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**APT REPORT ON**

**REGULATORY MATTER AND IMPLEMENTATION PRACTICES OF QUALITY OF EXPERIENCE IN MOBILE COMMUNICATIONS**

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**Table of Contents**

[1. Scope 2](#_Toc11996524)

[2. Current situation of APT members 2](#_Toc11996525)

2.1 Market nformation……..……………………………………………………………….3

[2.2 Questionnaire Response from APT members 2](#_Toc11996526)

[3. Approaches to quality of experience assessment in mobile communication network 5](#_Toc11996586)

[3.1 Introduction to QoE 5](#_Toc11996587)

[3.2 Approach to QoE assessment 5](#_Toc11996591)

[3.2.1 User data simulation 5](#_Toc11996597)

[3.2.2 Crowdsourcing Data 6](#_Toc11996601)

[4. Issues for consideration 7](#_Toc11996606)

[5. Conclusion and recommendation 8](#_Toc11996608)

[ANNEX 10](#_Toc11996609)

[Sharing experience of Viet Nam 10](#_Toc11996610)

**REPORT ON REGULATORY MATTER AND imPLEMENTATION PRACTICEs OF QUALITY OF EXPERIENCE IN MOBILE COMMUNICATIONS**

# Scope

For years, Quality of Services has been known as the description or measurement of the overall performance of a service. Besides, QoE is a well-established methodology for measuring and understanding the overall level of customer satisfaction of service. While QoS is aimed at parameters and measurement criteria with set target along with compliance control, regulator enforcement and sanctioning, QoE is a tool for comparing service offers, testing the speed of Internet access, checking the coverage map and collecting feedback from users. From operator perspective, QoE is an useful instrument to understand their customer and keep them sufficiently satisfied while managing network. From regulator perspective, of which consumer protection is one of its mandates, QoE might be a source of data to provide users with transparent information on actual performance of provided services so that they can make better decisions of choice. With its focus on user’s perspective of the overall value of providing service, QoE could be an important tool that monitor quality of mobile communication services and provide sufficient collected data for policy making, effective regulations and information transparency.

Mobile communications is moving forward to packet, Internet-based multimedia services. The actual performance of Internet connection is critical to facilitate all kind of services – for example, good quality video streaming requires sufficient download speeds and low levels of packet loss, while VoIP telephony requires sufficiently low latency. The report provides overview introduction to QoE, its regulatory matter and implementation practices in mobile communications, focused on broadband Internet access. The measurement of broadband access performance on mobile communications and Internet access speeds experienced by in Viet Nam will be used as a case study.

# Current situation of APT members

**2.1 Market information**

Mobile communication services are becoming more and more popular and play important roles in the digitized socio-economy and people everyday life. The improvement satisfaction the customer’s is the importance mission of regulators as well as operators. Asia Pacific area is the largest mobile market in the world and number of mobile subscriber is fast growth every year. This makes difficult for operators as well as regulator to maintain and improve the user’s perceived quality of a service.

|  |  |  |
| --- | --- | --- |
| **2.2 Questionnaire Response from APT members** | | |
| **No.** | **Question** | **Responses** |
| 1 | Which are most popular mobile services in your country? Mark more than one if needed. | Japan, Malaysia, Vietnam  ■Voice telephony services on 2G/3G/4G networks  ■Internet access service on 3G/4G networks  ■Streaming video service on 3G/4G networks |
| 2 | Do you have a regulation for monitoring quality of mobile services?  Yes  No | Yes: Japan, Malaysia, Viet Nam |
| 2.1 | If answer is “Yes”, which services are being monitored? | Malaysia, Viet Nam:  ■Voice telephony services on 2G/3G/4G networks  ■Internet access service on 3G/4G networks  Japan:  ■Voice telephony services on 2G/3G/4G networks |
| 3 | Do you have standards for quality assessments of mobile services? If yes, proceed to 3.1. If the answer is no please skip to question number 3.5. | No: Japan  Yes: Malaysia, Vietnam |
|  | **A. If answer is “Yes”** |  |
| 3.1 | Voice telephony services on 2G/3G/4G networks |  |
| 3.1.1 | Essential KPI and assessment method | **Malaysia:**  - KPI: Dropped call ratio, call success rate.  - Method: Objectively measurement  Viet Nam:  - KPI: Mean opinion score, call success rate call drop rate, coverage  - Method: Objectively measurement  Data from operator.  Customer opinion survey |
| 3.1.2 | For quality of conversation, which standards are used for quality of conversation metrics? | **Malaysia:** N/A  Vietnam:  Subjectively evaluation: ITU-T Recs P. 800, P.800.1, P. 831, P. 832 that provide MOS (1 - 5 scores) for voice call quality assessment  ■ Objectively evaluation and intrusive method: ITU-T Recs P.862/P.863  Objectively evaluation and non-intrusive: ITU-T Recs P.561/P.562  Other (specified) |
| 3.2. | Streaming video service on 3G/4G networks | Malaysia: N/A |
| 3.2.1 | Essential KPI and assessment method | Viet Nam:  - KPI: Service successful access ratio, service access time, video quality, audio quality, audio/video synchronization.  - Method: Objectively measurement  Data from operator.  Customer opinion survey |
| 3.2.2. | For quality of streaming video, which standards used for assessment? | Viet Nam:  Subjectively evaluation: ITU-T Recs P. 910 that provide MOS (1 - 5 scores) for video quality assessment  ■ Objective perceptual method and full reference: ITU-T Rec J.247  Objective perceptual method and hybrid non reference: ITU-T Rec J.343.1 |
| 3.3 | Internet access service on 3G/4G networks | **Malaysia:**  KPI: Speed, Latency, Packet loss.  Method: Objectively measurement.  Viet Nam:  KPI: Service coverage, Service success access ratio, Service setup time, Mean data rate.  Method: Objectively measurement  Data from operator.  Customer opinion survey |
| 3.4 | Other service |  |
|  | **B. If the answer is “No”** |  |
| 3.5 | What is your approach to monitor in term of quality for services on the mobile communications network? | Japan:  According to the Telecommunications Business Act (Law No.86 of 1984) and related ministerial ordinance, Telecommunications carriers installing telecommunication circuit facilities for mobile phones or PHS must define self-standards in advance with respect to the quality of service and strive to maintain that standards. Also, Telecommunications carriers are obliged to report the quality of service every year to the Ministry of Internal Affairs and Communications. |
| 4 | Do you publish the quality assessment results?  Yes  No | Yes: Malaysia, Viet Nam  No: Japan |
| 4.1 | If Yes, what kinds of media are being used to publish the quality assessment results of services on the mobile communications network? Mark more than one if needed. | Malaysia, Viet Nam:  ■ Website  Newspapers  Social media |
| 4.2 | If Yes, which periods are being used to publish the quality assessment results of services on the mobile communications network? | **Malaysia:**  Monthly  Quarterly  Half-yearly  ■ Yearly  Viet Nam  Monthly  ■ Quarterly  Half-yearly  Yearly |

From the response of APT members and other relevant sources, the maintainment and improvement satisfication the customer’s are the importance scope of operators, regulators. They have regulations for monitoring quality of mobile services to enforce quality ensure and improvement upon operators to satisfy the customer’s requirements. Such approaches have usually been performed by collecting data from diversified sources such as driving/walking test, autonomous testing probes, customer surveys or collection of operator’s network performance data.

The exponential growth of smartphone penetration in the region makes universalizing access to Internet services and it’s also advantage to conduct assessment quality of mobile service experience.

# Approaches to quality of experience assessment in mobile communication network

* 1. **Introduction to QoE**

Quality of Experience can be defined in many ways. The simple understand, QoE is how a user perceives the usability or degree of satisfaction with application and service performance in communication networks. More specifically in recommendation ITU-T P.10, QoE is defined as “The delight or annoyance of the user of an application or service”, while ETSI defines QoE as a measure of user performance based on both objective and subjective psychological measures of using an ICT service or product.

Recently, EU Qualinet Community proposes the definitions of QoE as the degree of delight or annoyance of the user of an application or service. It results from the fulfillment of his or her expectations with respect to the utility and/or enjoyment of the application or service in the light of the user’s personality and current state. In the context of communication services, QoE depends on service, application, device and context of the user.

Although there are several definitions of QoE, generally QoE is a kind of user satisfaction description with application and service performance in communication networks.

**3.2 Approach to QoE assessment**

QoE depends on the end-user perception, in principle, the assessment of QoE must be performed by subjective testing with metrics such as the mean opinion scored through survey. For example, to determine listening or image quality, users are asked to rate the speech or image quality of a mobile communication network by selecting from five-point Mean Opinion Score (MOS) scale (1 is the lowest perceived quality and 5 is the highest perceived quality).

Due to the required resources and human effort to perform QoE assessment is too high and the result may differ significantly from different user groups. In order to evaluate QoE, it is possible to measure objective QoE centric parameters/KPI through quality estimations by objective techniques. Objective method have more advantages, they eliminate the limitations of subjective methods.

In order to estimate the user perceived quality of mobile service, there are different methods including:

* User data simulation: This means that tests are done by specific devices which simulate end-user for measurement.
* Crowdsourcing data: This means that tests are done by end-user application measurement (EAM). EAM is the daily use of an end-user's mobile phone is employed for measurement with an application or browser under the user’s control.

**3.2.1 User data simulation**

User data simulation is one key method to assess quality of mobile service, with the goal of collecting measurement data as a function of selected location and time. This method is based on emulation of a typical user using services provided in a mobile network by the mobile QoS test-equipment. This equipment can be installed in a vehicle, in public areas or can be carried around by a pedestrian. For example, with voice service, regulators use specific device that support Perceptual Evaluation of Speech Quality (PESQ) or Perceptual Objective Listening Quality Assessment (POQLA) to test MOS for mobile voice service.

User data simulation provides a snapshot view of the mobile operator’s quality of service. It provides a realistic picture of network performance from a user’s point of view and the good way for regulatory purposes. Operators also use this method to optimize your network when they deploy new base stations or when costumers inform the operator about bad coverage, bad quality of voice or data. Thank to use GPS receiver to record the location of the geographical position of each point of measurement, it is easy to identify points that have problems. Afterwards the results are used to improve the performance of the mobile network.

This simulation is convenient to use, however it will be limited time, roads so this method is difficult to apply to the total area in the mobile network and data collected may not be representative of the behavior of real consumers on each network. In order to resolve this problem, a larger number of measurement points, samples can make results more reflective of national experience but this adds to the cost.

**3.2.2 Crowdsourcing Data**

Technologies used in mobile network are development from GSM (2G) to WCDMA (3G), LTE, LTE-A (4G), recently is 5G. In addition, the growing up numbers of smartphones and other Internet accessible portable devices, mobile users, IoT devices have been shifting from traditional communication services such as voice and text message to use of Internet services.

Data crowd-sourcing provides an alternative to the traditional subjective testing, aiming at reducing the resources necessary for conducting subjective testing by utilizing smartphone user’s, Internet source. Data crowd sourcing is usually organized by operators or regulators. In this method, any user could install the application software on their mobile devices for testing their individual Internet access performance at any place and any time of their preference. The testing result will be anonymised which means that removing any information that identifies which particular computer/mobile phone/connected devices that data originally came from. The backend system to receive and process collected data through Internet from user’s mobile devices.

In Internet environment, the speed of connections is a key parameter to assess quality of Internet access service. Crowdsourcing measures speed of Internet access service based on packets transmitted between end users and dedicated servers. The speed is calculated by amount data transferred and a given period in time. When a test starts, the mobile application establishes the connection with the dedicated server, which can be located at the Internet eXchange Point (IXP), as an independent point for all mobile network operators. Sometime, the current signal strength is also measured. After testing, anonymous data will be collected and shown on a map with speeds, technologies, time periods and mobile operators in their regions.

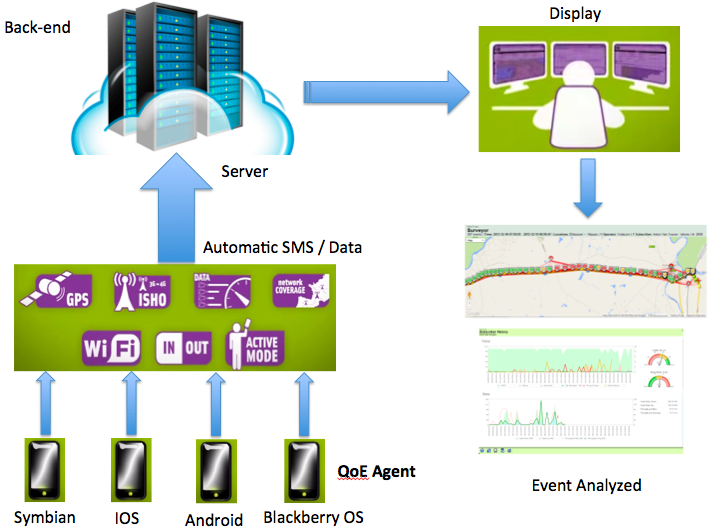


Figure 1 – Mobile agent solution

The main advantages of this approach are that enable to gather information about experience of anonymous end-users from anywhere, anytime and representing real-life conditions with low cost. Crowd-sourced data is with a huge volume of data collected from real users on real devices, the result of crowd-sourced accurately represent real user experience on their smart phone across a broad range of geographic areas, times and situations. However, in some cases crowdsourcing cannot replace on other measurements. This is especially in areas of weak network coverage or simply the situation when mobile phone users are complaining because of a bad reception.

# Issues for consideration

From these analyzes above, there are some methods to estimate quality of experience in mobile communication as survey, simulation, crowd-sourced data. The survey method has been widely utilized since it is since it is simple. However, it will be time consuming and expensive because large samples of participants are needed to achieve QoE evaluation results. Simulation method used for regulation purpose and its limited time, road test. With the popularly of Internet, estimating the quality of experience was replaced by crowd-sourced data on end-user’s smart devices. However, implementation practices of crowdsourcing data have some issues for consideration as follows:

**Mobile networks or Wi-Fi networks**: With crowdsourcing approach, end-user smartphones become measurement devices experience mobile communications. However, end user could connect to Internet base on mobile networks as well as on Wi-Fi networks, crowdsourcing approach need to separate collected data these networks to estimate correctly quality of experience mobile communications.

**Benchmarking:** In principle, quality of service benchmarking between operators must perform under the same conditions. This means all operators need to be measured simultaneously, at the same location and under the same test conditions. This is difficult to perform by data crowdsourcing approach. Using simulation method enables comparisons the quality of mobile services between operators because this method adaptive all above conditions

.

**GPS co-ordination data:** The GPS co-ordination data will show the exact location of the geo-graphical position of end-user. Operators or regulators know the points that end-users have problems with network performance. GPS co-ordination data also show a part of the end-user context. Thus GPS co-ordination data should collect when operators/regulators perform quality of mobile measurement.

**Participation of end-users**: The prerequisite condition for every successful crowdsourcing is having a large volunteer, as the power of crowdsourcing directly comes from the number of participants. Motivating users to participate in a crowdsourcing application is very importance. However, volunteers install software on their cellphone, anonymized volunteers need to consider. Anonymization allows operator/operator used database for quality of mobile service analysis without compromising the privacy of the end-users. Therefore, personal identifiers (IMSI, IMEI) or IP addresses are not collected on the database.

**Time to measure**: The timing of measurement can affect results. For example, end-user could have more bandwidth on the off-peak hours so they could access Internet with good performance and the measurement could have a good result. But in the peak hours of the mobile network contribute to the quality variations experienced. Therefore, it is important that tests are run cover almost all the days of a week over a few months.

**Location of the test server**: The measurement quality of Internet access service is based on packets transmitted between clients and servers so the location of a server is relevant to the performance measured. A position deeper in the network will result in poorer performance values and reflect closer to the users' experience in the access Internet, since the degradations of the path between the interconnection point and the test server will be included. For all tests a dedicated test server should be used and it should be located at a point close to domestic Internet exchange Points.

**Technical perspective**: The speed of a service may be limited when the amount of data consumption has exceeded the data capacity offered by the ISP. For example, end-user use limited data package that mean when end-users reach their data limit, speed of Internet connection will be automatically limit. The result of measurement is not correctly capacity of network. Thus this approach is not as well suited for measuring the gap between advertised speeds and actual speeds.

# Conclusion and recommendation

Quality of services has been used as measurable, observable characteristics indicated as parameter/criteria of telecom services that bear on its ability to satistify customers’ need. However user expectation and context varied by time. End-to-end service quality combined with user expectation and context result in quality of experience. In this regards, while the regulatory approach of QoS is based on command and control, the QoE is consumer empowerment, which would be tools for consumer to compare offers, checking the speed of their Internet access themselves without waiting for regulator to set up time-consuming drive test, feedback interactively to the operator, etc.

This report has listed several approaches for measuring the experience of mobile Internet access service, including:

* User data simulation
* Crowdsourcing data

which are becoming more popular in measuring the end user quality of experience. Depending on the objective and regulation policy, regulator/operator could use one or both of the above methods to measure quality of mobile experience.

From regulator perspective: In order to use method of user data simulation, regulator should mandate to setting regulatory framework for the measurement and compliance of quality of mobile criteria, reporting and publishing of parameters. Regulator could use crowdsourcing method to provide users with transparent information on actual performance of provided services. They need to develop tools to customers free install on their cell phone. Regulator should have policy to encourage mobile users to install and share your usage experiences. They need to care about anonymous mobile users or non-personal data relating to mobile users’ quality of experience.

From operator perspective: Operator could use both of the above methods to understand their customer, optimize network and improve quality of user experience, quality of service.

**ANNEX**

**Sharing experience of Viet Nam**

Like other regulatory bodies in the world, the role of the Viet Nam Telecommunications Authority (VNTA) is to perform a multitude of tasks, which include the quality management of the service provider’s. The basic of VNTA’s quality of popular mobile service regulation are given by:

* Law on telecommunications.
* Circular 08/2013/TT-BTTTT on the management telecommunications service quality.
* Circular 35/2017/TT-BTTTT list of telecommunications services subject to quality management.

These regulations were developed to maintain a mobile market on the basis of competition, fairness, and transparency. These obligations are monitored and enforced through consumer oriented methodologies:

* Conduct of quality of mobile service measurement: Drive/indoor/fix outdoor measurement of all operators is done in different geography areas to ascertain the quality of mobile phone users experience.
* Quarterly operator reports: Quality report submission by operators enables the authority to assess the network level performance of each operator.
* Publication of measurement results on the social media.

In order to estimate quality of popular mobile services, Viet Nam has published national technical standards for mobile voice service, broadband Internet access service and video streaming service, includes:

* QCVN 36:2015/BTTTT “National technical regulation on quality of telephone service on the Public Land Mobile Network”.
* QCVN 81:2014/BTTTT “National technical regulation on quality of Internet access service on the IMT-2000 Public Land Mobile Network”.
* TCVN 11302:2016 “Streaming Video service on the IMT-2000 public land mobile Network-Quality of service requirements”.

These national technical standards set out technical parameters and non-technical parameters with the targets for service quality monitoring. Technical parameters are network and service quality focused while non-technical KPIs are customer focused with parameters as user’s complains. Furthermore, the coverage map-related issues are included in these standards obligating network operators to announce service quality to the digital map. In the next session, we will introduce detail about these parameters, test methods as well as some quality of popular services measurement results in Viet Nam.

**KPI and assessment method**

In Viet Nam, quality of mobile services measurement is carried by VNTA and results are reported quarterly on the website VNTA’s. The measurement method used for mobile services is user data simulation, detail as the following:

* Measurement is performed on quarterly basis or requested.
* Voice measurements were conducted in drive, indoor and outdoor test mode. Measurement equipment collects network data by simulating in mobile-to-mobile scenarios with a pre-defined time duration call (60s – 180s). For each of the voice call, quality of speech samples was measured using POLQA P.863 algorithm.
* For Internet access service, VNTA makes file transmission over FTP protocol from smartphone/data card to dedicated server located at Vietnam Internet Exchange (VNNIX) and vice versa. Performance KPIs measure based on fix data transfer times (60s-180s), we choice files with a size big enough not to be completely downloaded/uploaded before reaching the end of the transfer time. Data measurements are performed in drive, indoor and outdoor test mode. Data tests assess network availability, stability and speed of network. VNTA also used scanner to obtain radio network parameters.

Table 1. KPIs and assessment method for mobile telephony service in Viet Nam

| **No.** | **Key Performance Indicator** | **Content** | **Target** |
| --- | --- | --- | --- |
|  | Radio network availability | The probability that end user can access to the radio network | ≥ 95 %. |
| 1. | Call Setup Success Ratio | The probability that end user cannot access the service when requested | ≥ 98 % |
| 2. | Call Cut-off ratio | Probability that successful call attempt is ended by a cause other than user’s intentional termination | ≤ 2% |
| 3. | Speech Quality (\*) | Full reference, intrusive algorithm, which is conformed to ITU-T P.863 | At least 90% of evaluated calls get the mark of 3 or higher |
| 4. | Accuracy of Charging | Accuracy of charging for voice call duration | ≤ 0.1% |
| 5. | Accuracy of Billing | Accuracy of billing for voice calls | ≤ 0.1% |
| 6. | Service availability |  |  |
| 7. | Customer’s complaint ratio | Ratio between the number of complaint and total number of subscribers |  |
| 8. | Response to customer complaint | Each customer complaint shall be responded within 48 hours |  |
| 9. | Customer care availability | Availability of customer care centre |  |

(\*) KPI used to estimate quality of mobile service experience, before, ITU-T P.862 used to estimate speech quality of mobile telephony service.

Table 2. KPIs and assessment method for Internet access service in Viet Nam

| **No.** | **Key Performance Indicators** | **Content** | **Criteria** |
| --- | --- | --- | --- |
| 1. | Radio Network Availability | The probability that end user can access to the radio network | ≥ 95 %. |
| 2. | Service access availability | Probability that a subscriber can establish a PDP context and access the service successfully | ≥ 90 % |
| 3. | Service access set-up time | Time period need to access the service successfully, from starting the dial-up connection to the point of time when the content is sent or received | ≤ 10 seconds |
| 4. | Session Failure Ratio | The proportion of uncompleted sessions and sessions that started successfully. | ≤ 10% |
| 5. | Mean Data Rate (\*) | Average data transfer rate measured through the entire connection time to the service | At least 95% samples Pd ≥ Pmin  Pd ≥ 0,8Vd  Pu ≥ 0,8 Vu |
| 7. | Customer’s complaint ratio | Ratio between the number of complaint and total number of subscribers |  |
| 8. | Response to customer complaint | Each customer complaint shall be responded within 48 hours |  |
| 9. | Customer care availability | Availability of customer care centre |  |

Beside user data simulation method, in 2017, VNTA launched a pilot project to measurement quality of mobile service by smartphone of consumers. The pilot project use solution Nemo Customer Experience Monitor (CEM) of Keysigh. Nemo CEM Anite consists of Nemo Qmon application running on smartphones and Nemo Qview back-end solution for analysis and reporting.



**Figure 2: Nemo CEM Anite**

This project allows end-users install, conduct performance tests from their mobile devices and send result to us. This tool helped us to measure quality of customer experience includes broadband speed, signal strength of mobile networks.

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