows, 2015). Essentially, the "box" is connected to the

router and is thereby connected to the home network directly (sitting between the end user's device and the router). Most devices that use this approach monitor the network traffic and run the diagnostics when the Internet is not being used. This ensures a higher level of accuracy and does not interrupt the user.[6]

On the back-end, the tests are run both within the ISP domain (dependent on the provision of test nodes by the ISP) and in the International domain, using popular websites and test nodes provided by the SamKnows platform (Sam Knows, 2012).

The software approach uses an application accessed by the user that connects the user's device to a remote host responsible for running the application. The tests are carried out in relation to a pre-defined server or dynamic server selection (based on the user's locality and test requirements). Unlike in the previous hardware approach where the connection speeds are tested directly off the router, with this approach the state of the end-user device can be a cause for concern. For example, the operating system, viruses, browser (if a web-based application is being used as opposed to a desktop application) may affect and distort results. The insecurity associated with accessing an application from an unknown source (and one that may alert the anti-virus software installed on the machine) is a difficult barrier to overcome. This was found to be a hindrance and one of the reasons as to why crowdsourcing methods, although ideal, do not work for this type of exercise (Wattegama, C., & Kapugama, N. 2009). The biggest advantage however, is the cost aspect. From an end user perspective there are no costs involved. The costs for hosting, administration / maintenance are generally relatively low and are usually borne by the implementing party.

3.2 Active Testing vs. Passive Testing

Passive testing methods do not place an additional load on the network. Instead it measures the performance of traffic streams that traverse predetermined nodes of the network. Generally, this calls for the use of expensive probes at the different points of

[6] For more discussion on broadband diagnostic metrics and measurement methods, see Chetty et al. 2013. "Measuring Broadband Performance in South Africa". ACM DEV 2013, Cape Town, South Africa.

the network (IXIA, 2009). Results from passive testing methods do not provide an actual snapshot of the user's broadband experience (Sundaresan, S., de Donato, W. & Feamster, N., 2013). Active probing on the other hand involves a test between two points, usually the client and the server. This type of testing is better suited for end-to-end testing, as ruling out different segments of the network (e.g., the access network vs. the core network) can pose challenges. A report by Epitiro (2011) says that while operators prefer passive testing because it can be used to give a snapshot of their core network, the regulators prefer the active testing method as it is more appropriate for benchmarking, among others. The main disadvantage, however, is the inevitable bandwidth utilization. Users who take part in such tests have to be made aware that there will be impacts on the data caps (e.g., if a download test has been designed such that a 10-MB file will be used for the download, this means that each time a user runs this test it will eat up the data cap). Both approaches discussed in section 3.1 can be carried out using either active or passive methods.

3.3 Single Threaded vs. Multi-Threaded Sessions

Most performance measures produce vastly different results based on the methodology that has been adopted (Bauer, S., Clark, D. & Lehr, W, 2010). The use of single-thread vs. multi-thread transmission control protocol (TCP) sessions is a factor that contributes to these discrepancies. The main concern with single-thread sessions is the limitation of the receive window. The application may appear to freeze if a single task overloads the main running thread. In reality, most applications use multiple threads. Therefore, the results received by an application that is based on multiple TCP threads will be closer to the actual achieved speed. Multi-threaded sessions are more robust, more susceptible to loss and emulates the access link more accurately (Sundaresan, S., de Donato, W. & Feamster, N., 2013). In the case of measuring throughput, there is a disadvantage in using single-threaded session as it is more likely to have adverse effects caused by packet losses.

3.4 Methodology Design

Irrespective of the approach, the real value addition is in the methodology adopted. A sound method ought to consider the following:

Download speed is not the only parameter that matters. Although commonly used and easily understood by many, download speed is not the sole parameter that determines quality, especially in the cloud era. Therefore, it is important to use an approach that has the capability to tests multiple metrics. For example, upload speeds and latency are vital characteristics when using services off the cloud.

Time dependent variances need to be addressed. Bursts in traffic, the busy hour, etc. can have severe implications on the overall analysis of broadband performance. Therefore, it is important that tests are run over a period of time, on multiple days including both weekdays and weekends and at multiple time slots each day to negate any effects caused by asymmetric data traffic patterns.

File size matters. Due to the different algorithms used when files are being downloaded (traffic shaping algorithms) there is danger in using a small file size to test download speed. The basic premise is that the file ought to consume the whole bandwidth; therefore, large files (e.g. a 10MB file to measure a 2Mbps broadband plan) will increase the accuracy.

Testing multiple domains helps identify problem areas. Testing, for example, within the ISP network, the national domain (within the country but to a server located within another ISP's network) and the international domain really adds value in analyzing the bottlenecks (Figure 4 & Figure 5).

Desktop-based speed tests are better. Desktop applications that run speed tests offer higher levels of accuracy, as browsers can have adverse effects on results obtained from web-based equivalents. However, users may perceive downloading a speed-test application as a potential security threat. As a result, uptake of such applications may prove to be a challenge.

QoSE is affected by the access network infrastructure and location of tester. The user's experience is also a function of the physical medium used in the access network (e.g., copper, fiber) and the distance from the exchange / BTS. Therefore, a country's broadband performance cannot be derived from results received in one location, and it can be misleading if quality is reported at country level. Any negative or deceptive effects

are thus minimized by reporting results for a city or locality as opposed for the whole country.

The testing methodology designed by LIRNEasia and the Indian Institute of Technology (Madras) provides insight into the broadband service experienced in South Asia. Well-designed diagnostics can also identify segments in the network that are problem prone. Figure 4 illustrates the difference between the download test carried out within the local ISP domain and the international domain, suggesting the problem is in international connectivity.

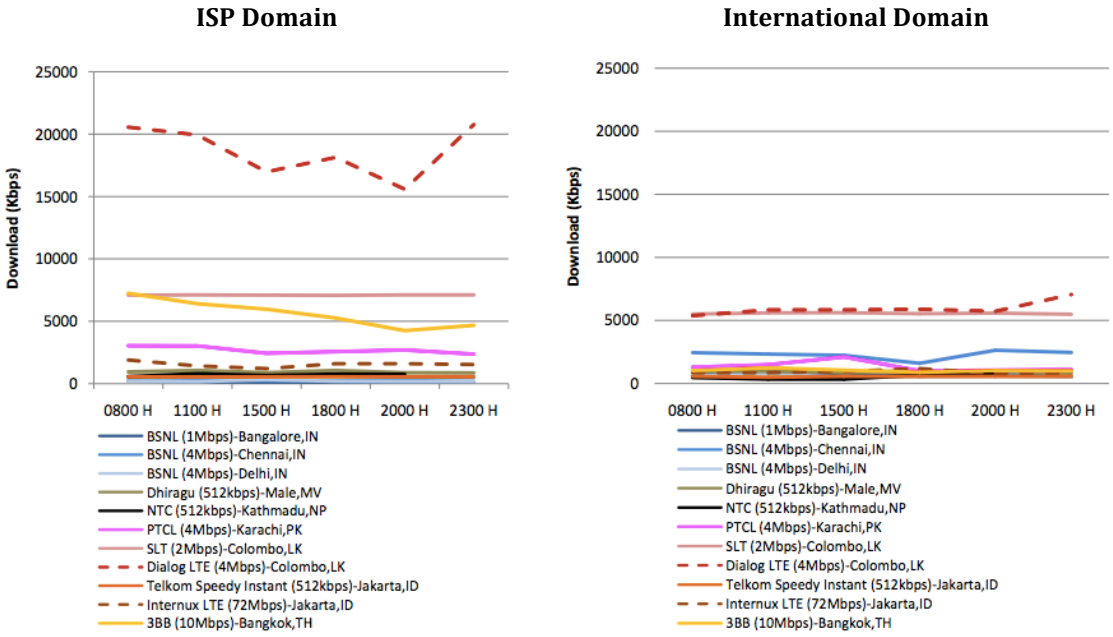

Figure 4: Download speed of the ISP domain vs. the International domain (LIRNEasia, 2014)

Similarly, the round-trip time also deteriorates when data hosted overseas is accessed as opposed to locally hosted data (Figure 5). This characteristic of broadband is particularly important in interactive applications, such as Skype and networked games, and can severely affect the user's experience.

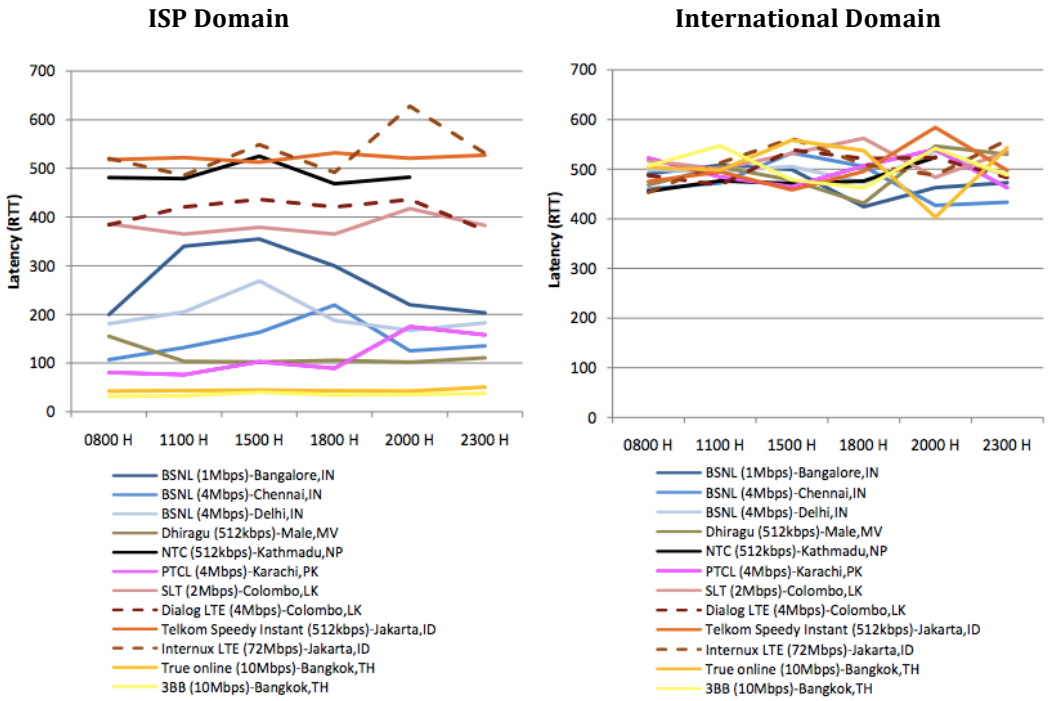

Figure 5: Latency in the ISP domain vs. the International domain (LIRNEasia, 2014)

When first implemented in 2007, the LIRNEasia method depended on a volunteer computing model. However, this model poses many challenges primarily because it requires trust between the volunteers and the program implementers.[7]

4 Who is responsible for measuring broadband performance?

All stakeholders (NRAs, service providers, consumers) benefit from broadband performance measurements, but there are factors to consider when deciding on who is best suited to take on the responsibility (Figure 6).

The main issue with consumers measuring performance is that it lacks uniformity in terms of the methodology adopted, and the risk of inaccurate results is far greater. Not necessarily due to malicious behavior, but because there are a number of factors, such as

[7] A form of distributed computing in which the general public volunteers processing and storage resources to computing projects.

the operating system, the browser, and virus-infected machine, etc., being used. Consumer-driven initiatives are important nonetheless, and assist in holding operators accountable.

	Regulation/Monitoring approaches			
	Self regulation by operators	**Direct monitoring by regulators**	**User satisfaction surveys**	**Demand-side (user) testing**
Intrusiveness on network	None	High	None	Negligible
Regulator participation	Medium to Low	High	Depends on survey	None
Operator participation	High	High	Depends on survey	None
User participation	None	None	High	High
Subjectivity of results	Medium to Low	Medium to Low	High	Low

Figure 6: Approaches to Broadband Monitoring and Regulation (Gonsalves, T. A. & Bharadwaj, A., 2009)

Network operators usually perform their own set of diagnostics for internal quality monitoring purposes. However, their focus is the more technical 'quality of service' aspect as opposed to the user centric 'quality of service experience' view. Further, operator-initiated diagnostics is usually on the segments of the network with the best connectivity that does not accurately emulate the access network. Therefore, from a consumer perspective, and given the nature and mandate of NRAs, the regulator is better positioned to measure broadband performance. The challenge is to adopt a sound methodology and present the data with transparency, in a manner that can be comprehended by the general public.

The purpose of measuring broadband performance should also be addressed. If it is to enable users to make informed decisions when selecting a service provider, then the more useful comparison will be within a small geographic location as opposed to city or country level. However, if it were for regional or international comparison, then the data must be aggregated in a manner that makes it representative of the whole country; however, given the attributes and the volatility of broadband, the accuracy of the aggregated data can be disputed. At that level, in order to compare countries, it is also important that the same (or at least similar) data collection methods are followed.

4.1 Country Examples of Regulator-led Implementations of Broadband Performance Measures

4.1.1 Sri Lanka

The Telecommunication Regulatory Commission of Sri Lanka (TRCSL) introduced a web-based download speed and bandwidth measuring facility in 2011. The tool measures end-to-end Internet download speeds from servers situated in Germany and the USA, since the majority of outbound data traffic routes to servers in either Europe or in the USA. These servers have been selected based on locations that have the presence of Tier-1 networks to ensure that the system provides best possible congestion-free, reliable network paths.[8] Users have to select the file size for the download-speed test and are advised to do so based on the speed of their connection (the recommendation is posted on the NRA's web site). Although the software allows for the general public to run tests of their own, the results that are published monthly are taken from the tests carried out by the TRCSL. A random location (often in and around the capital) is selected and a laptop with the software running is left in that random location for a period of 24 hours. These locations may or may not be known by the operators prior to the test. The results are published on a monthly basis and are used as the industry norm for benchmarking both fixed and mobile broadband performance.

[8] Information obtained via multiple conversation with the head of the broadband monitoring unit at the TRCSL

4.1.2 India

The Telecommunication Regulatory Authority of India (TRAI) first defined their recommendations for measuring broadband performance in the Broadband Policy of 2004 and more recently in the National Telecom Policy of 2012. The method, however, is operator-centric. The key performance indicators along with the appropriate benchmarks / the minimum performance requirements are defined. TRAI requires operators to collect these indicators and report them on a quarterly basis, with the possibility of non-compliance penalties. The parameters include broadband speed > 256 Kbps, service availability / uptime > 98%, packet loss of < 1%, among others. However, when the onus is on the operators to produce the results, unless there are counter diagnostics conducted by the NRA, the validity of the results can be questionable. Demand-side / user-satisfaction surveys are also carried out. These surveys include questions on customer satisfaction on speed and network availability (up time / down time) (TRAI, 2011). However, the intangible nature of these broadband characteristics makes it challenging for a user to communicate satisfaction levels. Each network characteristic also has a different degree of importance to different types of users, which adds to the complexity. Survey questionnaires using the likes of Likert scales (wherein respondents are asked to indicate their level of agreement with a given statement using an ordinary scale), therefore, are not the best measure of satisfaction of broadband performance. It can also be misleading to use such satisfaction surveys to generalize the overall broadband performance of a district / province.

4.1.3 Singapore

The Infocommunication Development Authority of Singapore (IDA) conducted public consultations on its proposed QoS standards, and the summary of responses mirrors the dynamics and the different requirements of the stakeholders of broadband described in this paper (although not the intention of the IDA document). While the operators request the IDA to refrain from setting performance benchmarks and penalties, the general public calls for stringent standards to ensure customer requirements are met (Figure 7).

The IDA's decision to proceed with setting of the QoS standards was based on the fact that, at the time, the market was still developing and that relying solely on market-driven incentives would have been premature (IDA, 2000). It would also not have been in keeping with the regulator's mandate of having the best interest of the consumers in mind. Therefore, the IDA published performance indicators (network availability > 99%, Latency < 50ms and < 300ms for local and international segments, respectively, among others) with a non-compliance penalty (IDA, "QoS Standards for Retail Broadband Internet Access Service"). The IDA has been publishing results on their website and has made much progress in defining and developing further the methods and quality standards used for benchmarking.

Parameter	Operator Comments	General Public Comments
Latency	The proposed < 300ms for the International segment should only apply if traffic is routed via undersea cables.	300 ms is not adequate to support interactive application (e.g., video streaming, online games, etc.).
Bandwidth Utilization	The cost of maintaining 25% traffic-free bandwidth would affect both the service provider and the customer. This benchmark was also deemed unnecessary in a competitive market.	Requested for operators to reveal their amounts of purchased bandwidth so that consumer can makes informed choices when selecting a service provider.

Figure 7: Selected comments from operators and the public in relation to IDA proposed QoS standards (IDA, 2000)

4.1.4 The Philippines

In December 2010, the National Telecommunications Commission (NTC) drafted a memorandum order (MO) on minimum speed of broadband connections, which contained a clause allowing telcos / ISPs to put restrictions on the amount of data that can be accessed by a user per day. These data caps were contained in the fair usage policies (FUP) of the ISPs. Probably pressured by the public uproar that followed, the

NTC conducted public consultations in January 2011 to invite comments from concerned stakeholders on the memo. A few months after, NTC issued MO 07-07-2011. A number of key stakeholders found the MO to be anti-consumer and ineffective, as it contained only one QoS parameter to be measured (i.e., service reliability) and had no clear regulatory action against telcos for non-compliance. But in the absence of any official means to measure QoS, the MO was ineffective. Three years later, the Philippine Senate initiated an investigation on slow and expensive Internet service. This presented an opportunity to inform decision makers of broadband QoSE. The results of the QoSE study was also presented in various conferences and meetings, and shared on social media. Concomitant to the Senate hearings, the NTC conducted a series of public consultations and technical working group (TWG) meetings to update and improve MO 07-07-2011. LIRNEasia, through this author, submitted its comments and participated in all the dialogues. The NTC positively welcomed the recommendations of LIRNEasia. As of this writing, the TWG has agreed to issue two separate MOs for fixed and mobile broadband. The NTC is also in the process of procuring a hardware and software-based testing tool, whose specifications will be based on the inputs of the TWG.

5 Broadband Quality in the Philippines: Lessons learnt, Challenges faced

There has been much debate about the impact of research in the policymaking processes, but a recent study by Harris (2015), which focused on ICTD research concluded that "while ICT4D researchers are interested in influencing both practice and policy, they are less inclined toward the activities that would make this happen, especially engaging with users of their research and communicating their findings to a wider audience" (p. 1). In a survey, Harris revealed that while most ICT4D researchers agree that "research-based evidence is important for shaping policy" (91.1%) and, at the beginning of their research, had intended "to use the results to influence professional practice (85.8%)… and government policy (74.6%)," only 51.4% of the survey respondents include "communicating the results of their research to the public in their research design." More importantly, "only 34.3% of respondents claim to spend much time synthesizing their findings into compelling stories, and 27.8% in communication programs targeting policy-makers" (p. 10). Finally, only 25.7% invest time in advancing a political position or policy.

This section will show how research can be used for policy reform advocacy. It will illustrate how LIRNEasia's QoSE study has been used and disseminated in different forms with the intent of influencing key decision-makers and stakeholders in the telecom sector (legislators, regulator, and concerned government agencies such as the Department of Trade and Industry and the Department of Justice Office for Competition), and inform various advocacy groups, media, and consumers about the state of Philippine Internet.

Philippine Internet. The Philippines has been a laggard in terms of Internet access, quality, and affordability. As of end-2014, only 37% of its population was able to go online. According to a 2012 survey by the Department of Education, 83% of its 38,569 elementary schools reported not having Internet access in their area, wired or wireless. Wholesale and retail Internet services are very expensive compared to other countries. Business-grade bandwidth of 1Gbps that costs $6 per Mbps in Australia, $5 in Hong Kong, and $2 in the USA would cost $25 to $45 per Mbps in Manila and $70 in Cebu (Jones, 2014). Fixed broadband connection that costs $2.30 per Mbps in Thailand, $10.30 in Malaysia, and $16.80 in Indonesia would cost $20.35 in Manila (Ookla, 2014).

The Philippines has two major telecom companies: PLDT, the incumbent telco who also owns mobile operators Smart Communications, Talk 'N Text, and Sun Cellular (bought out by PLDT in 2011); and Globe Telecom, who owns Globe and Touch Mobile. PLDT and Globe also own and operate international gateway facilities, backhaul, national backbone networks, and the last mile. Combined, PLDT (62.08%) and Globe (21.47%) make up about 84% of the telecom market. PLDT and Globe, and their subsidiaries, are also the largest ISPs in the country. The PLDT Group, however, has an overwhelming lead in the Internet market (85% of total market).[9]

By law, ISPs are not allowed to build their own backbone network; only telcos with Congressional franchises can. Hence, all ISPs need to link to the big telcos for Internet connection. Since the government does not have its own backbone, it, too, has to connect to the telcos like any regular client.

[9] Estimates are based on visible ASNs of customers populations published by APNIC. See http://stats.labs.apnic.net/cgi-bin/aspop?c=ph.

There is weak local IP peering among ISPs. The Philippine Open Internet Exchange (PHOpenIX) is the only carrier-neutral IX point in the country run by the Advanced Science and Technology Institute (ASTI) of the Department of Science and Technology (DOST). All major telcos / ISPs are peered through the PHOpenIX except the PLDT Group.

Telecom infrastructure seems wanting and unable to cope with the growing demand for broadband service. While it is true that an archipelago, such as the Philippines, is more difficult to connect, poor QoS is experienced even in places like Metro Manila, a highly urbanized, densely populated, and geographically contiguous area.

Influencing the decision makers. In April 2014, an infographic posted by ASEAN DNA showed that out of 13 countries, including members of the Association of Southeast Asian Nations (ASEAN), USA, China and Japan, the Philippines had the slowest average Internet speed. The infographic went viral and triggered a public outcry about the poor quality of Philippine Internet.[10] In May 2014, a meeting to discuss the major challenges in Philippine Internet, and their possible solutions was called for by a neophyte senator and his staff. Among the problems cited were the lack of competition, weak and ineffective regulation, poor local interconnection, and "territorial" connectivity. The recommendations put forward included (i) the need to update relevant laws and policies in order to promote competition and better regulation (where necessary, such as in broadband QoS), (ii) local IP peering through a carrier-neutral Internet exchange points (IXPs) to improve latency, and (iii) sharing of infrastructure (i.e., cellular towers, utility corridors) to reduce cost of expanding access. That same month, the senator initiated an investigation, which focused mainly on the problems and solutions discussed during the meeting. From May 2014 to February 2015, four Senate hearings and two TWG meetings have been conducted. Further, there have also been numerous consultancies with the senator's staff, both online and offline, where other informed stakeholders (from government and civil society) have been brought in to the discussion.

[10] The Facebook post has since garnered 5,438 shares, as of this writing. See https://www.facebook.com/ASEANDNA/photos/a.494193073943978.121343.494189467277672/801684926528123/.

In June 2014, a presentation was made highlighting the state of broadband QoSE in the country at the Philippine Network Operators' Group (PHNOG) forum on IP peering. Two key points received special attention: (i) poor performance of Philippine ISPs in terms of actual versus advertised speed (truth in advertising); and (ii) Philippine ISPs offered the lowest value for money among all the ISPs in the region that were tested, considering the actual speed and cost of the data plan (see Figure 8 and Figure 9). These points were quoted by media and mentioned in the following Senate hearings.

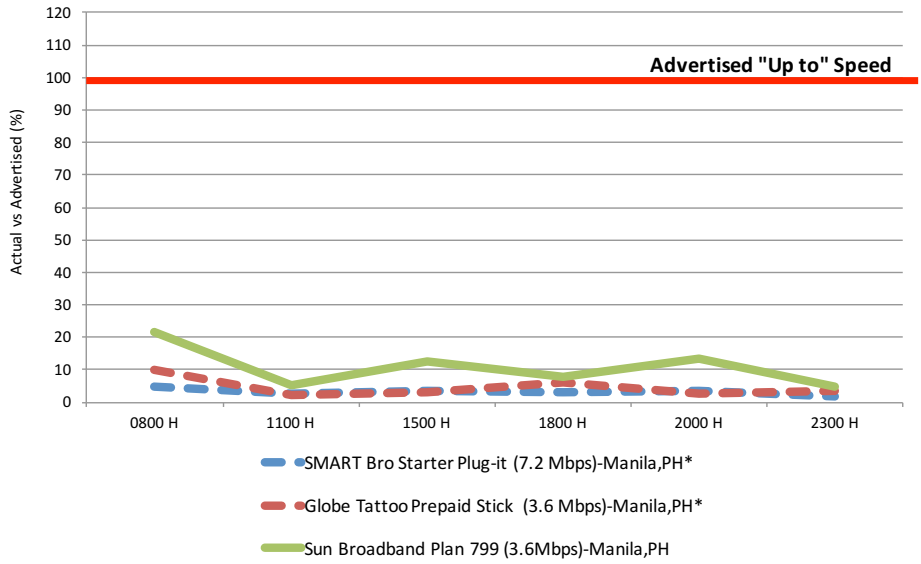

Figure 8: Actual vs. Advertised Speed of Major ISPs in the Philippines (LIRNEasia, 2014)

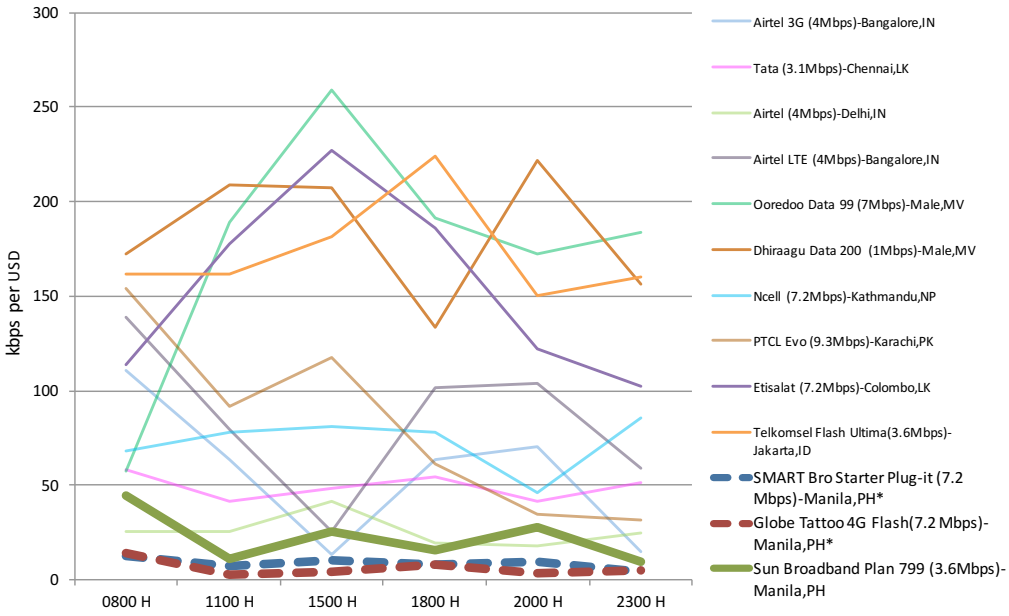

Figure 9: Value for Money in terms of Data Charges vs. Actual Speed (LIRNEasia, 2014)

Participation in the Senate hearings presented opportunities (i) to get introduced to key stakeholders from the telecom industry, concerned government agencies, the regulator, and various advocacy groups; (ii) to get invited to participate in related public consultations by government (NTC), local and international conferences (National Competition Conference; RightsCon); and to be cited as an "expert" by media (including major dailies and online news sites).

As a result of the Senate hearings, the NTC initiated a public hearing and consultation to update MO 07-07-2011, which sets the standards for broadband QoS in the country. Although comments and recommendations were presented at these meetings, there was some resistance from industry players who are not used to having policy think tanks and reform advocates participate in the NTC hearings.

Spreading the word. Exploring the use of various media in order to bring the study to a bigger audience helped promote the relevance of evidence-based policy recommendations.

- Writing about current issues, especially in specialized publications, can put a researcher on people's radar. This author, for example, wrote about the results of the QoSE study on Telecom Asia, an industry publication, where it was well received (225 Facebook likes, 34 retweets as of this writing).[11]
- Sending email blasts to personal and professional networks, posting on Facebook and Twitter, and engaging in online forums help disseminate information faster. However, in using social media, the research needs to be in a format that is easy for the public to digest (e.g., tweeting about a study and its results using only 140 characters at a time). This is assuming that researchers are on social media to begin with. See Figure 10 for a comparison of audience response to two tweets about the same QoSE study, but written differently.
- Preparing a 1-2 page policy brief that can be customized and sent out to specific people is very important. This author prepared policy briefs custom-made for legislators, for technical experts, and for the media.

[11] See Mirandilla-Santos. 2014 September 10. The myth of broadband in the Philippines. Telecom Asia. http://www.telecomasia.net/blog/content/myth-broadband-philippines.

Figure 10: Comparison of audience response between two tweets about LIRNEasia's broadband QoSE study.

Networking, networking, networking. There is no substitute to face-to-face networking, especially for young or budding researchers who intend to influence public policy through their work. A lot of effort should be made in reaching out to people who can contribute to enriching one's knowledge about the issues being researched. For example, this author initiated meetings with a number of technical experts (mostly network engineers and administrators), lawyers, and legislative staff members to discuss the QoSE study and other related issues. In some cases, it helped that people were familiar with Telecom Asia and the Senate hearings. These networking opportunities helped establish rapport and build trust—two of the most valuable resources in policy advocacy.

6 Recommendations and Conclusion

Most applications and services available on the Internet, specially cloud services require a certain minimum level of quality in order to perform. This minimum requirement will also determine the uptake of these services. A study by Aberdeen Group says that a one second delay reduces customer conversation by 7 percent, customer satisfaction by 16 percent and page views by 11 percent, thereby highlighting the importance of broadband quality of service experience.

The cloud clearly shifts the focus of these broadband characteristics. With servers located all over the world, network latency gets more complicated than a single client-server connection. Apart from the inevitable latency between the client and the server it queries, there is a compounding effect caused by the latency in the virtual data center (the collection of servers and databases that are accessed when the client makes a request). Users are also increasingly using the cloud as a redundant external storage mechanism and are storing files, photos, system back-ups etc. remotely. The sheer volume of content being uploaded suggests that network operators need to rethink the data caps and the uplink speeds, which are often considerably less than advertised download speeds.

Added complications emerge when measuring the performance of mobile networks. In wire-line and fixed wireless networks, there is a static relation between the number of users and the exchange/base station. In mobile networks, the number of users served by a base station is not under the control of the operator, nor is it under the control of any user. Therefore, the load on a base station can vary within a very short span of time, resulting in tremendous variation on QoSE. Based on operator configurations, such occurrences may cause the cell to dynamically resize, thereby effecting changes to the user experience, including, in some cases, disruption of service.

Quality of service experience is a time dependent variable. From an operator perspective guaranteeing high quality 24/7 is near impossible. It is extremely resource intensive and will be too costly for the end users. Therefore, some form of middle ground has to be

achieved and regulators are best positioned to ensure that a reasonably good service is offered to users.

To do this, adopting a sound methodology is imperative. While the hardware approach proves to produce high levels of accuracy, whether or not it reflects the actual experience of the user is questionable. With operators providing test nodes, it is likely that these servers reside on better-designed parts of the network with high connectivity and bandwidth assigned to it. The software approach on the other hand is easy to deploy and can be used reflect a user's experience, however based on the method adopted and the user carrying out the tests (e.g. the use of a virus infected machine, issues with the user's home Wi-Fi, etc.), the result can have a significant level of inaccuracy. Therefore, finding the right balance between the two approaches is vital. There is also great value in conducting the performance diagnostics for different segments of the network, as opposed to only focusing on International servers or servers that are closest to the user's location, as some software applications do.

In reality, benchmarking broadband performance is a resource-intensive exercise and therefore only best efforts can be made. There isn't a right or wrong way of measuring performance as each approach has its advantages and disadvantages, and various methods are implemented based on the resource availability, not necessarily because it was the best approach available. The richer the data set, the better the chances of aggregating the data to reflect the near-actual service levels of a city / town. A regulator-driven hybrid approach (hardware and software) along with user participation will be more likely to create a rich data set of performance measures, which will, in turn, provide a better understanding of the broadband performance of a locality.

The Philippine experience has shown how a broadband QoSE study can be used to inform policymaking and regulation, up to a certain degree of success. However, it also revealed that having the technically correct method and recommendations is not enough. Efforts need to be made for the study to be accessible, not only to peers and experts, but to decision makers and consumers, as well. Researchers (and institutions) must also seize opportunities at critical junctures in the policy process where the study can be relevant and most useful.

While recognizing the woes and weaknesses of government, researchers must learn to work with and support government, because often it is public officials in key posts who make decisions that can make or break reform initiatives.

Apart from having the correct technical analysis, communicating the idea to the right audience is equally important. Key takeaways from the author's experience:

- Labour over a 1-page policy brief as much as you would a 30-page policy paper. Make the message and medium both accessible.
- Be present. Take that 2-hour cab ride to the legislative house to attend a 20-minute meeting. A face-to-face exchange and handshake with a policymaker could earn you some political and social capital. Participate in conferences and seminars where key stakeholders are expected to attend. Get yourself invited, if necessary.
- Deliver. Policymakers and regulators need all the technical backstopping they could get. Write those talking points, develop that position paper, and prepare those slides. Submit on time.

The authors have presented the various approaches of measuring broadband performance along with technical and non-technical challenges of each. The complexities associated with broadband via the mobile network have been discussed. As the process of taking research to policy in the Philippines is still ongoing conclusive remarks cannot be made; however, the authors have provided some guidance on how, as researchers, we may influence the policy process.

Acknowledgments

This research was carried out with the help of a grant from the International Development Research Center (IDRC) Canada and UKaid by the Department for International Development, United Kingdom. The authors would also like to acknowledge Senator Bam Aquino, for championing ICT policy reforms within and outside the Senate; Jaime Faustino, for being a mentor on development entrepreneurship; Rohan Samarajiva, Helani Galpaya and LIRNEasia staff for all the training, support, and opportunity to make evidence-based policy analysis and recommendations; and Democracy.net.ph, Internet Society and DOST - Advanced Science and Technology Institute (ASTI), for generously sharing their time and effort, insights, and network as fellow ICT policy-reform advocates in the Philippines.

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