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Consultation Paper

Review of Existing and Formulation of New KPIs in Fixed Broadband Quality of Service (QoS) Regulations

Pakistan Telecommunication Authority

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1. Introduction

1.1. Background and Purpose

1.1.1. Pakistan Telecommunication Authority (PTA), is a corporate body established under Section 3 of the Pakistan Telecommunication (Re-organization) Act, 1996. The function of the Authority is to regulate the establishment, operation and maintenance of telecommunication systems and provision of telecommunication services in Pakistan. It is the prime responsibility of PTA to protect the rights of licensees as well as user of telecommunication services.

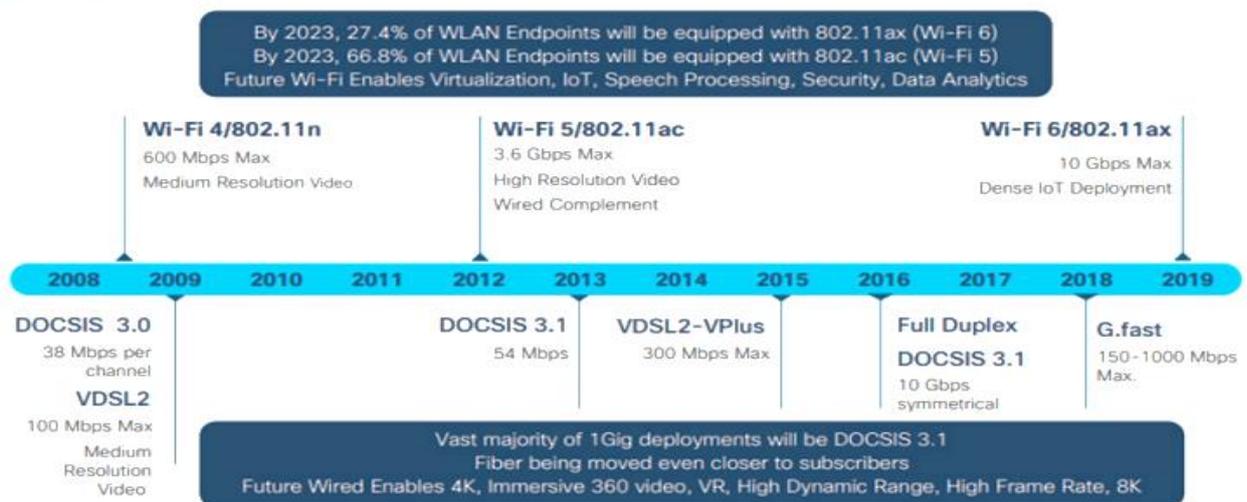
1.1.2. The Broadband (i.e. Fixed Line) Quality of Service (QoS) Key Performance Indicators (KPIs), have been outlined in Broadband Quality of Service Regulations 2014, gazette notified in August 2014 referred as “*BB QoS Regulations 2014*”. Due to the growing number of subscribers the quality of broadband services is of concern to PTA. As per PTA’s vision of “*Protecting Consumer Interest and ensuring high quality ICT Services*”, these indicators are created to establish quantifiable and measurable standard parameters; which the service provider is entailed to provide and the user has a right to expect thus invariably enhancing consumer satisfaction.

1.1.3. The “Broadband” services, as defined in BB QoS Regulations 2014 is “always on” service with a data rate equal to or greater than **256 Kbps** or as adopted by the Authority from time to time. Similarly, in line with the goals envisioned in Telecom Policy 2015, which emphasis on the Widespread availability of affordable broadband services, provided over fixed or mobile networks with characteristics that support contemporary and new digital applications and content. According to section 9.3 of the said policy, PTA is required to monitor the broadband quality of service provided by the service providers according to its key performance indicators, including committed bandwidth and outage commitments with the customer. With the technological development and the introduction of G.fast Technology, the theoretical speed has been enhanced to 1000Mbps (max) along with the promulgation of WiFi-6 /802.11ax protocol/standard, where the data rates of 10Gpbs (dense IoT Deployment) has been attained, the definition of minimum downlink speed for term “Broadband” needs to amended from **256kbps** to **4Mbps**. Also, the used cases of Fixed Wireless Access (FWA) broadband in 5G telecommunication technology is ultimately considered as substitute for wireline connection in the last mile, enabling the transfer of high speed data between two points.

1.1.4. Moreover, by 2025, Pakistan also aims to connect 75% of Metropolis, districts, town, tehsil and union council with Optical Fiber Cable based fixed/wireless access network with an average user data throughput of 50Mbps in its Major cities.

1.1.5. The technological development in the field of Broadband can be summarized as below:

Historical evolution and future of wired and wireless technologies (Cisco, 2020)



Source: Cisco. 2020. "Cisco Annual Internet Report (2018-2023)". <https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.pdf>

The broad band fixed internet services have been revolutionized with the introduction of GPON technology, enabling the provision of ultra-high speed internet services to the consumers.

Specification differences between GPON, XG-PON and XGS-PON (Huawei, 2018)

Specifications	GPON	10G PON	
		XG-PON	XGS-PON
Maximum Line Rate	Downstream: 2.488 Gbit/s Upstream: 1.244 Gbit/s	Downstream: 9.953 Gbit/s Upstream: 2.488 Gbit/s	Downstream: 9.953 Gbit/s Upstream: 9.953 Gbit/s
Maximum Physical Transmission Distance*	60 km	100 km	100 km
Maximum Split Ratio**	1:128	1:256	1:256

* The physical reach is defined by split ratio, optical module size, and fibre quality.
 ** The actual split ratio depends on the optical module model and fibre distance.

Source: Adapted from Huawei. 2018. "What are the differences between GPON, XG-PON and XGS-PON?". <https://forum.huawei.com/enterprise/en/what-are-the-differences-between-gpon-xg-pon-and-xgs-pon/thread/475409-100181>

1.1.6. To ensure a level playing field along with a competitive environment and subscriber satisfaction, performance measurement with a common standard regarding QoS is a must. Customers' opinion should also be taken into consideration in this regard. With the advancement in technology and the introduction of bandwidth hungry applications, it is about time to set some

benchmarks/thresholds for Broadband Service Providers (BSPs) which they must comply with in order to ensure consumers' satisfaction.

1.2. Regulatory Approaches

The Regulatory bodies across the globe adopt following approaches in order to regulate the telecommunication sector: -

QoS & NP - Command and Control	QoE - Consumer Empowerment	Encouragement and transparency
Parameters and measurement criteria	Tools to compare offers	Operators set own targets
Targets set	Speed testing tools	Publicize results
Data collection, validation, reporting	Coverage maps	Industry codes of conduct
Compliance control, enforcement and sanctioning	Other apps Feedback from users	

1.3. Quality of Service (QoS)

1.3.1. Quality of Service (QoS) refers to the ability of a network or service to satisfy the end user. QoS is defined in ITU-T Recommendation E.800 as *"the collective effect of service performances, which determine the degree of satisfaction of a user of the service"*. International Standardization Organizations such as International Telecommunication Union (ITU), International Organization for Standardization (ISO) and European Telecommunication Standard Institute (ETSI) define Quality of Service as:

- a. ITU-T Rec.E.800: *"Totality of characteristics of a telecommunications service that bear on its ability to satisfy stated and implied needs of the user of the service"*.
- b. ETSI-TR102157: *"Quality of Service (QoS): the ability to segment traffic or differentiate between traffic types in order for the network to treat certain traffic differently from others"*.
- c. ISO-8402: *"The totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs"*

1.3.2. In general terms, Quality of Service (QoS) refers to the ability of a network or service to satisfy the end user. QoS therefore concerns aspects of services that consumers experience directly. The ultimate beneficiary of QoS regulation shall be the customer. To this end, QoS regulation shall assist end users in choosing their Service Provider by providing transparent, objective and comparable information across Service Providers.

1.4. Network Performance (NP)

1.4.1. Technical performance aspects of telecommunication networks are assessed by Network Performance (NP) parameters rather than QoS parameters. While QoS and NP parameters are different in nature and serve different purposes, it is clear that there exist intrinsic relationships between QoS and NP parameters, one having a direct or indirect, and sometimes even inverse, influence on the other. It should be noted that the distinction between QoS and NP is not always clear-cut. The performance of any network can be gauged by measuring performance of its network

elements one by one, or by measuring the performance of the whole network i.e. the combination of the performance of all single elements. ITU-T Recommendation I.350¹ provides a conceptual categorization of Quality of Service (QoS) and Network Performance (NP) metrics.

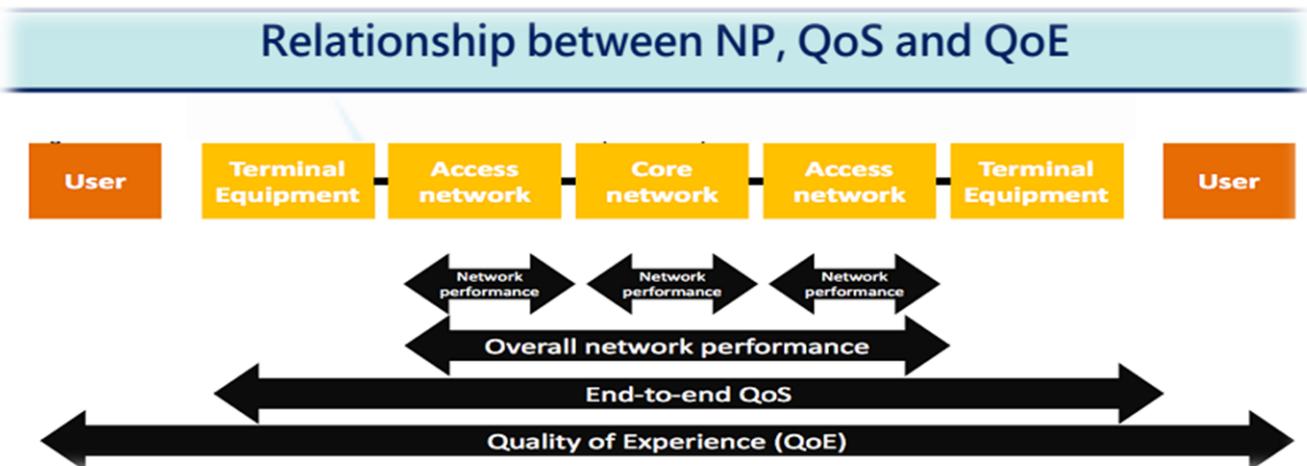
Quality of Service parameter	Network Performance parameter
User oriented	Network provider oriented
Service related attributes	Network element and technology related attributes
Focus on user observable effects	Focus on planning development (design), operations and maintenance
Observed at service access points for the users, independent of network process and events	Observed at network connection element boundaries, e.g. relating to protocol specific interface signals

1.4.2. On the same line, the below tabulated KPIs for both QoS and NP Parameters are proposed to be implemented in the Broadband QoS Regulations – 2021.

1.5. Quality of Experience (QoE)

1.5.1. ITU-T Recommendation P.10/G.100 defines Quality of Experience (QoE) as *“the overall acceptability of an application or service, as perceived subjectively by the end-user”*. In 2016, this definition has been modified by ITU-T Study Group 12, as *“Quality of experience (QoE) is the degree of delight or annoyance of the user of an application or service”*.

1.5.2. QoE focuses on the entire service experience and includes the whole path from user to user including the end-user expectation, perception and context of use. QoE is further elaborated in ITU-T Rec G.1011. The psychological profiles and emotional state of a user influences QoE, due to its subjective nature of measurement and customer perception regarding a specific service. In any assessment of the QoE, the description of the influencing factors need to be included: -



¹ ITU-T Recommendation I.350

1.6. Encouragement and Transparency

The Regulatory shall strive for the creation of Fair Regulatory Regime to promote investment, encourage Competition, protect consumer interest and ensure the high quality services as well as implementing the transparent environment across the board.

1.7. QoS Regulatory Framework

1.7.1. QoS Regulatory Framework starts with setting Standards defined by International Standardization Organizations such as ITU-T as well as regional bodies e.g. ETSI in Europe. These Standards can be implemented as part of the license conditions as well as regulations or industry guidelines. QoS is defined through a given set of parameters that are measurable. Such quality parameters that are defined for QoS measurements in a given country (or globally) are referred to as Key Performance Indicators (KPIs.) QoS KPIs can be **technical** and **non-technical**. Examples of technical KPIs include Service Availability, Network Availability, Jitters, Packet loss, DL/UL Throughput, Latency etc. Non-technical KPIs are customer centric, and may include parameters such as customer services, service provision, billing accuracy, network outage, etc. After defining the KPIs, different measurement methods can be used, which may differ from one country to another. National Regulatory Authorities (NRA) as well as Network Service Providers (NSPs) monitor QoS KPI.

1.7.2. Different approaches exist in the monitoring of technical and customer centric KPIs. Technical monitoring of KPIs can be performed by network auditing, probe stations on selected locations, etc. The customer focused KPIs are monitored by consumer surveys. The purpose of monitoring the values of the defined KPIs is to detect degradation of the QoS when it appears, and to apply appropriate actions to enforce QoS. Such QoS enforcement can be performed by publishing KPI monitoring results on a public website, through press releases, via directives etc., with the aim of informing consumers. However, if such enforcement approaches are not enough to enforce QoS, then more drastic QoS enforcement should be undertaken through financial penalties or through dispute resolution mechanisms.

1.7.3. A harmonized and common approach to regulate QoS is necessary to enable greater quality prospects for consumer, irrespective of their locations.

1.8. Selection of KPIs and Target Values

1.8.1. QoS Key Performance Indicators (KPIs) characterize the level of the service quality and customer satisfaction. QoS parameters represent subjective and abstract user perception of quality in terms of numeric values. QoS KPIs are essential for effective QoS management. They should be simple to use, provide accurate representation of customer perception, and be commonly accepted as standards. KPIs shall be comparable and measurable and shall be possible to distinguish between parameters for specific service types.

1.8.2. While defining QoS KPIs involvement of operators is beneficial and desirable. The factors need to be considered are the practicability for operators to measure the parameter, practicability for regulator and independent third party to audit the results and the measurement should retain the customer experience aspect.

1.8.3. QoS Regulations are based on the definition of QoS KPIs that will be monitored for the purposes of QoS enforcement. A target is defined as a potential value for a parameter that must be reached if quality is to be regarded as satisfactory. Three (3) classes of KPIs determine the user

experience i.e. a) Customer Interface, b) Network Infrastructure KPIs and c) Service Functionality KPIs.

1.8.4. KPIs targets are set by the Regulator based upon consultation, keeping in view current KPIs values obtained through monitoring operators' data.

1.9. Compliance and Enforcement

1.9.1. QoS Results are published by the Regulator in order to carry out comparisons between operators' performance. The main purpose of publishing information on QoS is to better inform consumers. Regulators should publish information on performance on their websites while requiring operators to send this information periodically to consumers, along with their bills. QoS information examples that should be published include the QoS results from the network audit campaign (testing, consumer survey, etc.). This information should be made available as soon as possible.

1.9.2. Ensuring compliance is highly recommended in QoS regulation. There are two (2) approaches in implementing QoS regulations i.e. Encouragement Approach and Enforcement Approach. For the regulator to proceed with the enforcement approach, it may start with recommendations and move towards obligations. The regulator can adopt a range of techniques, starting from naming-and-shaming strategies to tighter regulation, financial penalties and finally more drastic legal enforcements. However, doing so can involve extensive legal processes and may take a long time. A schedule of penalties may be announced publicly to ease implementation.

1.9.3. As a general principle, it is recommended that both encouragement and enforcement should be graduated and proportional. Whenever feasible, the regulator should engage in constructive dialogue with operators on quality problems. This should not be seen as a process of telling the operator how to run their business, but of asking targeted questions that can trigger the operators to review and reconsider their approach in areas with specific problems.

2. International Best Practices

2.1. Choosing QoS KPIs

2.1.1. There is a degree of flexibility allowed when deciding which QoS KPIs are to be chosen and measured by the Regulator. The Regulators in consultation with stakeholders are free to choose among the QoS KPIs that are appropriate, taking into account national circumstances and other factors, such as, the meaningfulness and usefulness of KPI, the underlying costs, time needed to implement the measurement and possible monitoring systems, changes required to adapt and modify current methodologies and allowing for the possibility of comparing new results with previous records. Also the concept of “**Net Neutrality**” has been implemented across the countries for equal access to the scar resources of internet to all the users. The biggest challenge to the BSPs shall be maintaining the Net Neutrality by providing the Quality services to the consumers.

The minimum QoS KPIs for Broadband Internet Services being measured across multiple countries are summarized and tabulated below for reference: -

Service	KPI	Definition
Fixed Broadband	Service Availability	The availability of the internet services to the end users during the testing period.

Internet Services	Network Availability	Network Availability is the measure of the degree to which the network is operable and not in a state of failure or outage at any point of time.
	Download Speed (kbps/Mbps)	The actual download speed available to the subscriber.
	Upload Speed (kbps/Mbps):	The actual upload speed available to the subscriber
	Network Latency/Round Trip Time (RTT, milli-sec).-(msec)	The network shall be checked for delay in order to gage the user perception about the services being provided.
	Packet Loss (%).	Packet loss is the percentage of packets lost to the total packets transmitted between two designated points.
	Jitter (ms).-	It is useful to see how varied the latency results are so that network stability and broadband stability can be determined

2.2. BEREC QoS KPIs & Measurement Method

2.2.1. Leading countries like U.S., U.K., and Australia have launched speed measurement programs for monitoring broadband performance. These programs aim to increase transparency for subscribers, and encourage performance-based competition. The QoS, as perceived by the end-user, is a crucial factor for both customers and service providers and with the profusion of ever evolving technologies, networks and services with different levels of QoS, it is becoming increasingly more complex to manage, measure and regulate QoS. Indeed, quality can be impacted by many factors at the network level and along the value chain, including the device, hardware, infrastructure, service and applications. BEREC suggested a list of QoS parameters, definitions and measurement methods shown in table to be used, where appropriate.

QoS KPI	Definition	Measurement Method
Supply time for initial connection	ETSI EG 202 057-1 (clause 5.1) The duration from the instant of a valid service order being received by a direct service provider to the instant a working service is made available for use. This should exclude cancelled orders.	ETSI EG 202 057-1 (clause 5.1.3) It is measured by: a) The times by which the fastest 50%, 95% and 99% of orders are completed; b) The percentage of orders completed by the date agreed with the customer and, where the percentage of orders completed by the date agreed with the customer is below 80%, the average number of days, for the late orders, by which the agreed date is exceeded.
Bill correctness complaints	ETSI EG 202 057-1 (clause 5.11) The proportion of bills resulting in a customer complaint about the correctness of a given bill per service.	ETSI EG 202 057-1 (clause 5.11.3) It is measured by a percentage.

Response time for operator services	ETSI EG 202 057-1 (clause 5.6.1) Time elapsed between the end of dialing to the instant the human operator answers the calling user to provide the service requested. Applicable to both fixed and mobile services.	ETSI EG 202 057-1 (clause 5.6.3) It is measured by: a) mean time to answers; b) percentage of calls answered within 20 seconds.
Frequency of customer complaints	ETSI EG 202 057-1 (clause 5.9.1) ETSI EG 202 843 The number of complaints logged per customer per data collection period.	ETSI EG 202 057-1 (clause 5.9.3) ETSI EG 202 843 Statistics: Number of customer requests to - technical support - commercial support Number of customer complaints related to - repair services - network/service management by the customer - cessation Number of customer complaints of any kind.
Customer complaints resolution time	ETSI EG 202 057-1 (clause 5.10.1) The duration from the instant a customer complaint is notified to the published point of contact of a service provider and is not found to be invalid to the instant the cause for the complaint has been resolved.	ETSI EG 202 057-1 (clause 5.10.3) It is measured by: a) the time by which the fastest 80% and 95% of complaints have been resolved (expressed in clock hours); b) the percentage of complaints resolved any time stated as an objective by the service provider.
Latency	ITU-T Y.2617 The time between the first bit of a packet of a source entering a network, being received by the destination, which immediately sent a bit back to the source, and then the last bit of the packet arriving at the source across the network (round trip delay).	It is recommended that delay is measured using: <ul style="list-style-type: none"> • UDP with ICMP or TCP as fall back option, • at least 10 measurements, and • calculated as an average of recorded roundtrip time values (typically expressed in milliseconds). The measurement server should return any UDP packet payload immediately, allowing the client to calculate delay. The Unix echo service could be used for this function. The measurement setup should be insensitive to (user) clock changes during the measurement.
Jitter	ITU-T Y.2617 The difference between the delay of the selected packets.	It is recommended that the delay variation (jitter) is calculated as mean deviation based on the samples collected for the delay measurement.
Packet Loss Ratio	ITU-T Y.2617 The total number of packets failing to deliver through the network divided by the total number of transmitted packets within a specific time window.	If a packet is not received back within a certain timeout (e.g. 3 seconds), it is considered as lost for the purpose of packet loss measurements. Recommended to send a large number of IP packets (e.g. at least 1000). Delay and packet loss measurements are typically performed over a longer period of time in order to allow for the time varying nature of network performance in packet-switched networks.

2.3. European Union (EU)

The most widely mandated existing QoS indicators across Member States include the following:

- Supply Time for Initial Connection
- Fault Rate per Access Line
- Fault Repair Time
- Bill Correctness Complaints
- Customer Service
 - Time Between Request for Service & Start of Service
 - Fault Frequency and the time to Troubleshoot & Eliminate Faults
 - Frequency of Complaints about Billing
- Internet
 - Data Transfer Speed
 - Web Page Loading Time
 - Latency
 - Jitter
 - Packet Loss Rate

3. Amendments in Quality of Service Regulations

3.1. Existing & Proposed Quality of Service Regulations

The **Broadband Quality of Service (QoS) Regulations, 2014** has a scope and applicability to all fixed broadband services for the purpose of identifying the minimum quality of service standards and associated measurement. However, with the advancement in the Broadband Technologies, migration from legacy network onto modern GPON/FTTH technologies, some of the KPIs included in the BB Regulations 2014 may not be applicable and needs to be reviewed/amended in accordance with the international practices.

3.2. Network Availability

The Network Availability is defined in Broadband Quality of Service Regulations 2014 *as under*:

The parameter shall check the availability of the network or service, as is claimed or "advertised" by the BSP. This shall verify operator coverage claims. It is a binary check.

KPI	Definition & Formula	Benchmark
Network Availability	<i>The parameter shall check the availability of the network or services as claimed by the Broadband Service Provider (BSP)</i>	<i>Binary Check (Yes/No)</i>

3.2.1. Amendment in Network Availability

Network Availability (>=99.9%):-It is the measure of the degree to which the network (Access and Core network) is operable and not in a state of failure or outage at any point of time. It measures the total downtime of the network, including the ATM switches, multiplexers, routers, e-mail facilities (if provided) and connection to Internet backbone over a month. All scheduled downtime for the purposes of maintenance and upgrading of the network system will be excluded from the calculation. However, all access network operators must keep their users informed of such maintenance times. Please note that reported downtime should include any downtime caused by upstream service providers.

Network Availability = (Total operational minutes – Total minutes of service downtime) / Total operational minutes’ x 100%

KPI	Definition & Formula	Benchmark
Network Availability	<p><i>The parameter shall check the degree to which the network is operable and not in a state of failure or outage at any point of time.</i></p> <p>Network Availability = (Total operational minutes – Total minutes of service downtime) / Total operational minutes’ x 100%</p> <p>1). Access Nodes 2). Core Nodes</p>	<p>1). >=99% 2). >=99.9%</p>

3.3. Link Speed

The Link Speed is defined in Broadband Quality of Service Regulations 2014 as under:

The link speed (LS) shall be checked against the advertised speeds. Actual link rates shall be measured during the proposed ‘T’ test times. Once a link has been established successfully, sustainability of the service shall be checked.

3.3.1. Amendment in Link Speed

It is proposed to delete this KPI from broadband QoS Regulation.

3.4. Service Availability

The Service Availability is defined in Broadband Quality of Service (QoS) Regulations -2014 as: -

KPI	Definition & Formula	Benchmark
Service Availability	<p>It is the measure to ascertain the availability of services to the end users. The metric shall check for the availability of the internet service. During testing if N attempts are made to connect to the internet and if the attempt failed F times then:</p> <p>Service Availability = (1-F/N) x 100%</p>	<p>≥99.9%</p>

3.4.1. Amendment in Service Availability:

The KPI is proposed to be renamed as “**Service Up Time Success Rate**” and is redefined as: -

Service Up Time Success Rate (>98%):-It is the measure to ascertain the broadband service up time to the end users in case of planned or unplanned start of device. During the testing period, if N attempts are made to connect to the internet and if the attempt failed F times then:

$$\text{Service Up Time Success Rate} = (1-F/N) \times 100\%$$

An attempt is declared as a failure, if internet connection is not established within time as per following classification of services: -

- i. Terrestrial FLL Services (xDSL, FTTx, DOCSISx, etc.): **60** Seconds
- ii. Satellite FLL Services: **120** Seconds

Under this KPI following parameter shall be checked:

- (1) Connect time (for instances when the modem is started afresh or rebooted)

KPI	Definition & Formula	Benchmark
Service Up Time Success Rate	It is the measure to ascertain the broadband service up time to the end users in case of planned or unplanned start of device. During the testing period, if N attempts are made to connect to the internet and if the attempt failed F times then: Service Up Time Success Rate = $(1-F/N) \times 100\%$	$\geq 98\%$

3.5. Retainability (minutes).

The Retainability is defined in Broadband Quality of Service Regulations 2014 as under:

This KPI shall check the retainability of the service over a period of 60 minutes. No disconnection over a period shall be termed as Grade A. The BSPs are graded from Grade-A to Grade-E.

Grade A	Grade-B	Grade-C	Grade-D	Grade-E
60 min	<60 and ≥ 45	<45 and ≥ 30	<30 and ≥ 15	<15 and ≥ 5

3.5.1. Amendments in Retainability:

It is proposed to delete the KPI from QoS Regulations.

3.6. Bandwidth

3.6.1. Down Load Speed (Kbps/Mbps): - The actual download speed available to the subscriber shall be measured. Keeping the reasonable loading level in the infra network links up to ISP node, and the fact that in general for normal broadband operations data rate is lower than the advertised/planned data rate, the data speed must be at least 60% of the advertised hi speed of broadband service plan, of both download and upload, and this must be experienced at least 70% of the time. For example, if the broadband download service plan is 1000 Kbps, a pass result shall be considered if data speed is 600 Kbps or better. The Download Speed shall be checked in a manner identified in Table 5 in Annex A. Subsequent grading shall be applied as provided in table 5.1 in Annex A.

Data download speed = Size of the test file (data) in ISP Server (in MB) / Transmission Time (in seconds) required for error free transfer of the entire data.

Size of test file should be at least 10MB. It should be downloaded from website of the BSP and/or PTA's website as long as the choice is consistent for all. For other download packages the file size shall be adjusted accordingly to maintain the same anticipated download time.

3.6.2. Amendment in Download Speed:

The KPI is proposed to be renamed as "*Download Data Throughput*" and shall be defined as follows:

Download Data Throughput (kbps/Mbps): The download data throughput is defined as the data transmission rate that is achieved for downloading specified test files between a remote web site and a user's computer in order to check the actual download speed available to the subscriber. Keeping the reasonable loading level in the intra network links up to **ISP node**, and the fact that in general for normal broadband operations data rate is lower than the advertised/planned data rate, the data speed must be at least 80% or above of the advertised speed of broadband service plan, and this must be experienced at all the time.

Download Data Throughput = Size of the test file (in MB) / Transmission Time (in seconds) required for error free transfer of the entire data.

Size of test file should be at least **5GB in size**. It should be downloaded from website (using either of **HTTP or FTP protocol**) of the BSP and/or PTA's website and /or from <http://speedtest.tele2.net/> or any site decided by the Authority, as long as the choice is consistent for all. For other download packages the file size shall be adjusted accordingly to maintain the same anticipated download time.

KPI	Definition & Formula	Benchmark
Download Data Throughput	The data transmission rate that is achieved for downloading specified test files between a remote web site and a user's computer in order to check the actual download speed available to the subscriber. Download Data Throughput = Size of the test file (in MB) / Transmission Time (in seconds) required for error free transfer of the entire data.	$\geq 80\%$ of Advertised speed

3.6.3. Upload Speed (Kbps/Mbps)

The Upload Speed is defined in Broadband Quality of Service Regulations 2014 as under:

Methodology used for calculating upload speeds shall be similar to download speeds. The Upload speed shall be checked in a manner identified in Table 5.2 in Annex A, for e.g. if the Broadband upload service plan is 256 Kbps a pass result shall be considered if data speed is 153.6 Kbps. The grading shall be done subsequently.

The BSPs are graded from Grade-A to Grade –E with Grade-A being the best Service Provider.

3.6.4. Amendment in Upload Speed.

It is proposed to rename the KPI to “*Upload Data Throughput (kbps/Mbps)*” and to be defined as: The Upload Data Throughput is defined as the data transmission rate that is achieved for Uploading the specified test files between a user’s computer to remote web site or in order to check the actual upload speed available to the subscriber. Methodology used for calculating upload speeds shall be similar to download speeds. The Upload Data Throughput must be at least **50%** of Download Data Throughput and must be experienced during all the time. (*e.g. If a package has a Download Data Throughput of 10 Mbps, and the test is conducted for 100 minutes, the Average Upload Data throughput must be 5 Mbps for 100 minutes.*)

Upload Data Throughput = Size of the test file (in MB) / Transmission Time (in seconds) required for error free transfer of the entire data.

KPI	Definition & Formula	Benchmark
Upload Data Throughput	The data transmission rate that is achieved for uploading specified test files between a user's computer and a remote web site in order to check the actual upload speed available to the subscriber. Upload Data Throughput = Size of the test file (in MB) / Transmission Time (in seconds) required for error free transfer of the entire data.	$\geq 50\%$ of Download Data Throughput

3.6.5. Download/ Upload Speed Ratio.

This KPI shall be intimated first by the service provider to be followed by the Authority to check for conformity through test measurements.

3.6.6. Proposed Amendments in Download/Upload Speed Ratio.

In the Broadband Quality of Service Regulations, this KPI is proposed to be deleted.

3.7. Contention Ratio.

The Contention Ratio is defined in Broadband Quality of Service Regulations 2014 as under:

It is the ratio of peak bandwidth utilization of a BSP averaged for the last three months obtained from operator’s Multi Router Traffic Grapher (MRTG), to the total sum of the individual bandwidth sold to the residential subscribers of the same operator.

Contention Ratio= Avg. of three months Peak BW (MRTG): \sum BW sold to relevant subscribers

3.7.1. Proposed Amendment in Contention Ratio.

In this KPI, the following amendments are suggested:

It is the ratio of peak bandwidth utilization of a BSP averaged for the last three months obtained from operator’s Multi Router Traffic Grapher (MRTG), to the total sum of the individual bandwidth sold to the subscribers of the same operator.

KPI	Definition & Formula	Benchmark
Contention Ratio	<p>It is the ratio of peak bandwidth utilization of a BSP averaged for the last three months obtained from operator’s Multi Router Traffic Grapher (MRTG), to the total sum of the individual bandwidth sold to the subscribers of the same operator.</p> <p>Contention Ratio= Avg. of three months Peak BW (MRTG): \sum BW sold to relevant subscribers.</p>	<=80%

3.8. Round Trip Time (RTT, milli-sec).

The Packet Loss is defined in Broadband Quality of Service Regulations 2014 as under:

RTT shall be measured up to the Broadband Remote Access Server (BRAS). *A packet must have a delay of no longer than 110 ms based on a minimum standard packet size of 32 bytes. RTT shall be tested using 'ping*' and shall be from the destination address provided by operator within its network as identified in Table 6 in Annex A. Subsequent grading shall be applied as provided in table below: -*

Round Trip Time (For Local Latency in msec) - BSP-A			
Grade-A	Grade-B	Grade-C	Grade-D
<=70 msec	>70 msec & <=80msec	>80 msec & <=90 msec	>90 msec & <=110 msec

3.8.1. Proposed Amendment in Round Trip Time (RTT).

The KPI is renamed as “*Network Latency/Round Trip Time*” and is defined as: -

Network Latency/Round Trip Time (RTT, milli-sec): - Latency or Round Trip Time is the amount of time it takes for packets to travel from one device to another. It is used to measure the delay on a network at a given time. RTT shall be measured **up to the edge node of network, connected with internet cloud or any server decided by the Authority.** The latency must not be greater than the threshold defined as per following classification of services: -

Benchmark

- (1) *Within local network: <= 30 msec;*
- (2) *International Segment-Terrestrial <=110msec;*
- (3) *International Segment-Satellite <= 500msec*

KPI	Definition & Formula	Benchmark
Network Latency/RTT	Latency or Round Trip Time is the amount of time it takes for packets to travel from one device to another. It is used to measure the delay on a network at a given time	<i>Within Local Network <=30msec</i> <i>International Segment –Terrestrial <=110msec</i> <i>International Segment- Satellite <=500msec</i>

3.9. Packet Loss (%)

The Packet Loss is defined in Broadband Quality of Service Regulations 2014 as under:

Packet loss shall be calculated using ‘ping’ as identified in Table 7 of Annex-A. The minimum number of packets that shall be tested at one time is 100, which may be reviewed by the Authority from time to time. The formula to measure packet loss is defined as follows: **Packet Loss = [L/(L+R)] *100**

Where, L = Number of Lost Packet, R = Number of packets received. Subsequent grading shall be applied.

3.9.1. Proposed Amendments in Packet Loss

The following amendments are proposed in this KPI:

Packet Loss Ratio (<= 1%). This indicator measures the percentage of the data packets transmitted from the source and fails to arrive at their destinations. The most common causes of packet loss are high latency or encountered congestion along the network route. A small amount of packet loss is expected, and indeed packet loss is commonly used by some Internet protocols to infer Internet congestion and to adjust the sending rate to mitigate for the congestion.

Packet Loss Ratio= (Total Number of Packet Loss* 100%)/Total Number of packets Sent.

KPI	Definition & Formula	Benchmark
Packet Loss	This indicator measures the percentage of the data packets transmitted from the source and fails to arrive at their destinations. Packet Loss (%) = [Total No. of Packet Lost/ Total No. of Packet Sent] x 100%	<= 1%

3.10. Jitter (ms)

The Jitter is defined in Broadband Quality of Service Regulations 2014 as under:

Jitter shall be calculated using ‘ping’ as identified in Table 8 of Annex A. The minimum* samples shall be 100. If RTT avg. is the average RTT, derived out of 100 samples, and RTT 1, RTT 2....RTT 100 are the RTT for individual packets then jitter shall be calculated as follows:

Jitter = $\sum(\text{RTTavg}-\text{RTTk})/100$ (magnitude shall be used without ‘+/-’ signs) Subsequent grading shall be applied as provided in below table:-

Jitter				
Grade A	Grade B	Grade C	Grade D	Grade E
<15 msec	>15 ms & 20ms	>20ms & <25ms	>25 ms & <30ms	>30 ms

3.10.1. Proposed Amendments in Jitter.

Jitter (ms) (<=15msec): Jitter refers to small intermittent delays during data transfers. It can be caused by a number of factors including network congestion, collisions, and signal interference. Technically, jitter is the variation in latency — the delay between when a data packets are transmitted and when it is received. It is the term used to refer to the variation in latency. High amounts of jitter cause packets to be delivered out of sequence. In contrast, latency is the amount of time it takes for packets to travel from one device to another. The more latency there is within a network the longer it takes for packets to reach their destination. The Jitter shall be calculated using ‘ping’ as identified in Table 8 of Annex-A. The minimum samples shall be 100.If RTT avg is the average RTT, derived out of 100 samples, and RTT 1, RTT 2....RTT 100 are the RTT for individual packets then jitter shall be calculated as follows:

$$\text{Jitter} = \sum (\text{RTTavg}-\text{RTTk})/100 \text{ (magnitude shall be used without '+'/' signs)}$$

KPI	Definition & Formula	Benchmark
Jitter	Jitter is the term used to refer to the variation in latency. This which mostly occurs during packet switching, but which can be monitored by following the ratio of the sum of average delays in each packet (variable delay) and the volume of packet received.	$\leq 15 \text{ msec}$

4. New Key Performance Indicators (KPIs)

4.1. Webpage Loading Time².

Webpage Loading Time is assumed to have direct influence on the customer satisfaction with the service provided by the network and its operator. The time required for loading a website is known as Webpage Loading Time.

KPI	Definition & Formula	Benchmark
Webpage loading Time	<i>The time that it takes to load a standard webpage. Measured by loading a standard reference page and recording the amount of time that this page takes to load.</i>	<i><= 3 Seconds</i>

4.2. Voice over Internet Protocol (VoIP)

VoIP is a method and group of technologies for the delivery of voice communications and multimedia sessions over Internet Protocol (IP) networks, such as the Internet. It is a technology that allows to make voice calls using a broadband Internet connection instead of a regular (or analog) phone line.

KPI	Definition & Formula	Benchmark
VoIP Call Setup Time	<i>The time between sending of complete call initiation information by the caller (A-Party) and in return receipt of call setup notification. $VoIP\ Call\ Setup\ Time = t_2 - t_1$ Where t_2 is ringing time and t_1 is invite time</i>	<i>< 7.5 Sec</i>
VoIP Mean Opinion Score	<i>The degree of speech quality that a listener perceive at the terminal with a talker at the other end in case of VoIP Call</i>	<i>> 3</i>

4.3. Net Neutrality

The "**core principles**" of **net neutrality** must be followed by all licensed BSPs across the country. The BSP shall not be involved in unlawful Blocking of applications, websites or any other content on the Internet by Slowing or "throttling" Internet speeds. Network providers shall transport all services on equal basis regardless of their types. Telecom development of Internet is the NGN. Traffic management mechanisms shall be used by ISPs to optimize the flow of traffic within their networks. Special measures shall be taken to overcome the traffic congestion which may be met in IP networks when traffic increases to a level at which routers run out of buffer space and are forced to start dropping some IP packets, which typically occurs, randomly.

5. Non-Technical KPIs

The user centric KPIs shall be monitored and maintained by the BSPs as per the provision of licenses and Regulations promulgated for the purpose.

5.1. Proposed Amendments in Non-Technical KPIs.

It is proposed to delete the Tariff Comparison KPI from Fixed Broadband QoS Regulations

² ETSI ES 202 765-4 V1.2.1 (2014-05)

6. Broadband Service Testing and Reporting Requirements

6.1. National Measurement of Broadband (NMB) Program

In addition to Authority's own conducted surveys and tests, all BSPs shall carry out quarterly testing of the quality of service of its Broadband services being provided to the consumers and the records of which shall be submitted to Authority as and when required.

Moreover, as per best International practices, the Authority intends to implement and execute the National Broadband Measurement Program (**NMB**). For this purpose, the Authority may plan and execute a recurring program (and when required under special circumstances), through its officers/authorized representatives or an agency appointed by it or through an automated mechanism designed for it (dedicated applications, etc.), henceforth called "**NMB Partners**". This survey shall gauge the performance of broadband service in the country with the aim to improve availability of broadband services to consumers and the program will be built on principles of openness and transparency.

(1) The Methodology for the National Measurement of Broadband (**NMB**) programs survey shall be as follows:

- (a) Through media outreach, PTA and NMB Partners/BSP shall select a group of consumers to volunteer. PTA, NMB Partners in consultation with BSPs, shall select the panel of the volunteers from the large pool of prospective participants according to a plan designed to generate a representative sample of desired consumer demographics, including geographical location, ISP, and speed tier. The goal is to cover the maximum number of BSPs and broadband technologies i.e. DSL, cable, fiber-to-the-home, fixed terrestrial wireless, and satellite, provided that the confidentiality of information of a volunteer shall be ensured during the testing by the respective BSP.
- (b) For measuring fixed broadband speed, a dedicated device pre-configured with custom testing software for measuring internet performance, shall be provided and placed inside the volunteering consumer's homes by BSPs, directly connected to the customer end router via Ethernet cable to directly accesses fixed internet service being delivered to the home. All the KPIs included in these Regulations shall be measured **Every Other Hour, 24x7** and after getting the results of thousands of Off-Net and On-Net tests, the results shall be calculated, compiled and reported to Authority, as per the format specified by the Authority.
- (c) The testing equipment having built in storage capacity not accessible to the user, and having the LAN interfaces of at least 1Gbps speed, Wi-Fi radios supporting 802.11n/ac/ax standards, shall be capable to interact with On-Net and Off-Net testing servers, along with the capability to fetch the complete list of test servers upon first execution of the test batch and performs a simple round trip time measurement to each. The device shall select the test server with the lowest round trip time to test against from that point forward.
- (d) Testing measurement servers (**with adequate computing, storage and networking capabilities**) having installed the test scheduler along with reporting databases, and other testing probes involved in the survey and firewalled, shall be provided by the BSPs at its own cost at premises designated by the Authority. The relevant BSP

shall provide the Authority with access to such equipment in real time for the information generated by these systems.

- (e) The Authority may depute its representatives to be present at the quality tests and surveys carried out by the BSPs.

6.2. Reporting Requirements

(a) The data collected during the National Broadband Measurement (NBM) program shall be submitted to the Authority within Fifteen (15) of the completion of the drive, whereas the Network Performance (NP) Parameters shall be submitted on Quarterly basis or at such intervals as the Authority may direct from time to time, and in the form and format as prescribed by the Authority. The BSPs shall keep a record of the said quality tests and surveys, in such form and manner as the Authority may specify. This record shall at all times be open to inspection and audit by the designated representative of the Authority, with or without notice to the BSPs.

(b) The record of all data shall be retained and maintained in the safe custody of the BSPs for a period of three (03) years.

(c) The Network Performance (NP) KPIs, to be measured, collected and reported to the Authority as per given schedule: -

Parameters/KPIs to be checked at Network End		
<i>Network Performance Parameters</i>		
<i>Indicator/KPI</i>	<i>Standard</i>	<i>Reporting Period</i>
Network Availability (1) Access Network (2) Core Network	(1) $\geq 99\%$ (2) $\geq 99.9\%$	Quarterly
Data Throughput (1) Download Data throughput ³ (2) Upload Data throughput	(1) DL \geq xx Mbps (2) UL \geq xx Mbps	Quarterly
Contention Ratio	$\leq 80\%$	Quarterly
Network Latency/Round Trip Time (1) Within Local Network (2) International Segment-Terrestrial (3) International Segment-Satellite	(1) ≤ 30 msec/ month. (2) ≤ 110 msec/month. (3) ≤ 500 msec/month	Quarterly
All Non-Technical KPIs:	As per license conditions and Regulations	Quarterly

6.3. Inspection of Quality of Service: - (1) The Authority may conduct inspections, surveys, tests or make surprise checks through its designated representative or conduct performance audit of the

³ Officer of the Authority to decide the node/port or customer for provision of required parameters

quality of service offered by BSPs from time to time to ensure that services are provided in accordance with the standards prescribed in the license, these Regulations or as determined by the Authority from time to time.

(2) In order to carry out the tests and surveys the BSPs shall provide connections (on non-discriminatory basis) to PTA within one week of request, extend full co-operation and provide all required assistance to the designated representative.

(3) The Authority may, if circumstances so require, engage a consultant to conduct the quality of service audit.

(4) The designated representative shall prepare an inspection report of such Quality of service inspections, which clearly spell out the shortfalls, if any, observed during the inspection. This report shall be provided to the BSPs. The BSPs shall immediately take all remedial measures to remove the shortfalls identified in the report and submit a compliance report within fifteen (15) days by confirming that all the specified shortfalls have been removed.

6.4. Publication of Quality of Service Reports. -- (1) The Authority may publish survey results, service test results, and ratings of the BSPs for information of the general public.

(2) All survey results, service test results and ratings of the BSPs shall also be available for the information of the general public on the website of each BSP.

7. Provisioning of QoS Monitoring System

(1) As per the terms and conditions of the license, which is reflected as follows, “The Licensee shall provide, at its own cost, state-of-the-art system(s) (equipment hardware, firmware, software) at premises designated by the Authority and ensure its upgrading, updating, security and safety in best possible, in order to measure and record traffic, billing, call detail records, IP data records, voice over IP, grey traffic analysis and mitigation, network threat detection, malware analysis, critical information protection, web analysis, web content filtering, IP consumer trend and OTT applications visibility and **Quality of Service (QoS)** in a manner specified by the Authority. The Licensee shall provide the Authority with access to such system, and the information generated by such system/equipment, and shall extend full co-operation and assistance to the Authority in connection with the Authority's exercise of these service provision and quality monitoring. The Licensee shall also be obliged to appear before the Authority, when called upon to do so, to answer any query on these matters put by the Authority.

(2) Every BSP shall extend the access of their broadband network(s) to the Authority for the extraction of all the detailed KPIs/parameters in the Regulations.

(3) The testing methodology shall be issued by the Authority and may be modified from time to time.

QUESTIONS FOR CONSULTATION

- Q1. Whether prescribed QoS KPIs, as per existing QoS Regulations, sufficient to effectively monitor QoS of Fixed Broadband networks? Please provide suggestions with justifications.
- Q2. Depending on the speed, is there a need to define different categories of broadband? If yes, then kindly suggest the categories along with the reasons and justifications for the same. If no, then also justify your comments.
- Q3. Whether the proposed QoS KPIs, sufficient to effectively monitor QoS of Fixed Broadband networks (Metallic, Optical Fiber Network, Satellite, etc.)? Please provide suggestions with justifications.
- Q4. The Authority seeks views on the proposed changes to Broadband Network Latency (Ping Time) standard for the mandatory standard for Quality of Service (Wired Broadband Access Service).
- Q5. Whether the ranges and values prescribed for new proposed QoS KPIs are in line with best international practices/ global benchmarks? Please justify with reasons.
- Q6. Authority intends to introduce the National Speed Measurement (NMB) program. Feedback and suggest the methodology to be implemented for measuring the speed of a customer's broadband connection.
- Q7. The need of the extent of policy or regulatory intervention by way of mandating certain checks relating to contention ratio, latency, and bandwidth utilization in the core network be determined. Please suggest your input in this regard along with the reasons and other ways to increase the performance of the core networks.
- Q8. Should it be mandated for TSPs and ISPs to declare actual contention ratio, latency, and bandwidth utilization achieved in their core networks during the previous month to their customers while communicating with them or offering tariff plans? Please elaborate.
- Q9. To improve the consumer experience, what should be the minimum standards/specifications for consumer devices available in the open market? Will any such policy or regulatory intervention have potential of affecting affordability or accessibility or both for consumers? Please justify your comments.
- Q10. Any other feedback which is relevant to QoS Regulations for the fixed broadband technologies like terrestrial (e.g. fiber optic, metallic), non-terrestrial (e.g. HAPs), and satellite technologies.
- Q11. There are two KPIs suggested for VoIP services in line with best international practices. Shall there be additional KPIs to be introduced for monitoring of the VoIP services?