LATVIAN JOURNAL OF PHYSICS AND TECHNICAL SCIENCES
2016, N 5

DOI: 10.1515/lpts-2016-0037

ELECTRONICS

INVESTIGATION OF SERVICE QUALITY OF MEASUREMENT REFERENCE POINTS FOR THE INTERNET SERVICES ON MOBILE NETWORKS

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To ensure that end-users and consumers have access to comprehensive, comparable and user-friendly information regarding the Internet access service quality, it is necessary to implement and regularly renew a set of legislative regulatory acts and to provide monitoring of the quality of Internet access services regarding the current European Regulatory Framework. The actual situation regarding the quality of service monitoring solutions in different European countries depends on national regulatory initiatives and public awareness. The service monitoring solutions are implemented using different measurement methodologies and tools. The paper investigates the practical implementations for developing a harmonising approach to quality monitoring in order to obtain objective information on the quality of Internet access services on mobile networks.

Keywords*: Internet access, quality of service.*

1. INTRODUCTION

The electronic communications sector is characterised by the dynamic development of broadband electronic communications networks in mobile environment.

To maintain a high quality level by the dynamic variations of technologies for provided services, the national regulatory authority should carefully follow all aspects of regulated service quality in the electronic communications sector, determine service quality parameters, their values and perform measurements to ascertain if quality requirements imposed for electronic communications services are complied with.

The scope of investigations included in this paper also covers the topics defined under the Position documents and Regulation of the European Parliament and of the Council, which entered into force last quarter of 2015.

Furthermore, the consumers require the explanation of the minimum, actual, normally available, maximum and advertised download and upload speed of the Internet access services, particularly for mobile Internet services.

The main objective of the research is to compare different measurement approaches in order to find the optimal solution for the quality assessment of Internet access services on mobile networks. The paper includes the recommended quality parameters and reference points of the mobile Internet access services from the consumer perspective. Certain types of mobile broadband measurements are provided practically using measurement initialising software on notebook computer and Visualware Inc [1] measurement system software placed on server connected to the Internet exchange point. Application of Quality of Service (QoS) measurement metrics considered in the paper is useful as the basis for further research.

2. LEGISLATIVE ACTS AND REGULATORY FRAMEWORK

The Internet has developed over the past decades as an open platform for innovation with low access barriers for end-users, providers of content, applications and services and providers of Internet access services. The existing regulatory framework aims to promote the ability of end-users to access and distribute information or run applications and services of their choice [2].

To reach main goals concerning open Internet access, the European Parliament and the Council of 25 November 2015 are laying down measures concerning open Internet access and amending Directive 2002/22/EC on universal service "Universal Service Directive" and users' rights relating to electronic communications networks and services and Regulation (EU) No 531/2012 on roaming on public mobile communications networks within the Union [2]. The Position (EU) No 14/2015 of the Council at the first reading with a view to the adoption of a Regulation concerning open Internet access was adopted by the Council on 1 October 2015 [3].

Article 22.1 of the Universal Service Directive (USD) requires the Member States to ensure that undertakings providing publicly available electronic communications services publish comparable, adequate information for end-users on the quality of their services. At the same time, USD 22.2 encourages regulatory bodies to specify, inter alia, the quality of service parameters to be measured and the content, form and manner of the information to be published in order to ensure that end-users have access to comprehensive, comparable, reliable and user-friendly information [4].

To provide information on the best practices for monitoring the quality of retail Internet access services and recommend a harmonized minimum set of parameters and measurement methods, there are the following technical documents – The European Conference of Postal and Telecommunications Administrations (CEPT) Electronic Communications Committee Report 195 (ECC Report 195) on Minimum Set of Quality of Service Parameters and Measurement Methods for Retail Internet Access Services [5], and CEPT ECC Recommendation (15)03 (ECC Recommendation 15) on Provision of Comparable Information on Retail Internet Access Service Quality [6].

Degradation of network performance of IP-based networks may be due to general congestion in the network or targeted traffic management may cause it. Descriptions of these issues are included in the Body of European Regulators for Electronic Communications (BEREC) documents related to the framework for quality of service in the scope of net neutrality [7]–[9].

European Telecommunications Standards Institute (ETSI) and International Telecommunication Union (ITU) deliverables, namely ETSI EG 202 057 [10], ETSI TS 102 250 [11], ETSI EG 203 165 [12], ETSI EG 202 765 [13], ITU-T Recommendations Y.1540 [14] and Y.1541 [15], establish and define a set of user related QoS parameters.

3. OVERVIEW OF BASIC MEASUREMENT PRINCIPLES

What parameters should be measured, how they should be measured and where they should be measured – these are essential questions for receiving comparable information on the quality of Internet Access Services. Parameters about transmission speed, delay, delay variation, packet loss ratio and packet error ratio are necessary for evaluating the quality of retail Internet access services. Classification of measurement principles by QoS assessment reference points is possible by the following scenarios [5]:

A. QoS Evaluation of the Internet Service Provider Leg

Only the network section directly influenced by the Internet service provider will be assessed. The Internet service provider leg consists of the access network part and the service provider network part of the connection of the customer to the Internet service provider [10].

B. QoS Evaluation of the Access to National Internet Exchange Point

By the QoS evaluation of the access to a national internet exchange point (IXP), the test server is located at a national IXP. This scenario will allow comparing the QoS access to the IXP of the different Internet service providers in a specific country.

C. QoS Evaluation of Access to International IXP

For the QoS evaluation of the access to an international IXP the test servers are located at national internet exchange points in several countries. This would allow for comparisons between the connectivity of Internet access services of different countries. This test scenario practically covers the QoS assessment for international links with different countries.

4. RELEVANT PARAMETERS FOR INTERNET ACCESS QOS ASSESSMENT

Based on the analysis provided in ECC Report 195 and ECC Recommendation 15, it may be concluded that five groups of parameters are relevant for inclusion in the minimum set for the general evaluation of the Internet access services [5], [6].

A. Transmission Speed

Transmission speed minimum and average values are expressed in megabits per second (mbps) or kilobits per second (kbps). The data transmission rate is achieved separately for downloading and uploading of specified test files between a remote web site and a user's terminal equipment – computer [5], [10].

B. Delay

Delay average value is expressed in milliseconds (ms). The delay is half the time in milliseconds that is needed for an Internet Control Message Protocol (ICMP) Echo Request/Reply (Ping) to a valid IP address [5], [10]. Some measurement tools provide the Round-Trip Time (RTT) assessment that is the length of time it takes for a signal to be sent plus the length of time it takes for a signal to be received.

C. Delay Variation

Delay variation or Jitter value is expressed in milliseconds (ms). For a given pair of IP packets, parameters represent the difference between the delays in one direction measured for two consecutive packets [5], [14]–[15].

D. Packet Loss Ratio

Packet loss ratio value is expressed in percent (%). It is the ratio of total lost IP packet outcomes to total transmitted IP packets in a population of interest [5], [14].

E. Packet Error Ratio

Packet error ratio value is expressed in percent (%). It is the ratio of total errored IP packet outcomes to the total of successful IP packet transfer outcomes plus errored IP packet outcomes in a population of interest [5], [14].

5. QoS MEASUREMENT TECHNIQUES USED FOR THE EXPERIMENTS

Before the profound investigation, the QoS measurements were performed as a feasibility study to various reference points with different measurement tools located in different places within the Internet environment. Usually the test servers are hosted by Internet service providers and connected to their core network nodes. The access capabilities to the operator test servers differ from other Internet access service providers because the interconnection links are sometimes of very different capacity. More equivalent measurement results are achieved when the dedicated test

server and reference point are located abroad but this way allows assessing the international links without objective possibility to compare Internet service providers at a national level. The achieved measurement results, particularly on mobile networks, sometimes are obtained incomparable because the measurement techniques and algorithms were different. These obstacles require some unified approach to apply for the provided measurements.

For the investigations, measurements were performed by lots of web interface based online tools, more focused on OOKLA Speedtest tool [20], RTR-NetTest online tool [21], Visualware Inc. online test tool [1] and Latvian regulatory authority – SPRK Internet access QoS measurement system ITEST [16].

OOKLA Speedtest tool ranks mobile networks using the average download performance for the fastest available technology. This provides an accurate view of the typical performance you can achieve using a modern smartphone or tablet on a given mobile network [21].

RTR-NetTest online tool allows measuring speed of data connection in both directions – downlink/uplink and latency of data connection. RTR-NetTest online tool is located at Austrian national internet exchange point and this test tool practically covers the QoS assessment for international links from different countries.

Visualware Inc. online test tool provides different types of Internet access tests such as speed measurements, VoIP measurements, quality and video streaming tests. Visualware Inc. measurement tool uses reference servers located in different countries around the world and this test tool also covers the QoS assessment for international links.

Comparing different options of measurement principles classified by QoS assessment reference points and measurement software types, further investigations are provided via the user interface of web page based measurement software. The measurement server is located nearby the Internet exchange point and with 1-Gibabit links is connected to the main exchange point.

General measurement principles and connection data flows are shown in Fig. 1.

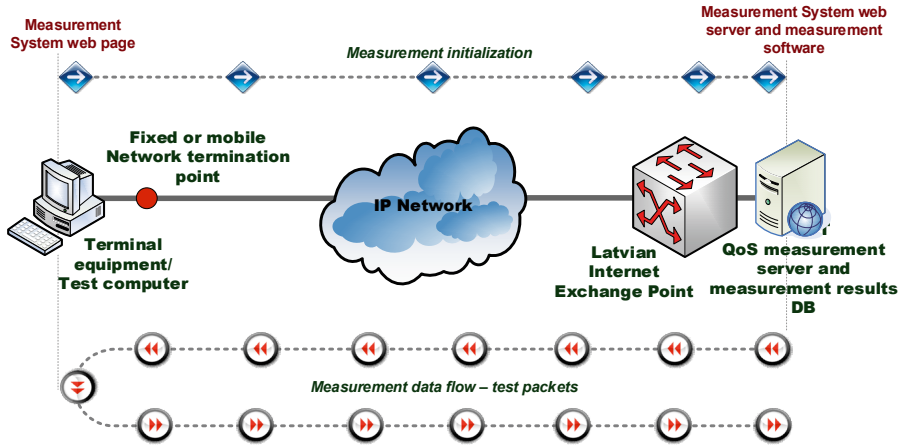

Fig. 1. Illustration of QoS measurement reference points and general QoS evaluation principles with access to a national internet exchange point [5].

As measurement system software Visualware Inc. [1] module "MyConnection Server BusinessCenter" was used. The Internet access QoS measurement system IT-EST is hosted by the Latvian regulatory authority – SPRK and is freely accessible at SPRK's website [16] from Latvian IP addressing space. The measurements were performed on three mobile GSM/UMTS operator's networks using notebooks with Windows operating system (Internet Explorer and Chrome browsers) with sequentially connected Huawei USB stick modems E3372 and Huawei E593 type routers, which support communication in all typical frequency ranges for 3G and 4G services [17], [18], [19].

Two types of measurements were performed in this paper – short-term measurements in different geographical locations and long-term measurements in certain locations. As the routers were collocated quite closely, for the most sure and believable measurement results the USB dongles and routers were connected one by one to exclude simultaneous data transmission and to avoid possible radiofrequency signal interference. The used measurement sequence scenarios defined by measurement management software script commands and for one measurement cycle are shown in Fig. 2. In the first scenario, three measurement sessions are provided in one operator's network. The second scenario allows changing the operator's networks for each new measurement session. The advantage of this scenario is better measurement sequence but this scenario requires the extra time for equipment reconnecting to the networks after a single measurement session.

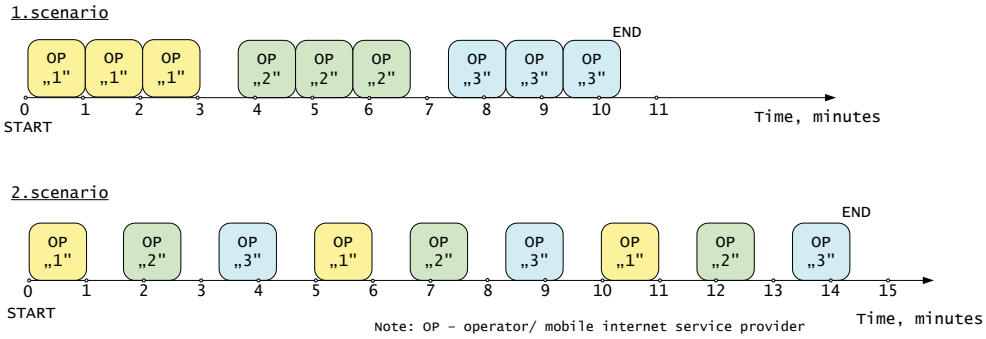

Fig. 2. QoS measurement session sequence scenarios.

6. PROCESSING OF QOS MEASUREMENT RESULTS

The main objective of this section of the paper is to compare two types of provided measurements in order to make conclusions in a given area from the consumer perspective.

For the short-term measurements, average values gathered during all measurement sessions were produced and calculated as arithmetic mean values categorized by network technology by each measurement location and as common value per operator's network. For the long-term measurements, transmission speed average values were processed within one-week and one-day frame calculating arithme-

tic mean values hour by hour. One-day example of the long-term measurements is shown in Fig. 3.

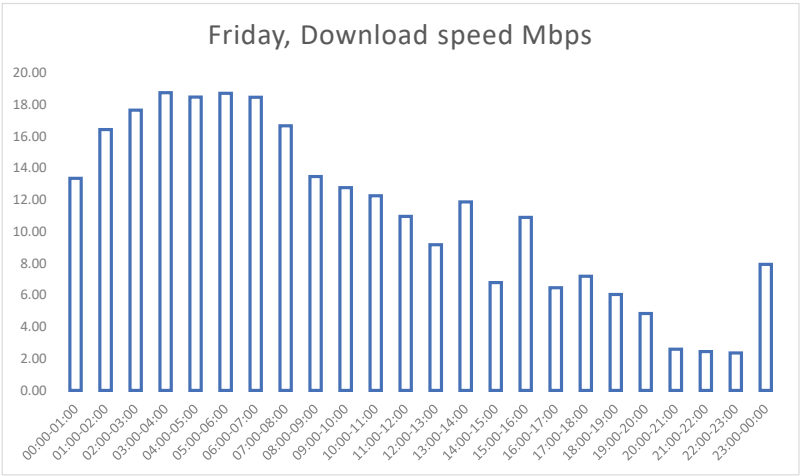

Fig. 3. Example of the long-term measurements of 4G download speed value deviation during 24 hours.

Collected measurement data were processed for the download and upload transmission speed, latency, delay variation or jitter and packet loss ratio. The latency deviation was about 300 milliseconds on 2G networks, about 60 milliseconds on 3G networks and up to 30 milliseconds on 4G mobile networks. For instance, recommendation is that one-way latency should not exceed 150 milliseconds. The collected measurement data were divided by generations of mobile technologies for calculating average latency variations on mobile networks. As shown in Fig. 4, latency value on 4G mobile networks is quite enough to ensure comfortable use of all services available on the Internet if the Internet access speed is sufficient for providing specific services.

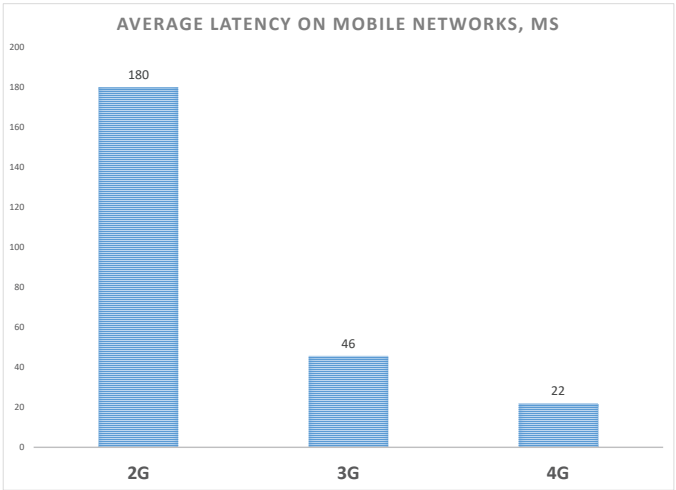

Fig. 4. Example of the average round-trip latency variations for different generations on mobile networks.

The actual measured transmission speed maximum values depend on 3G or 4G network technologies provided in a given measurement location. Typically, maximum actual transmission speed by dedicated previously mentioned measurement conditions does not exceed 30 % of maximum theoretical speed advertised by vendors – 100 or 150 Mbps, while the deviation of the transmission speed strongly depends on the Internet usage activities in a certain geographical area.

7. CONCLUSIONS

The proposed measurement techniques applying the same measurement tool to all measurements and using dedicated reference points, i.e. from a network termination point to a national Internet exchange point, allow reaching reliable and comparable information about mobile broadband Internet access quality provided to consumers. The provided measurement methodology offers the guidance for the practical implementation of regulatory framework regarding comprehensive and user-friendly information publishing.

Taking into account that the mobile network performance in peak hours and by "heavy" user's activities slows down, short-term measurements are more useful if a large number of measurement places are chosen. However, long-term measurements give the objective information about the Internet service capability available to end-users and network resources sufficiently during a daytime.

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PAKALPOJUMU KVALITĀTES MĒRĪJUMU ATSKAITES PUNKTU PĒTĪŠANA INTERNETA PAKALPOJUMAM MOBILAJOS TĪKLOS

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K o p s a v i l k u m s

Lai nodrošinātu lietotājiem pieejamu atjauninātu un atbilstīgu informāciju par interneta piekļuves pakalpojumu kvalitāti, ir jānodrošina pastāvīga regulējošo normatīvo aktu, kā arī pakalpojumu kvalitātes uzraudzībā izmantoto mērīšanas un monitoringa metodiku aktualizācija atbilstoši Eiropas elektronisko sakaru nozares

regulēšanas ietvarā noteiktajām vadlīnijām. Šobrīd, saistībā ar pakalpojumu kvalitātes tehnisko uzraudzību, Eiropas Savienības dalībvalstīs nav ieviesti vienoti mērīšanas instrumenti vai rīki pakalpojumu interneta piekļuves pakalpojuma kvalitātes monitoringa nodrošināšanai, kā arī nav piemērotas vienotas metodikas mērījumu nodrošināšanai. Pakalpojumu kvalitātes uzraudzības praktiskā nodrošināšana katrā Eiropas Savienības dalībvalstī ir atkarīga no nacionālo regulatoru iniciatīvas un tehniskajām iespējām.

Pētījuma nozīmīgākais uzdevums ir pakalpojumu kvalitātes mērīšanas metodikas galveno pamatprincipu definēšana, vienotas un objektīvas kvalitātes uzraudzības nodrošināšanai, tādejādi sniedzot iespējami visaptverošu un salīdzināmu informāciju par pakalpojumu kvalitāti, tās izmaiņām un attīstības tendencēm gan lietotājiem, gan pakalpojumu sniedzējiem. Analizēta dažādu interneta piekļuves pakalpojuma mērīšanai izmantotu algoritmu un mērījumu atskaites punktu jeb mērīšanā ietverto elektronisko sakaru tīklu posmu izmantošana, kā arī nozīmīgāko raksturojošo parametru izvēle kvalitātes novērtēšanā.

Pētījuma rezultātā ir sniegti ieteikumi pakalpojumu kvalitātes uzraudzībā izmantojamo mērīšanas principu piemērošanā, kā vienu no kritērijiem nosakot, ka pakalpojumu kvalitātes mērījumu veicami posmā no elektronisko sakaru tīkla pieslēguma punkta līdz nacionālajam interneta apmaiņas punktam. Tas nodrošina pakalpojumu sniedzējiem iespējami labāko savstarpēji salīdzināmas informācijas iegūšanu, vienlaikus objektīvi raksturojot lietotājiem pieejamo interneta piekļuves pakalpojuma kvalitāti, kā arī pakalpojumu kvalitātes izmaiņu dinamiku.

11.02.2016