CONSUMER PROTECTION ASSOCIATION
HIMMATNAGAR
DIST. : SABARKANTHA
GUJARAT

Comments

on

Review of Quality-of-Service Standards
for
Access Services (Wireless and Wireline)
and
Broadband Services (Wireless and Wireline)

Introduction :

Regarding QoS and QoE measurements in 5G technology, a number of studies have carried out various measurement approaches. The absence of measurement standards and the value of QoS and QoE for 5G provides opportunities and variations in the measurement objects, methods, and data acquisition. For example, in some researches they used mathematical approaches, meanwhile in some they have used a virtual approach. An approach that uses statistical analysis is also carried out as in research. Location and type of device also influence the measurement of QoS and QoE as in researches.

Trust to modern telecommunications networks plays an important role as a driver of technological and market success of any technology or telecommunication services. Most of the technological approaches to this problem are focused only on network security and do not include such a factor as the quality of service (QoS), which also plays an important role in the formation of trust both from the consumers and the regulator.

Question-1: What are the possible reasons for increasing gaps between the QoS reported by the service providers and the QoS experienced by the consumers? How this gap can be bridged?

Comments :

Capacity overflows, heterogeneous delay and packet losses are the resultant factors of network congestion and overloading. Such sort of dominant factors degrade the Quality of Service (QoS) and finally the network enters in a state of communication cut off.

Salient foundations of poor QoS are network congestion, link overloading, routing metrics, design conflicts, server-side-scripting, denial of service attacks, RFC congestion schemes and weakness of existing TCP protocols.

QOS MANAGEMENT MODEL EVOLUTION IN MOBILE NETWORKS

By developing last generations of mobile networks 3GPP have made successful standardization of principles and models of services quality management at the network level, moreover the new feature to service quality management has been introduced in 3GPP networks.

Ensuring the quality of services (QoS) in 3GPP networks by their evolution from HSPA technology to LTE Advanced technology is based on the following principles :

- operator provide services management;
- differentiation of services quality and users;
- minimal involvement of the user terminal in services quality management process;
- support of QoS for client applications that are invariant to the access network;
- the rapid establishment of the sessions;
- continuity of quality management function with mobile networks of previous generations;

- convergence of services in the interaction of mobile networks with fixed access networks;
- rapid introduction of new services to the market.

Temporary borders of further development of QoS management principles at the network level in the new 3GPP releases and their implementation in 5G networks will depend on many market factors.

Implementation of QoS management principles at the network level suggests a steady increase the number of mobile applications that control QoS based on the service quality requirements and creation of necessary high level data exchange by Bearer services.

In 4G networks that based on QoS model management on network level have implemented new types of QoS management which can use QoS network model management. In these cases these old applications have to be refreshed. However we can meet some terminals where used QoS terminal model management. It means that two QoS management models coexisted in mobile terminals some years.

In 4G networks, unlike packet connections in 2G/3G networks, a typical service of data exchange with a predetermined class of QoS is ready to form a connection to the packet network when a subscriber terminal is connecting to the network. QoS options for data exchange services are determined by the QoS parameters in the user profile that stored in the SPR (Subscription Profile Repository) database. This situation is very similar to the QoS management in GPRS/3G networks. However, in 4G network, after transmission of the first data packet from user terminal, this packet is routed to the packet network PDN, where the PCRF node managing network policies and billing analyzes quality class of requested service in the chain "E2E". Depending on the requested service class PCRF node can use different modifications of the QoS parameters to all nodes involved in the management of QoS data services. LTE user terminal unlike 2G/3G user terminal has no opportunity to request a particular QoS class, and only LTE network is responsible for managing QoS. Similarly, 4G network subscriber can't request information about the QoS parameters, as is done, for example, through the use of a secondary context in the 3G network.

Feature of QoS management in 4G network is that one user terminal can simultaneously support a variety of active services in E2E chain and each of these services will have their own individual QoS profile. 4G user terminal may have up to 256 E-RAB (communication services between the AT and the S-GW) service connections by using protocols E-UTRAN, while in 3G networks identified only 15 different RAB-ID.

Thus on the assumption of current QoS management strategy 5G QoS management mechanism have to based on mechanism of QoS management in 5G network and supports by NFV software solutions.

For realization of QoS management in network one have to define main QoS parameters for future 5G network which will allow managing of quality for new technology.

QUALITY OF SERVICE (QOS) AND QUALITY OF EXPERIENCE (QOE) IN 5G :

Before discussing QoS and QoE on 5G technology, we should review the definition of QoS according to International Telecommunication Union (ITU):

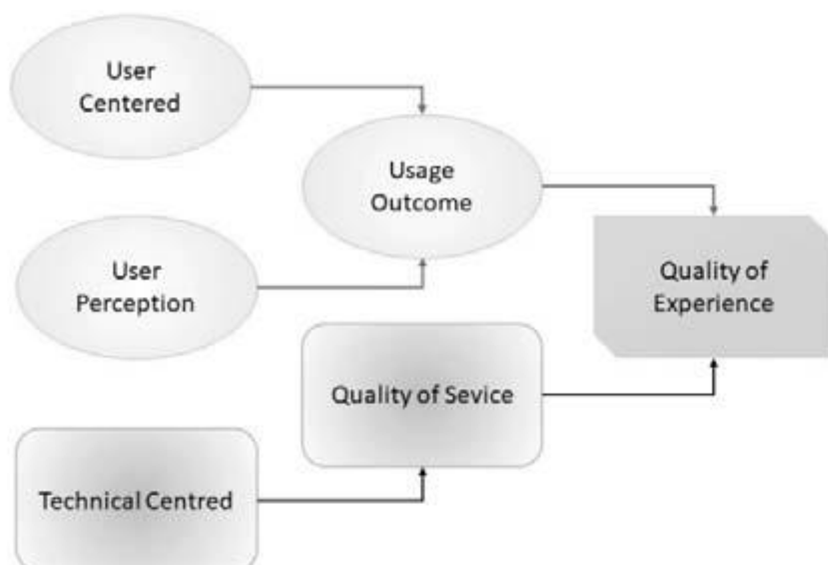
“Totality of characteristics of a telecommunications service that bear on its ability to satisfy stated and implied needs of the user of the service.”

Meanwhile, the ITU definition for QoE is

“the degree of delight or annoyance of the user of an application or service.” (Telecommunication Development Sector, ”Quality of Service Regulation Manual,” International Telecommunication Union (ITU - 2017).

5G technology with all its advantages is also expected to meet the values of QoS, QoE, reliability, and high security. Modeling to obtain QoS values from previous technologies may not be suitable for 5G technology. This is due to the value of QoE present in this 5G era. Parameters in QoS such as packet loss, loss rate, network delay, PSNR and travel time are considered less effective in 5G mainly for media communication with video because in the assessment of video media quality there is a satisfaction value represented in QoE. So even though the QoS parameter is still considered vital, it is not enough for the value of user satisfaction (M. Agiwal, A. Roy, and N. Saxena, “Next Generation 5G Wireless Networks: A Comprehensive Survey,” IEEE Communications Surveys & Tutorials, vol. 18, no. 3, pp. 1617–1655, 2016..)

Following figure shows the relationship between QoS and QoE. QoS, in this case, is a technical point of view on service quality and QoE is the point of view of user satisfaction with service quality. QoS parameters such as buffering, startup time, and good bitrate do not give high QoE values because there are various parameters of satisfaction associated with users and are unpredictable.

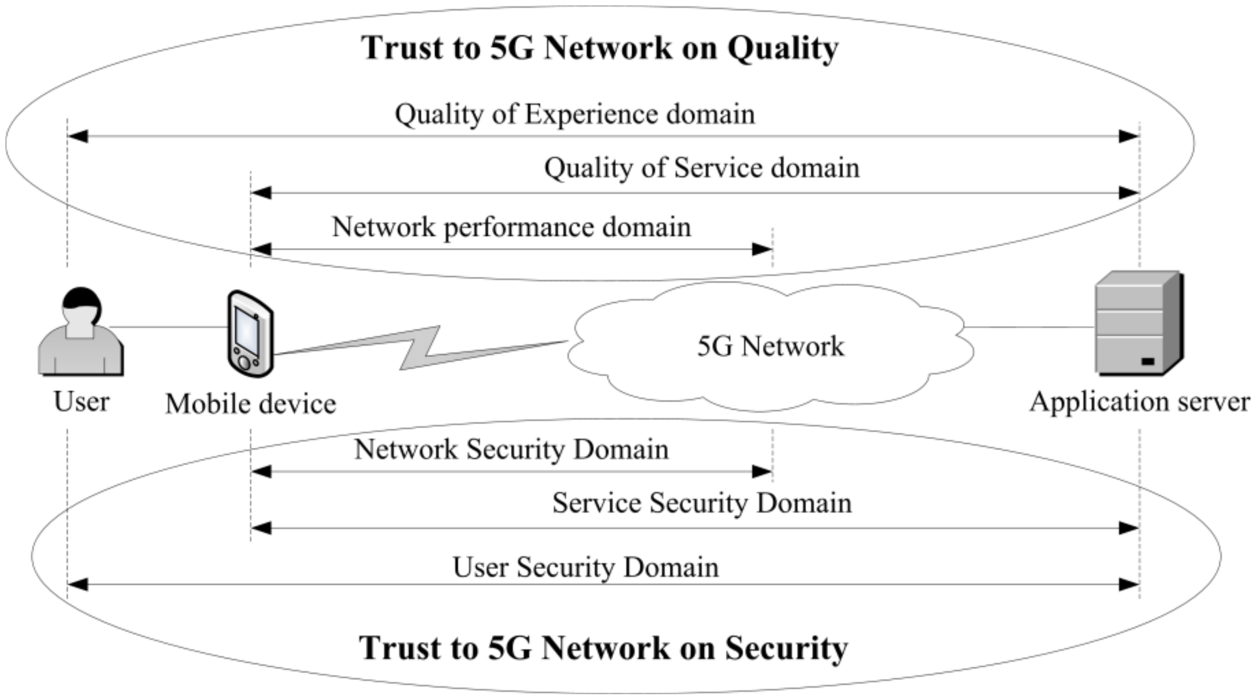


The value of QoS and QoE, especially in 5G technology, challenges how the two values can harmonized. There is one concept called Self

Organizing Networks (SON). This concept works on three features, namely reading network status, predicting user behavior, and dynamic adjustments to respond to the condition of a network. The SON concept is expected to help increase QoS and QoE simultaneously. Another concept in harmonizing QoS and QoE assessments is by combining objective and subjective parameters. Objective parameters are obtained from packet loss rate and latency which is communication traffic data, while subjective parameters are obtained from the Mean Opinion Score (MOS) method for user satisfaction through sampling. Through the quantization process, QoS mapping for QoE is obtained (L. Pierucci, "The quality of experience perspective toward 5G technology," IEEE Wireless Communications, vol. 22, no. 4, pp. 10–16, Aug. 2015.). This quantization process will be more effective using the Neural Network to produce optimal estimation values and quality expected by users in 5G technology.

5G technology provides more advantages than previous technology, especially in terms of speed and capacity. The 5G technology capability with each scenario opens up various opportunities and approaches to be able to calculate the quality value that this technology will provide. The opportunities mentioned above are still very open because there is no specific standard for 5G, no wide-commercial implementation, and also the probability of a variety of devices that can be handled by 5G. As a review from some research, there are three groups of measurement approaches of QoS and QoE on 5G technology. They are measurement objects, methods used, and data acquisition to be processed. Each group has advantages and disadvantages that can become its own potential. Hence the measurement needs to be adjusted to the location, the application, and the scenario that used in accordance with the conditions.

Quality parameters of 5G networks can be divided into three levels: Network Performance (NP), Quality of Service and Quality of Experience (QoE), as shown in Figure. NP and QoS are objective indicators that can be measured using specialized analyzers while QoE indicators are subjective, estimated by users on the basis of their personal experience. The deterioration of QoS and NP will primarily lead to lower trust to 5G networks of regulators and Business-to-Business (B2B), Business-to-Government (B2G) customers, while the QoE deterioration will lead to lower trust of mass market.



Quality and security levels of trust to mobile network

Mobile network QoS affecting all services :

QoS parameters has four layers, each of which provides the necessary precondition for the next layer, i.e., that a property belonging to layer N needs the presence of the properties of layer N − 1.

The first layer is network availability, which determines QoS from the viewpoint of the service provider than the service user.

The second layer is network access. From the service user's point of view, this is the basic requirement for all the other QoS aspects and parameters.

The third layer contains the other three QoS aspects:

- ✓ service access,

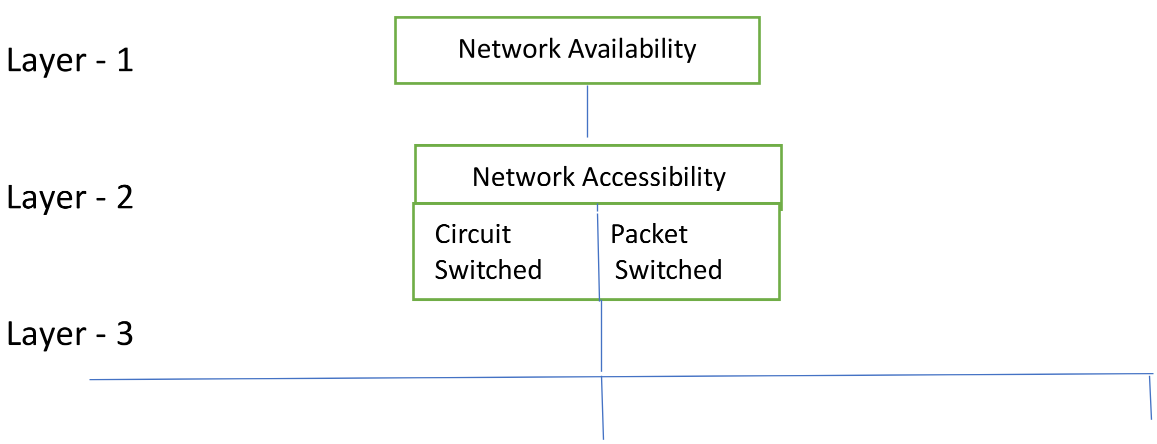
✓ service integrity and

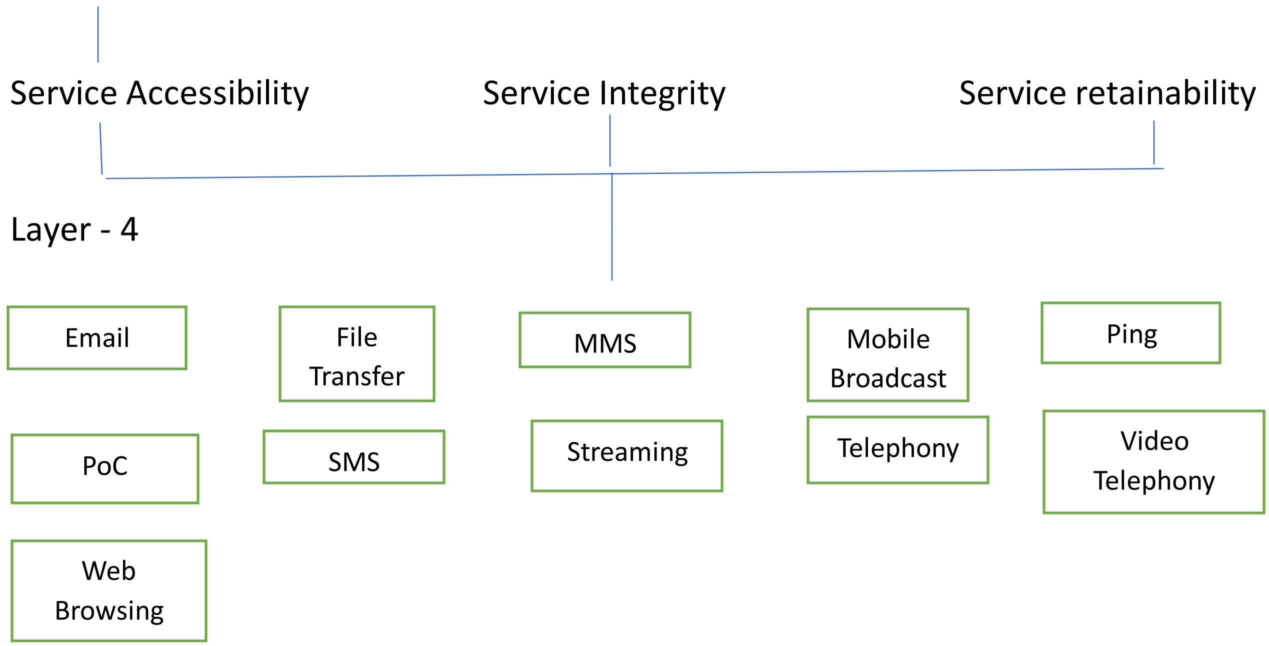
✓ service retainability.

The different services are located in the fourth layer; the performance of these services is characterized by service specific QoS Key Performance Indicators (KPIs). The first three layers are common to all mobile services or applications. They are characterized typically by the following parameters (KPIs):

- network availability;
- network accessibility;
- service accessibility;
- service integrity;
- service retainability.

In cases where the KPIs in layers 1, 2 and 3 are not maintained at a stable high level, it is useless to attempt to assess the QoS of any kind of service, because prerequisite conditions are not met and the relevance of QoS figures received will be close to zero.





Model for quality of service parameters - (adapted from [b-ITU-T E.804] and [b-ETSI TS 102 250-2])

Persisting problems with the KPIs for layers 1, 2 and 3 of a mobile network need to be resolved by the stakeholder in the interest of any mobile service and are therefore clearly out of scope of QoS considerations. First of all, layers 1 to 3 describe actually a kind of "pyramid of needs", i.e., before starting to think about service integrity (e.g., call drop rate in telephony), the service needs to be accessible first. Also, the "service" picture needs an overhaul. The "circuit/packet switched" division is legacy from 2G or 3G. Some of the "services" in layer 4 actually depend on each other or belong to different groups. There are "carrier services" such as the basic Internet protocol (IP), and also combined services using one or more such carrier services, e.g., the multimedia messaging service (MMS) that relies on the short message service (SMS) (which is actually an end user-related service as well) for notification, and uses packet data to actually transfer data. A "service" with the same effect for end users, e.g., some kind of over the top (OTT) chat with attached files, uses only basic packet data. In any case, there is no longer any real "technology dependency". If an operator decides to suppress Skype, or prioritizes certain video streaming, this is not the result of some fundamental ability or inability, but just the effect of some "traffic shaping" elements.

Possible solutions

Digital Services are realized through utilization of basic services provided by a network. Assuming that the reliability of Digital Services has to be very high, there are two basic ways to ensure this reliability.

- **Network centric:**

The QoS level for basic services provided by the network is sufficiently high to create the required reliability.

- **User centric:**

Robust end to end protocols on UE related infrastructure ensure the reliability of the actual service, even in the presence of deficiencies in the underlying functionality.

Such robustness can be described by key criteria for Services. Topmost is, for each transaction, a clear indication whether it was successful, which needs to be consistent for both sides. Assume a money transaction is composed of a number of steps, each step being the exchange of a data token. If the transfer of a data token has no clear "lost" criterion, but can take, in principle, indefinite time, a timeout needs to create a defined situation. The essential property of robustness is that, if a data token now arrives after its time-out, the protocol needs to ensure that this token is not causing any action any more.

With respect to practical aspects of service implementations, this poses some fundamental differences. When the main goal is to introduce Services in the near future, it needs to operate with the existing installed base of end user devices. This will automatically limit the spectrum of applicable methods to those which can be supported by those devices. A possible drawback of this approach is that if a technology has been deployed and is widely used, it will – as long as it is working without major problems – be difficult to replace, even if the new technology is superior. This may be less an issue with respect to end user devices as the penetration of smartphones continues to increase strongly due to their manifold advantages. It may be that these retaining factors are more on the side of infrastructure, as introduction of new technologies requires new investment that may, at least in the first years of usage, not be balanced by similar new opportunities to generate additional revenue.

QoS monitoring :

In order to secure the necessary quality level of Services, appropriate regulatory guidance and comprehensive performance targets need to be established. Basically, it would be possible to refer to basic performance measurements of respective carrier services (such as SMS, telephony (for DTMF or IVR) or packet data. Due to the nature of services implementation this will, however, be a surrogate with considerable risk of predicting actual service performance incorrectly. It is therefore – owing to the importance of the service – assumed that a better way of monitoring needs to be established. This monitoring should – while being fully aware of practical issues in definition and implementation – use actual use cases. The monitoring is proposed to have multiple forms that cover all stages of the technical life cycle of any service implementation.

Assessment and roll-out phase:

E2E performance measurements as professionally done by dedicated systems, e.g., under control of regulatory authorities.

Operational phase:

Regular E2E performance measurements as professionally done by dedicated systems, e.g., under control of regulatory authorities.

Considerations related to the fitness for the Services :

A successful introduction of Services via a mobile network requires fitness of the whole environment used, which is :

– fitness of the mobile network, to provide a minimum level of availability and accessibility;

– fitness of the mobile network to provide the services required for realization of Services;

– fitness of mobile devices used, to support the basic services used to realize Services;

– fitness of the service itself to provide useable interfaces;

– fitness of users to successfully use Services

– this may include the necessary skills to operate Services on phones as well as basic understanding of properties of Services in general, to protect users against exploitation of insufficient knowledge,

– fitness of the general society and the governmental institutions for Services.

There are even more issues remaining currently open, which will need further discussions:

- Mobile operators have increasing problems with the huge amount of data traffic in their networks. Therefore, if high speed fixed networks are available, there is a massive trend to use so called "WiFi offloading", where data traffic is redirected via Wi-Fi accesses to the internet backbone core. The consequences for Services seem to be quite unexplored, as yet.

In general, there is a correlation between the subjective QoE as measured by the MOS and various objective parameters of QoS. Typically, there will be multiple service level performance (QoS) metrics that impact overall QoE. The relation between QoE and service performance (QoS) metrics is typically derived empirically. Having identified the QoE/QoS relationship, it can be used in two ways:

1) given a QoS measurement, the expected QoE for a user can be predicted;

2) given a target QoE, the net required service layer performance can be deduced.

– These prediction and deduction steps are built on assumptions and approximations. Due to the complexity of services and the many factors that have an influence on QoS/QoE, there is no close one-to-one relationship that would allow statements like "If the bandwidth is increased by 200 kbit/s, then the rating by the user will rise by 0.5 points". To ensure that the appropriate service quality is delivered, QoE targets should be established for each service and be included early on in system design and engineering processes where they are translated into objective service level performance metrics. QoE is an important factor in services that are successful in the marketplace and is a key differentiator with respect to competing service offerings. Subscribers to network services do not care how service quality is achieved. What matters to them is how well a service meets their expectations (e.g., in terms of price, effectiveness, operability, availability, and ease of use).

Question-2: To support emerging applications and use cases please suggest a transparent framework for measurement and reporting of QoS and QoE especially in 4G and 5G networks considering relevant standards and global best practices.

Comments : Mentioned Above

Currently leading organizations in international standardization and development of telecommunication technologies such as: ITU, 3GPP, IEEE and ETSI have not formulated a strict definition of "trusted network". However, the trust to communication network significantly affects consumers' choice of communication operator, regulation of operators' activities by state bodies, as well as the market demand on communication services and equipment.

Definitions of QoS, QoE and Network Performance :

It is important to mention and clarify the differences and relationships between QoS, Quality of Experience [QoE], and Network

Performance [NP] since sometimes they can be confused with each other. Following Figure helps to locate where every term is present :

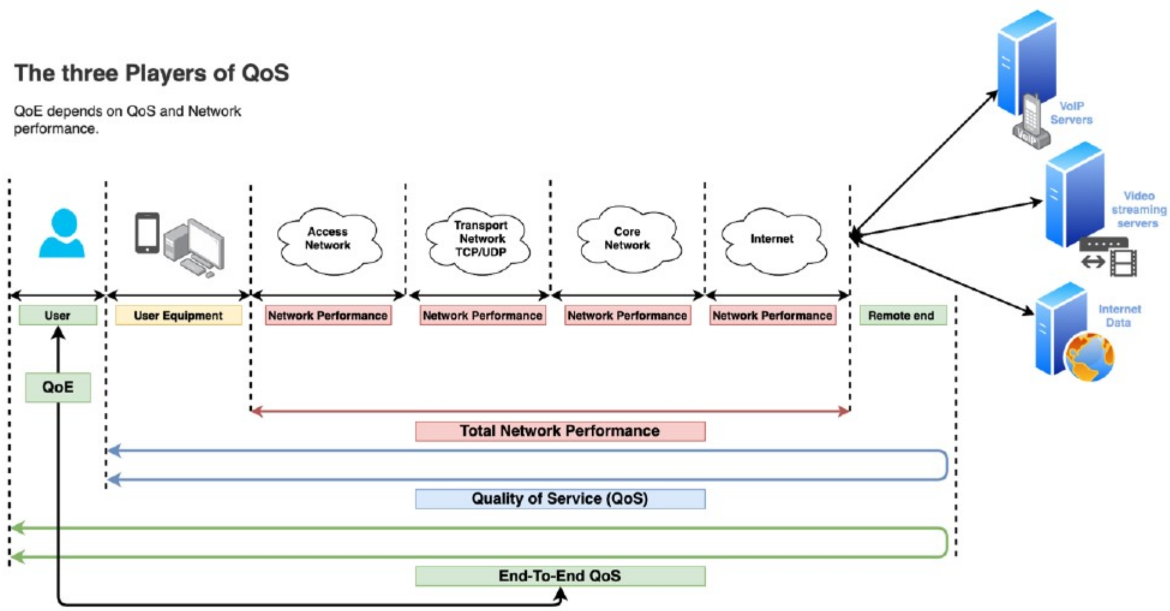


Figure - QoS, QoE, and Network Performance parameters depicted in network infrastructure.

NP, QoE, and QoS are related to each other. QoE depends on QoS and NP, i.e., if there is congestion in the network and consequently NP is lower, the result will be poor quality experienced by the end-user. As shown in above Figure and as defined in, NP is the technical part of QoS and contributes to QoS that the user experiences, i.e., delay, jitter, and bitrate.

Another aspect that we can see in Figure is that QoS is always end-to-end, being user to-content, user-to-user, or machine-to-machine. This means that QoS is affected by the NP of each component from beginning to end, that is, Access network, Core network, Transport Network, Servers or even the user's terminal, while QoE has a broader scope since it is affected by end-to-end QoS but also by the user's expectations.

QoE criteria

The evaluation of QoE is performed using a subjective test called Mean Opinion Score [MOS], whereas the evaluation of QoS is performed using objective measures.

The MOS is mainly used in services such as IPTV or video-streaming since this is a subjective measure given by the opinion of the user who is consuming the service or content. This measure is given by a single number between 1 and 5, as shown in Table :

Mean Opinion Score	Quality Classification
5	Excellent
4	Good
3	Fair
2	Poor
1	Bad

There are different applications/services on the Internet with different requirements and, in some cases, with certain QoS guarantees. All Internet traffic can be grouped into three main categories: audio, video, and data. Each specific type of traffic has its own characteristics that influence the performance of the network and QoS solutions.

If the QoS guarantees are weak in audio, high delay during VoIP call, or low bitrate in a video-streaming, the user QoE will be affected.

Audio Traffic related to QoS :

Audio is a type of conversational traffic, so it has similar requirements between conversations from A to B and vice versa. Among the requirements is a constant bitrate for both receiving and sending. This type of traffic is especially sensitive to delay and jitter. It is recommended that the delay should be less than 150 ms, and higher than 400 ms is not acceptable as users would start talking and disturbing each other.

When we talk about the IP environments, the delays are greater than 150 ms due to the buffering in every node.

All the nodes in the network have different buffer levels with different queue lengths that introduce different delays in the IP packets. In general, audio has a better tolerance to the errors than video because of human hearing can interpret broken words caused by IP packet loss. Typically voice traffic is a continuous two-way stream with strict delays, usually carried by RTP-UDP-IP protocol stack. Voice is considered a type of real-time traffic.

There are two types of voice services:

1. Voice over LTE [VoLTE]: where the telecom operators provide this voice service and therefore has certain guarantees in terms of QoS.
2. Over the top voice services [OTT voice services] commonly known as voice calls through Skype, Facetime, WhatsApp over the public Internet following a best effort protocol, although in the queues of the nodes is given priority to voice over IP packets.

Video Traffic related to QoS :

Video represents about 80% of Internet traffic, and the trend is growing. To save bandwidth, almost all video distributed over the Internet today is compressed. The most common video compression standard is MPEG-2 and MPEG-4, more information at Regardless of the type of video, whether it is a streaming video or a video call, the video is based on RTP-UDP-IP or HTTP-TCP-IP, the latter with longer delays due to the retransmission of lost TCP segments. In services such as IPTV, proprietary protocols such as IPTV protocol are starting to be used to offer live TV over the Internet.

Video is more tolerant of delays than audio but less tolerant of losses in defines the minimum requirements to offer an adequate QoS.

There are two types of two video :

1. The first type is Video calls, a type of bidirectional video with requirements very similar to the voice calls 150 ms delay in one

direction, and a maximum of 400 ms delay the tolerance to losses is 1% while the audio can be 3%.

2. The second type is one-way video with <10 s delay tolerance and 1% loss tolerance.

The use of QoS on the Internet is fundamental, although, by default, the Internet does not provide a QoS mechanism since it is based on best-effort.

QoS becomes vital when the amount of traffic is reaching the maximum capacity of the infrastructure, and this can happen at any point in the network since QoS is considered to be end to end. Therefore the use of mechanisms that help to decongest the network is necessary for each of the network nodes without distinguishing between optical fiber technology, coaxial cable, or cellular networks.

Mechanisms such as DiffServ and IntServ that were standardized in the late 1990s are crucial to ensuring QoS when there is congestion. They have not stopped evolving to adapt to the increase in network traffic and the arrival of new technologies as they will have to do in the future to offer QoS guarantees to key technologies such as the IoT or emerging cloud computing. The aim is still to offer QoS on the Internet as a whole and not to specific applications such as IPTV, VoLTE, or key users such as industry and business.

QoS in 4G :

Following are the types of classes that we can find in the definition of QoS for mobile communications, especially from LTE since it is the first technology to be based entirely on IP connectivity.

Table : Definition of the different types of class in QoS for 4G mobile networks :

Class	QoS Parameter	Examples
Conversational	Low delay, very low delay variation. Preserved time variation between IP packets.	Real-time services over IP: VoIP, conferencing.
Streaming	Preserved time variation within a given flow. No strict requirements for low delay.	Streaming services like audio and video.
Interactive	Low round trip delay time and low bit error rate.	Non-real-time services. Interaction client server. i.e., Web browsing, database retrieval.
Background (least priority)	Flexibility with delay and delay variation (jitter)	Email, file downloading

QoS in 5G Networks :

3GPP has established the first parameters for QoS in 5G networks in Release 15. At the same time as it was made to define the objectives of LTE in IMT-Advanced. The ITU has established in IMT-2020 the outline objectives for 5G networks, below are described both the new objectives for the fifth generation and a comparison with the previous generation.

Table : Objetives in IMT-Advanced (LTE) and IMT-2020 (NR 5G) defined by ITU, from (2)

	IMT-Advanced	**IMT-2020**
Minimum peak bitrate	Downlink: 1 Gbit/s Uplink: 0.05 Gbit/s	Downlink: 20 Gbit/s Uplink: 10 Gbit/s
Bitrate experienced by individual mobile device	10 Mbit/s	100 Mbit/s
Peak spectral efficiency	Downlink: 15 bit/s/Hz Uplink: 6.75 bit/s/Hz	Downlink: 30 bit/s/Hz Uplink: 15 bit/s/Hz
Mobility	350 km/h	500 km/h
User plane latency	10 ms	1 ms
Connection density	100 thousand devices per km2	1 million devices per km2
Traffic capacity	0.1 Mbit/s/m2	10 Mbit/s/m2 in hot spots
Frequency bandwidth	Up to 20 MHz/carrier (up to 100 MHz aggregated)	Up to 1 GHz (single or multiple frequency carriers)

To meet these objectives, besides increasing the transmission channels' capacity, increase the density of base stations, and use higher frequencies and greater bandwidth. Support for QoS in 5G networks also needs to be improved, which began in Release 15 with the introduction of new QoS flow identifiers (5QI). Following Table describes the most relevant new 5QI as the new QoS flow identifiers.

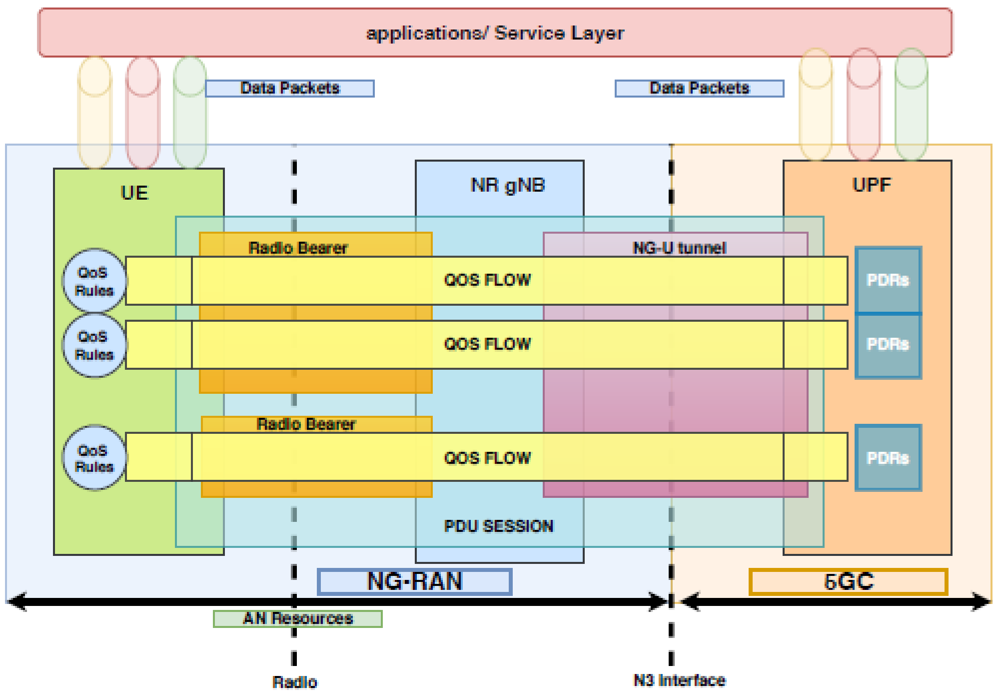
5QI	Resource type	Priority	Delay budget (ms)	Packet loss rate	Default maximum data burst volume	Targeted services
10	Delay Critical GBR	11	5	10^{-5}	160 bytes	Remote control
11		12	10	10^{-5}	320 bytes	ITS (intelligent transport systems)
12		13	20	10^{-5}	640 bytes	Other delay critical services
16		18	10	10^{-4}	255 bytes	Discrete automation

A new resource type category (Delay Critical GBR) oriented to URLLC has been introduced, although release 15 is oriented to eMBB, it is expected that in releases 16 and 17 more parameters will be introduced for URLLC and mMTC.

In the GBR categories. there is no change, the same parameters are maintained as in LTE and LTE advanced described in Table mentioned above.

The QoS in 5G is based on the QoS flows model as described in the following Figure, There are small differences from the model described above in the 4G network section.

QoS Flow architecture



The main idea is that when the PDU session is established, different QoS flows are created that carry similar traffic in terms of Class Indicators set in the QoS template. Therefore all traffic mapped with the same QoS flow will receive the same treatment in terms of scheduling policy, queue management, prioritization, and rate allocation, and so on.

In the N3 interface, each QoS flow is identified by its id, in this case, 5QI. In the PDRs (Packet detection rule), the UL and DL packets are associated with their correct transport through all the protocols and interfaces overall.

In NG-RAN, it is established that for each UE at least one data bearer (default bearer) and other possible additional bearers depending on the established QoS flows. Finally, to transport the information over the air NG-RAN associating UL and DL QoS flows with data bearers and to differentiate them from other UE that are connected, the QoS flows of each UE are mapped with their corresponding PDU session.

Finally, 5G NR also supports guaranteed flow bit rates (GBR QoS flows) and QoS with non-guaranteed flow bit rate as in the previous generation. However, as a new feature "reflective QoS" has been introduced which means that UE uses the same UL QoS parameters as those obtained through DL flow since one of the most significant improvements in 5G is the increase in uplink performance (UL), so similar QoS rules can be used due to this symmetry.

Before there was 4G and now 5G, QoS offered by mobile communications in its massive deployed technology is still in a premature state but that without any doubt promises many benefits as far as communications are concerned.

QoS is not something simple to implement or develop and that it takes a long time to implement the changes that guarantee the different end to-end service requirements. One solution that will facilitate the implementation of QoS is Network Slicing, which has been introduced 5G technology as a novelty.

Network Slicing will enable better QoS in the desired services, setting different slice with different priorities, delays, and bitrates that will allow dedicated QoS in URLLC, eMBB, and mMTC applications that until now have used a common mobile communications infrastructure. QoS measuring tools can be used to test and show the different performances of the network slices.

The applications available in the market are good options for measuring QoS. Each of them has its advantages and disadvantages, Qosium has a much more professional approach to research and industry environments, allowing more complex and diverse measurements and higher sensitivity in the results than G-NetTrack Pro. Meanwhile, G-NetTrack Pro offers less complicated results and only for mobile terminals, but its easy implementation is a plus for taking preliminary measures. These tools have shown the advantages and disadvantages of performing QoS measurements.

It would have been interesting to be able to take QoS measurements in 4G and 5G networks to show the most significant difference and capacity between both. Unfortunately, it has not been possible to take the measurements in 5G networks.

Typical Methods for Service Experience Evaluation :

Using MRs to Measure User Experience Distribution

Measuring Reports (MRs) from UEs contain information such as Channel Quality Indicator (CQI), rank, Reference Signal Received Power (RSRP) (of the serving cell and neighboring cells), and Global Positioning System (GPS). Based on the CQI and rank, the data volume transmitted in each Transmission Time Interval (TTI) at a location can be calculated. Based on mapping among the GPS and geographic grids (50 m x 50 m), the spectral efficiency and maximum transmission rate of a grid can be calculated. Since the transmission capability of a grid is shared by multiple users, the number of users transmitting data simultaneously in a cell must also be obtained in order to obtain the grid's user experienced rate.

The number of UEs that transmit data simultaneously in a cell can be obtained based on traffic statistics, including the number of UEs in Radio Resource Control (RRC)_CONNECTED state and the data transmission duty cycle.

Based on the MRs from GPS-enabled UEs, a fingerprint database that maps the GPS and RSRP data of each cell can be constructed on the network side. If the GPS function is not enabled on a UE, the UE can query the fingerprint database for grid mapping based on the cell RSRP in the MR. The UE can then participate in the calculation of grid-level experienced rate, improving the accuracy of experience evaluation.

VoLTE Experience Evaluation Method :

VoLTE service evaluation involves basic Key Performance Indicators (KPIs) and voice quality.

Basic KPIs can be evaluated by observing network KPIs. Call success rate and call drop rate correspond to the QoS Class Identifier (QCI) E-RAB

(E-UTRAN Radio Access) setup success rate and abnormal release rate on the RAN side respectively. Call setup delay on the IP multimedia core network subsystem (IMS) is observed.

Voice quality can be evaluated by the Mean Opinion Score (MOS) value. To obtain the MOS value, perceptual evaluation of speech quality (PESQ) standardized in ITU-T Recommendation P.862 or Perceptual Objective Listening Quality Analysis (POLQA) standardized in ITU-T Recommendation P.863 can be used to perform tests with assistance of special instruments. Specifically, VoLTE calls are tested in the network planning area by means of outdoor DTs or indoor fixed-point tests. The target UE is connected to a professional voice quality test instrument (such as DSLA) which outputs the MOS value. This evaluation method requires professional test personnel to perform a large number of tests on roads or indoors to obtain the voice quality of a network. This method features high accuracy but huge labour input and insufficient traversal.

As an alternative of DT-based voice quality evaluation, the packet loss rate, packet error rate, and jitter of uplink and downlink voice packets on the base station can be measured (periodically by the base station and then mapped to MOS values using algorithms). Statistics are collected by segment based on the MOS 0–5 range to obtain the distribution of different MOS values in a cell. This method can evaluate the voice quality of a network from a macro perspective without performing DTs, but the specific location of problems that compromise voice quality cannot be determined.

The grid-based MOS evaluation method combines the advantages of the preceding two methods. In this method, a network is divided into multiple 50 m x 50 m grids, with the RSRP and SINR of each location on the network obtained based on the MRs of UEs and then mapped to the grids. The voice quality in a grid is estimated based on mapping among the MOS value, RSRP, and Signal to Interference Plus Noise Ratio (SINR) determined in "VoLTE Experience Requirements on RF Performance." This method can be used to obtain the voice quality of a network from a macro perspective and identify specific areas where voice quality problems exist, thereby providing accurate input for network optimization.

Question-3: What should be the QoS parameters and corresponding benchmarks for ultra-reliable low latency communication (uRLLC)), and massive machine type communications (mMTC)?

Comments :

Ultra Reliable Low-Latency Communications [URLLC]

URLLC services involve new use cases, where there is a small data exchange that can be materialized in reliable and critical communications such as health care monitoring.

URLLC is the technology where the vital function of QoS can be noticed most since it is intended to provide connectivity to critical services over 5G networks. Therefore, offering very strict QoS on 5G technology is a very cutting-edge achievement. Since this technology can save many lives, future examples are the prevention of traffic accidents by avoiding a collision at the very last second or securing emergency service communications even in the most adverse conditions.

Massive Machine Type Communications [mMTC]

Massive IoT will be an extension of the current IoT services. This approach will give access to significant automation in every aspect of our life in professional and personal environments.

5G is also designed to provide service to technologies such as mMTC, whose ambitious goal is to support at least 1 million devices per square kilometer. These devices are known as IoT devices, which have very particular requirements. Among them, we must highlight a very efficient power consumption connection through the Access Network in 5G, NB access, for it has standardized a different architecture intended for mobile communications, reducing the complexity and increasing efficiency.

5G is entering into the market of vertical industries, mainly in health care and automotive offering service to applications such as Vehicle-To-X communications, Ultra-Reliable Low-Latency

Communications [URLLC] for remote surgery. As we will look further ahead, these applications have specific and strict QoS since it is vital to ensure bitrates, jitter, and delay as the leading players in QoS.

Question-4: Will there be any likely adverse impact on existing consumer voice(VoLTE/VoNR) and data services (eMBB) upon rollout of enterprise use cases of uRLLC or mMTC?

Comments :

Enhanced Mobile Broadband [eMBB]

eMBB focuses on offering high performance. In order to achieve high performance, it makes use of technologies such as [MIMO] multiple inputs multiple outputs to increase efficiency (bit/s/Hz) and channel capacity (bit/s).

5G networks use higher data rates according to the Shannon Hartley theorem equation. It means increasing the channel's capacity, and one suitable option is to increase the bandwidth. Therefore 5G networks need to use more of the bandwidth of the scarce spectrum available for mobile communications. New frequency bands have been added above 6 GHz, i.e., bands between 24-28 GHz and 86 GHz.

These new bands allow an increase in the capacity and the use of smaller cells that will allow a higher capacity per user, in addition to the possibility of reusing frequencies since the probability of interferences between base stations will be null since the higher frequency there will be a more significant attenuation; therefore, microcells will be able to be used taking advantage of better the spectrum and adding to the QoS that the users are going to receive since to have a higher number of distributed micro cells it will improve the conditions in the edges compared to the use of macro cells..

Question-5: If answer to Question-4 is 'No' then please explain how and if the answer is 'Yes' please suggest measures to ensure minimum guaranteed QoS for voice and data service for consumers.

Comments : No Comments.

Question-6: To achieve QoS and QoE end-to-end, it is essential that all network segments deliver the minimum level of QoS required by respective service, application or use case. In this context, please suggest QoS parameters and corresponding benchmarks for National Long Distance (NLD) and International Long Distance (ILD) segments of the network with supporting global benchmarks.

Comments : Mentioned in the Comments.

Question-7: What should be the approach for adoption of 'QoS by Design' framework by the service providers to ensure that new generation wireless networks are planned,

implemented and maintained to deliver required level of measurable QoS and QoE ?

Comments :

Quality of Service was a concept very well defined, modelled, quantified and measured for classical Telecom networks at ITU both at end to end user service level and at a network and system levels. When networks migrate towards multiservice multimedia services on IP mode, the complexity of quality description enlarges to more domains, parameters and concepts implying an increase of difficulty for definition, measurement and standardization. In addition several entities conceive the quality with different perspectives, as in ITU, ISO, IETF, ETSI, ETNO, etc.

For the point of view of a planner, it is not required to address all operational details but it is needed to focus more on the macroscopic parameters and values that impact on the network dimensioning and costing as those aspects are the ones that have to be quantified with anticipation for the decision making on architectures and business planning.

The variety of different definitions demonstrates the difficulties in assessing all aspects related to the term QoS either focussed on the network provider view or the customer perspective. Basically ITU-T is oriented towards an overall QoS description for the different services with two perspectives: -

i) Phases of the service life cycle to analyze like: service provision, service enhancement, service support, service connection, service billing, service management, etc.

ii) Criteria for the quality observation like: availability, accuracy, speed, security, reliability, etc.

It is important to understand that QoS differs from network performance. QoS is the outcome of the user's experience/perception in a global manner, while the network performance is determined by the performances of network elements one-by-one, or by the performance of the network as a whole. This means that the network performance may be used or not on an end-to-end basis. For example, access performance is usually separated from the core network performance in the operations of a single IP network, while Internet performance often reflects the combined NP of several autonomous networks.

Thus QoS is not only defined or determined by measures that can be expressed in technical terms (network performance parameters), but also by a subjective measure which is the user-perceived quality and his quality expectations. Then QoS has to take into account both:

- Customer view: QoS requirements and perception
- Service provider view: QoS offering and achievement

The combination of both views and their relationship forms the basis of a practical and effective management of service quality including the convergence of those perspectives. It has to be emphasized that standardization for quality in NGN context is in progress and a more complete vision will be available at the completion of new research.

QoS parameter types

Quality of Service parameters characterize the quality level of a certain aspect of a service being offered, and ultimately the customer satisfaction. QoS parameters represent subjective and abstract user-perceived "quality" in terms of quantified values.

QoS parameters can be used by service providers to manage and improve how they offer their services, as well as by the customers (end users or partner providers) to ensure that they are getting the level of quality that they are paying for. They have now been used to support commercial contracts such as SLA (Service Level Agreement) formulation and verification. They are also used in call-minute trading, where price is determined by volume and quality grade.

- **Objective and Subjective measurements :**

QoS parameters can be obtained from objective or subjective measurement methods. Objective QoS parameters are obtained from measurement of physical attributes of circuits, networks and signals. They are normally used as internal indicators for service quality characterization and improvement. The subjective QoS parameters are obtained by actually conducting well-designed customer opinion surveys. They are normally used as an external indicator, e.g. for customer relationship management.

➢ **Primary and derived QoS**

QoS metrics can be primary parameters that are determined by direct measurement of call characteristics or events, such as circuit noise, echo path loss, or signalling release cause. Alternatively, QoS metrics can be derived from a collection of primary parameters like Statistical calculation, opinion modelling based on measured parameters, opinion and equipment impairment factors, etc.

➢ **Survey of standardized QoS parameters**

Conditions for a parameter to be effectively used as reference for QoS management are:

- the existence of QoS clear metrics,
- simplicity of use,
- proven accurate representations of customer perception, and
- commonly accepted as standards.

Considering the different solutions/network architectures that exist, each Network Planning case has to be analyzed and dealt with by using more than just one planning tool. It means that maintaining and updating a unique tool is not the correct strategy to be applied for Network Planning.

The major concerned telecommunication Companies normally use different tools (or different packages integrated on a unique platform) for network Planning. They usually rely on the services of software companies who are in a position to provide quick updates as soon as required. Therefore, Network Planning should be dealt with as follows:

a) To analyze the Network Planning case, taking into account the different technical aspects of the issue.

b) After reaching the best solution in terms of cost and technical validity, to look for the appropriate partnership with whom to define a Project for the specific Network Planning case.

c) Implementation of the Project under the coordination and/or supervision of TRAI.

Network planning :

The selection of new technology hinges on projected needs and consequent network development planning. In developing countries like India, the needs may be substantially different in urban and rural areas, and infrastructure and technology requirements will differ. In choosing technologies for a new or existing telecommunication network, a very wide range of factors needs to be considered. The most difficult component of the network to build, and the least cost-effective to maintain, has proved to be the local access network. One of the main problems facing the developing countries is precisely the lack of access to broadband services, and low tele density. Adaptation of power-line communications and cable-television networks to provide telephony and internet services has converted them into broadband networks. The technology shall be of low cost, easy to maintain and adapted to the local environment. The rural population will need to be connected to the information society. Choosing efficient and cost-effective and fast-deployment technologies such as wired and wireless networks will improve accessibility.

The architecture of the information and communication infrastructure is changing to accommodate the requirements of a growing number of ICT-enabled services/applications (broadband, IP, mobile, multimedia, streaming, multicasting, etc.) and evolving to next generation networks (NGN). New-generation technology is being introduced in the networks, speeding up the convergence process, and obliging planners to apply different specialized up-to-date planning tools.

Network planning is a critical issue for network operators and network service providers in a time of globalization and intense competition. The current telecommunication market requires flexible and adaptive network planning methodologies for evolving network architectures to NGN. Practical guidelines, readily and easily applicable, should continue to be provided to be of use to operators and decision-makers. Moreover, there will be a need for powerful software tools to assist operators in developing their networks. TRAI should continue entering into formal partnership agreements with outside partners, positioned to provide the Union with appropriate planning tools suitable for specific network planning requests. Taking into account the above considerations, and in order to contribute to bridging the digital divide, this programme should apply the following measures:

a) providing advice on the design, deployment and maximization of digital networks at an increased pace, including the roll-out of wireline broadband technologies such as, but not limited to, optical-fibre, xDSL, CATV, power-line and wireless broadband technologies, and the establishment of satellite earth stations;

b) facilitating the introduction of digital technology;

c) facilitating the design, production and availability of digital terminal equipment;

d) enhancing technical skills and management know-how;

e) promoting digitization of analogue networks and applying affordable wireline and wireless technologies to facilitate people's access to ICT, thereby also improving quality of service;

f) encouraging research on the information society, extensive networking, interoperability of ICT infrastructure, tools and services/applications to facilitate accessibility of ICTs for all;

g) optimizing connectivity among major information networks via regional ICT backbones in order to reduce interconnection costs and optimize the routing of traffic.

The most typical tasks that the planner has to perform to solve the complexity associated to the previous requirements are summarized as follows:

- Initial situation analysis for economy, customers, services and network
- Problem partitioning
- Data gathering
- Definition of alternatives per scenario
- Mapping solutions per scenario
- Design, dimensioning, location and costing
- Optimization
- Sensitivity analysis to uncertain variables
- Plan selection and consolidation
- Reporting

Network planning processes

Due to the high speed of changes both on the environment and the technologies, the traditional planning activities that were performed in an separated way, today have to be strongly interrelated among themselves and to the other network related tasks. For that environment, the Strategic network planning, Business planning, Long term structural planning, Short/medium term planning have to be applied in iterative way with what-if analysis and also communicate with the related Network Management and Operation Support Processes like traffic measurement, performance measurement, etc..

Question-8: What measures are required to accelerate the adoption of AI for management of QoE to reduce consumer complaints protectively and to enable near real time reporting of QoS performance to consumers?

Comments :

Telecommunications service providers have an urgent need to reduce operational costs while supporting the rapid introduction of new services and products and identifying and leveraging monetization opportunities. AI/ML has emerged as a powerful technology that can support these needs.

While the journey of the application of AI/ML technologies in telecommunications networks has already begun, it has involved disparate and isolated approaches and has been applied within the current industry definition only as an afterthought. The step towards mass adoption and industrialization is yet to come and can be accelerated with the right level of industry alignment, supporting a multivendor ecosystem while still encouraging innovation enabled by the adoption of rapidly evolving technologies.

The industry has recognized that in order to transition to an industrialization phase and enable mass adoption of AI/ML, industry alignment is required. This results in all the major industry bodies trying to work out how they can leverage the technologies and claim their stake in the AI/ML landscape, leading to multiple and somewhat diverging directions being taken. To accelerate the coming industrialization phase and mass adoption, the industry must choose which guidance to follow.

AI/ML introduces new considerations to LCM and does so at a time when the industry is moving towards evolution of its software LCM with continuous deployment and integration. There are different approaches that can be taken, and taking an approach that maximizes end-to-end accountability is essential to accelerating adoption.

AI/ML should be adopted at all levels of a network architecture.

While enabling movement towards an aligned platform approach, service providers can benefit from a business-driven and use case–driven approach to the deployment of AI, covering required data, required insights and required actions.

It is recommended that telecommunications service providers and vendors do the following:

- pursue a use case–driven approach to prioritize network introduction
- enable the leveraging of rapidly evolving technologies from the IT and cloud industries to accelerate adoption by avoiding standardizing all the technology aspects that are rapidly evolving, such as model descriptions and data preparation (which are best covered as de facto technologies)
- focus the 3GPP-SA2 data collection on data collection using the Service Based Interfaces (SBI) events
- focus on aligning management data collection through 3GPP SA5 as well as the ORAN and ONAP ecosystem
- align 3GPP SA2, SA5, ORAN and ONAP perspectives of the functional architecture for AI/ ML functions and LCM

- focus network analytics specifications in 3GPP and ensure alignment with ONAP and ORAN while enabling the optimization for different domains as described by ETSI ZSM

Artificial intelligence (AI) technologies have already matured to the point where SPs have been applying them to their networks, often starting with non-time-critical processes, and are now applying them to the sensitive parts of their networks that directly impact user experience. The increased complexity of networks due to more services, new network technologies, and massive network densification further necessitates the application of AI in telecommunications networks as operations become more complex.

AI technologies can make many SPs' system functions more capable as well as enable new system functions and approaches. Some example applications include:

- improving network performance though better radio scheduling, paging and so on
- improving assurance of offered services and resources, moving from reactive to proactive — even in the face of increasing network complexity and heterogeneity

- improving optimization and use of existing resources, such as spectrum, transport, cloud infrastructure and network functionality
- improving experience management through both increased customer understanding as well as increased tailoring of the offered experience
- improving product and service definition, design, planning and offerings
- improving network and performance planning (such as radio, data center location and transport)

The maturing capabilities of AI have resulted in increased attention within standardization and open source communities, both from a purely technology evolution perspective as well as from an architecture definition perspective. While open source and standardization are enablers for increased AI adoption, the fragmentation which occurs in the early phases of industry specification can hinder adoption due to the uncertainty it creates, which occurs between different industry bodies as well as in different groups within industry bodies.

Consequently, SPs are facing a number of challenges today regarding which standards to follow, which aspects of open source should be utilized directly or via vendors, how to increase industry alignment for scale while simultaneously allowing for differentiation, how to leverage the scale of public cloud providers, how to collect and manage data, and how to support the Life Cycle Management (LCM) of AI models.

In order to accelerate the adoption of AI, it is important to have an overall view of the industry and establish an understanding of the driving organizations, including the challenges facing them.

Challenges for the adoption of AI in networks :

There are various organizational challenges facing the adoption of AI in telecommunications, and while we acknowledge such challenges, the focus should be on covering the functional aspects of networks.

Overall challenge for AI :

Beyond the open source and standards industry discussions, the application of AI/ML is being driven by real needs. Hence, both telecommunications service providers and vendors are already including AI/ML capabilities in their portfolios and networks; however, the adoption of AI/ML is at an early stage, and it is, therefore, worth reflecting on the barriers to the rapid adoption of AI/ML. Below are a few examples of these:

- The LCM of AI/ML models introduces new aspects beyond traditional software LCM
- There is a lack of access to data and the management of access to real data due to regulations regarding privacy and (Relevant data is required to develop and train AI/ML models.)
- Fragmentation and overlap in different standards and open source initiatives continues to diffuse industry focus and create hesitation.
- It takes time to build trust in automation technologies, as some of the conclusions are difficult to explain. A gradual introduction with the appropriate guardrails to allow human oversight and control is required.
- Cloud service providers typically provide their own (different) tools and interfaces, which creates a lock-in effect and challenges SPs' desire for openness, ultimately slowing down deployment and adoption.
- There is a lack of use cases qualifying returns on investment in the short.

Challenges concerning access to data :

Access to the relevant data at the right time is key for any analytics system and for developing and training AI/ML models. This requires an infrastructure towards a variety of data points and compute power to process. Unnecessary transfers should also be avoided, as the amount of data can be massive. Filtering and preprocessing close to the data points can greatly reduce the amount of data being transferred through the network. Initial AI/ML model training is being done by the vendor. This requires access to relevant data. The AI/ML model may need to be re-trained with local data to improve the prediction quality in the target network. Questions related to cost of data, ownership and privacy are important to be agreed between SP's and vendors and are part of a data ecosystem. The technical solution must comply with regulatory rules, trustworthiness and SP policies and the system functions need to support a wide range of flexibility to comply to differences in different countries.

Fragmentation among standardization bodies :

The industry significance of AI/ML is reflected in the strong interest that most standardization and open source communities have demonstrated in exploring how to apply AI/ML to their particular scopes and, in addition, their work to claim the lead on certain aspects of the architecture. As described above, there are specification efforts in at least ITU-T, ETSI ENI, ETSI ZSM, 3GPP, ONAP and ORAN. While much of the work is complementary, there is also fragmentation. Fragmentation diffuses focus and creates hesitancy for the adopters (both the network vendors and the SPs). This hesitancy is driven by the risk of inconsistent standards and the inefficiency of duplicated effort.

One aspect of this fragmentation is visible in the use cases being described as well as in the resulting specified insights created by AI functions described by the SDO/open source organizations. Examples of this include network load and slicing load, which are studied in SA2 with the NWDAF, in SA5 in the MDAF, and in ORAN around the RICs for the same problem. Aside from the inefficiency of specifying the work twice, this also fosters uncertainty for service providers when deciding which approach to adopt.

Another aspect of fragmentation is visible in the efforts that go into describing the different components of AI/ML-enabled functions, such as the inference functionality, training functionality, and data storage functionality. This is present in a number of standardization bodies. While alignment around the basic architecture and concepts is useful to the industry, overspecification can inhibit innovation, and many different specifications slow down adoption.

A further hindering aspect of fragmentation can be found in data collection and management, which refers to the ability to support AI/ML applications to request, collect and receive data (. Ericsson Technology Review for Data ingestion architecture for telecom applications. https://www.ericsson.com/en/reports-and-papers/ericsson-technology-review/articles/ data-ingestion-architecture-for-telecom). This is being studied within 3GPP SA2, 3GPP SA5, ONAP and ORAN and has potential for alignment.

Accelerating AI adoption :

1. Taking a use case–driven approach :

As seen above, there are fragmented standardization functions proposing overlapping use cases, and, at the same time, SPs have invested in AI infrastructure over the years. In order to identify how to apply or adopt standards in their networks, it is recommended that SPs take a value and use case–driven approach (where compelling use cases can be evaluated first), and then how to deliver those use cases from an end-to-end network (contextual) perspective can be studied. An example would be the explanation of how use cases connect from ORAN (rApps, xApps) to SA5 (MDAF, MDAS) to SA2 (NWDAF) specifications. Hence, SPs might need to engage with partners who take an end-to-end (contextual) approach to analytics to establish a better understanding of domains, data, models, interworking, open source modules and communities.

When it comes to compelling business-driven use cases, analytics use cases can be categorized into three areas, where the primary area is

i) Reduction of operational expenses (opex) and capital expenses (capex) and increased efficiency. New technologies require networks to be operated in an efficient manner, and this cannot be possible without utilization of AI.

ii) The second area is enhanced customer experience, where SPs want to differentiate themselves through a better customer experience in their network services.

iii) The third area is new revenues, where SPs offer new capabilities to enterprises or consumers, resulting in new business.

2. Making relevant adjustments to existing LCM processes and avoiding industry fragmentation

De facto–standardized telecom processes save our industry USD billions annually, as both suppliers and CSPs are able to avoid the cost of vendor/customer-specific software LCM tracks and deliverables. As AI/ML technology continues to be added, the industry should continue to avoid fragmentation and strive for de facto standards for LCM processes.

Optimizing the use of standards and open source :

In the field of telecommunications, standards have had a strong role in creating the industry and the ecosystem by defining the functionalities and inter-SP and multivendor interfaces. These standards have provided long-term guidance to the industry that is independent of the technology and, hence, can survive technology changes. At the same time, open source has moved from creating technology that can be used to build networks according to standards to create ecosystems around default interfaces. This is particularly useful where the technology is evolving rapidly.

One parallel is in the area of the cloud native ecosystem that has evolved around the cloud-native computing foundation (CNCF), which has created de facto interfaces around Kubernetes and is more efficient if standard organizations (such as ETSI NFV) can simply refer to or adopt these interfaces as de facto standards.

For AI/ML, standards have a strong role in and should be promoted for the following cases:

- specifying insights required for certain function scopes to support multivendor consumption of insights (such as those to enhance packet core functionalities in 3GPP SA2 or management insights in 3GPP SA5)

- specifying interfaces for a common way to collect and manage data (3GPP SA5)
- creating a common reference for the AI/ML architecture and LCM while avoiding over- specifying interfaces which will not benefit from multivendor deployments (such as training function or inference function interfaces) due to tight technology dependencies and the rapid pace of technology change

Open source has a strong role and should be promoted for:

- AI/ML technology, platforms and tools
- rapid innovation for different inference and training techniques
- technology for data storage and data storage interfaces
- reference realization of standards interfaces

Focus on a multi-cloud strategy for AI/ML :

Public cloud providers and companies addressing AI/ML have been investing in AI some time and have developed a strong heritage in generic AI capabilities. The portfolios of all cloud providers today include machine learning services, engines, and frameworks for the conversational, vision, language, and knowledge areas. On the training side, all cloud service providers also offer frameworks. The challenge comes from the lack of standardization of cloud service providers and the risk of a lock-in; hence, the recommendation is to have a multi-cloud strategy with the help of trusted partners.

Explainablity and trustworthiness :

Explainability and trustworthiness are key in AI systems in order to establish trust with the consumers of a system.

Trustworthy AI can be categorized in multiple dimensions, such as maintaining transparency on how an AI system uses AI, clarifying the consideration of different types of biases and ethics in model training, satisfying legal aspects, maintaining security and privacy, clarifying the data inputs and quality of data, and finally explainability of the AI methods used and the decisions made by them.

However, there should be requirements or associated studies in 3GPP on explainability and trustworthiness in AI-based systems.

Data sharing in an open data ecosystem :

An open and trusted data ecosystem is key for data sharing to accommodate the complexity of data exchange between SPs and vendors. Already today, data exchange is common for network optimization and root cause analysis purpose. With AI/ML, its becoming a key resource for data-driven developments creating AI/ML software.

Some important considerations in a data ecosystem are trustworthiness, data privacy, secure access and secure storage.

There is also the notion of public and non-public data. Public data is being made available from a product or service supplied by a vendor to individuals or entities for the purpose of product operations and/or service delivery. Non-public data, on the other hand, is data containing sensitive information relating to IPR or strategic business importance and is used by the vendor for innovation, product and/or service development, verification and deployment.

A data ecosystem also needs to support preprocessing close to the data points to avoid unnecessary transfers and network load. Massive data volumes can be a burden if not addressed in the architecture. Different data points need to be included in the ecosystem to allow for network-wide data access, such as RAN and core, to create better AI/ML software and to address the specifics from different network domains.

Yours faithfully,

(Dr. Kashyapnath)
President
Member organization : TRAI