REGIONAL INITIATIVES – EUROPE

Twinning between POLAND AND ALBANIA: TECHNICAL SPECIFICATIONS FOR A TOOL TO MEASURE QUALITY OF SERVICE

Telecommunication Development Sector

Twinning between Poland and Albania: Technical specifications for a tool to measure quality of service

This report was prepared by the International Telecommunication Union (ITU), Europe Coordination Office of the ITU Telecommunication Development Bureau (BDT). ITU would like to thank Mr Adam Siewicz from the Office for Electronic Communications of the Republic of Poland (UKE) for his expert knowledge. ITU would also like to thank Mr Piro Xhixho, Chairman of the Electronic and Postal Communications Authority in Albania (AKEP), Mr Rudolf Papa, Director of Cabinet, Mr Marcin Cichy, President of UKE, Mrs Anna Rogozinska, President's Representative for International Affairs, Director, Department of International Cooperation, and Mr Wojciech Berezowski, Head, International Affairs Unit, Department of International Cooperation, UKE.

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1 Introduction

The Internet has a significant impact on the socio-economic development of a nation. Protecting the interests of Internet users, in an increasingly competitive and complex market under the impact of the rapid evolution of technologies used to provide Internet access services, has become a priority for the authorities. The legal framework in force usually sets out the requirements providers of electronic communications to publish comparable, adequate and up-to-date information on the quality of Internet access services offered. Although operators offer a variety of detailed and accurate information, these may be unclear, and hard to find and compare.

It is in this context that a project was initiated by ITU at the request of the telecommunication regulator of Albania, AKEP, to develop a tool for measuring quality of service (QoS), under the WTDC 2014 Regional Initiative for Europe for the development of broadband access and adoption of broadband. This tool is expected to be an application to be developed on a defined IT platform, with specified functionalities, and prescribed in the technical terms of reference.

2 Twinning Initiative

Since the Office for Electronic Communications of the Republic of Poland (UKE) has considerable experience and know-how in QoS tool development, which they wished to share with other countries in the region, a twinning initiative was established through ITU. The expert Mr Adam Siewicz of UKE elaborated the specifications of the tool for measuring QoS for Albania.

AKEP, UKE and ITU representatives launched the project during the ITU-EC Regional Conference for Europe on Broadband Services and Infrastructure Mapping, held from 11 to 12 April, 2016 in Warsaw, Poland.

3 Purpose

The main purpose of the tool is to provide the Internet users in Albania with a simple measurement instrument allowing them to get accurate information about the quality of the Internet offered by service providers. The tool will enable AKEP to get a clear picture of the QoS and analyse broadband services in Albania based on customer experience.

The tool will also encourage providers of electronic communications to publish comparable, adequate and up-to-date information on the quality of Internet access services.

4 Justification

In 2012, AKEP issued a decision setting out quality indicators for the provision of Internet access services and requiring operators to publish metric values obtained for these indicators. At the same time, operators are required to include general conditions of service provision, such as appropriate levels of quality for the provided service, in end-user contracts. This reflects the priority for AKEP to protect the interests of users in an increasingly competitive and complex market under the influence of the rapid evolution of technologies used to provide Internet access services.

Measurement of such parameters will indicate a value closer to the actual experience in accessing the Internet, as they will include all network provider and other related network parameters. With the development of this tool, AKEP will have a strong control over the accuracy of measurements and

will be able to draw up statistics on the quality of Internet access services. In addition, test results and statistics about the quality of services provided to users will, as a whole, help them to make the necessary comparisons on services.

5 Project strategy

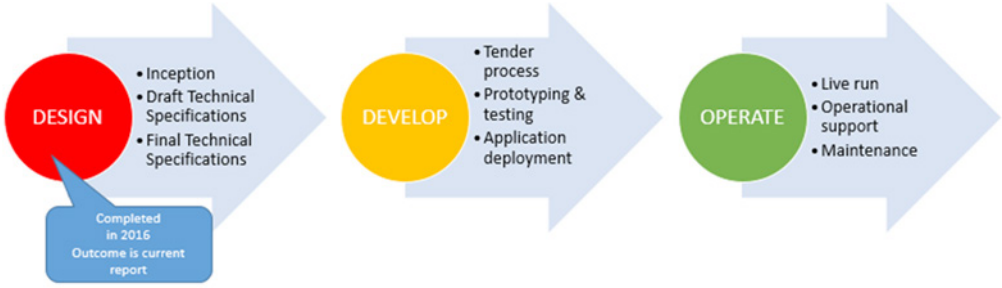
The QoS measurement tool will operate in a client-server environment and be publicly and interactively accessible from the AKEP website. All details of QoS tests executed by subscribers will be stored in a database, which can be used to generate reports regarding Internet service. Reports will also contribute to periodic statistics that are generated by AKEP, and will also serve for possible tests of broadband services.

The QoS measurement tool will include:

- user-friendly solution;
- centralized, flexible and compatible, available for different OS;
- increased transparency and user knowledge;
- improved QoS;
- reports and statistics.

The specific objective of the current assignment is to design and develop a tool to measure quality of service (QoS) in Albania. The technical specifications in this report will, after review and relevant endorsement by AKEP, be used to draft a tender for developing the QoS measurement tool, while also addressing any additional organisational/administrative requirements necessary to implement the project.

Figure 1: Phases for tool creation



Source: ITU

The tool creation follows a typical system development cycle starting with the design of the tool, then the development on the tool concluding with the operational system.

The work completed in 2016 was the design phase of the tool which had three milestones:

1. An inception phase where related documents were reviewed, the needs of AKEP were evaluated and expectations were specified.
2. A mid-term draft technical specifications document was developed for review by the AKEP team.
3. A final set of technical specifications was reached in agreement with the AKEP team.

As agreed in the inception report, the technical specifications proposed in chapter 6 have dedicated sections for:

- assumptions and definitions of terms;
- the detailed requirements specification of the tool;
- additional organisational/administrative requirements necessary to implement the project.

6 Technical specifications proposed

6.1 Assumptions and definitions

For the purpose of the project, the following assumptions, terms and definitions will be applied:

1) The "QoS based on customer experience" is based on the meaning of *QoE – Quality of Experience.*

   QoE is equivalent to the term used in the publication *QoS-3: Practice* which was defined in the European Commission Mapping of Broadband Services in Europe study where it is defined as "actual users experiences, to be pulled from crowdsourcing applications servers"[1].

2) The "tool to measure quality of service quality of service (QoS)" will be constructed based on BEREC model and methodology, which are presented in the document ECC Report 195, 17 April 2013 (Minimum Set of Quality of Service Parameters and Measurement Methods for Retail Internet Access Services) and where the evaluation of QoS is discussed as three main types:

   a) either client-to-server (peering-gateway) type, or

   b) client-to-server (IXP-gateway) type[2], or

   c) client-to-server: where the QoS test server is located in the AKEP autonomous system (AS)[3]

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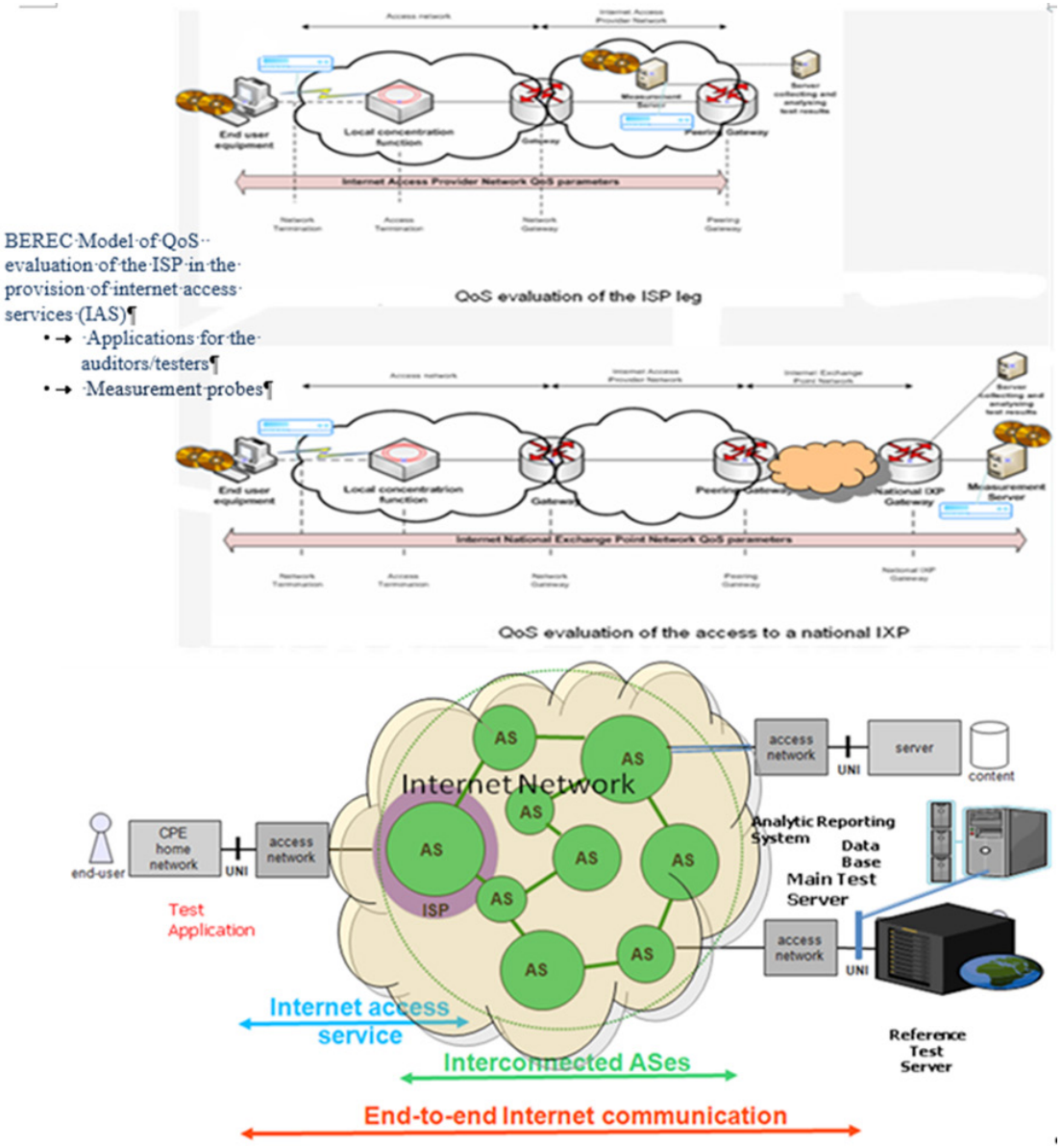
1 The term QoS-3 is available on the website https://www.broadbandmapping.eu/ and directly presented in the Methodology of the European Commission project "Mapping of Broadband Service in Europe" https://www.broadbandmapping.eu/wp-content/uploads/2015/07/TUV-Rheinland_Presentation_European-Broadband-Mapping.pdf

2 Albania has no national IXP, so for the purpose of the tool, model c) is recommended.

3 Real results vs. test results of QoS measurements: each test can pass through other autonomous system domains (AS) if even this leads to the same reference autonomous system- end-to-end Quality of Service over autonomous systems;
- tests cannot control or set up specific transit paths for test traffic via AS domains (each time could be different); since EQ-paths (end-to-end Quality of Service over heterogeneous networks) are end to end paths, they cross several autonomous systems;
- communications paths within an autonomous system are established by the use of internal routing protocols. For end-to-end reachability across several autonomous systems an external routing protocol (an inter-autonomous systems routing protocol called the Border Gateway Protocol (BGP) 7) is needed. Its primary function is to exchange network reachability (connectivity) information between the autonomous systems for eliminating loops. Routing decisions based on path, network policies and/or rule sets are taken manually (BGP has no automatic discovery mechanism); Connections between peers have to be set up manually, with peer addresses programmed at both ends.
- BGP can determine the packet path, can select the routes for exchange the packets etc. and decide in general, where such an exchange exists depending on the policy of the autonomous system owner. At the same time BGP allows this in a way that does not cause any problems with the operation of the Internet. The separate autonomous system allows an ISP (Internet service provider) to connect with the measuring system by using sufficiently high capacity links that are completely independent from other links of this ISP to any ISPs, CSPs and IXPs. Within its network the traffic is mixed with other traffic and treated equally. But inside this network there is no connection with other networks.

Figure 2: BEREC model of QoS



Source: BEREC

6.2 Recommendations

The recommended technical specifications are detailed in the following sections and tables.

6.2.1 Performance indicators and functions of QoS measurement tool

a) Title	Draft document- Technical Terms of Reference (ToR)- regarding tender for QoS measurement tool.
b) Legal basis	Law no. 9643 dated 20.11.2006 on Public Procurement, amended, Public Procurement Regulations, Law Nr.9918, dated 19.05.2008 "For Electronic Communications in the Re-public and Albania", amended, Regulation no. 16, dated 16.04.2010 on "Quality of Service Indicators", amended, and other regulation acts of AKEP.
c) Subject delegated to collect data	AKEP
d) Technologies involved	Fixed, mobile (GSM/WCDMA/HSPA/Wi-Fi/LTE/LTE-A).
e) Standards	Software and hardware products of project must conform international technical standards: ETSI and ITU deliverables, namely ETSI EG 202 057 ETSI TS 102 250, ETSI EG 203 165, ETSI EG 202 765, ITU-T Recommendations Y.1540, Y.1541 and Y.1564 establish and define a number of user related QoS parameters, RFC 6349, MEF 23.1<?>.
f) Networks involved	Internet access providers and owned by public entities.
g) Database data provision	By AKEP: This covers QoS indicators of all operators that provide Internet access to the public, i.e. to end users.
h) Periodicity of data updating	Quarterly, monthly.
i) Experimental start-up phase:	6- 9 months
j) Data collected	QoS indicators, geo-location of nodes, technology installed, usage degree i.e. real speed to headline speed.
k) Data formats and coverage diagrams	Decided by NRA- the competent Direction of AKEP.
l) Data protection	Anonymous data; only aggregated data will be published.
m) Expected form of publication	QoE (QoS-3) coverage maps as defined in Chapter 1.3.
n) Granularity	Albania geographical units including base administrative unit, municipality (which includes base administrative units) and district (which includes municipalities); NUTS3 and SPATIAL Directive requirements.
o) Database design	Shall allow future Integration of the database with actual (measured) QoS and actual demand, and other platforms<?>.
p) Coordination	AKEP Database: the competent service within AKEP will carry out coordination.

6.2.2 Functional requirements

a) **Performance:** Tool allows to perform at least 20 tests simultaneously accordingly for web test client and software application test client (optional); up to 10 test servers in the system with auto and manual server selection for test client; 100 000 tests per week; the source data will be stored in the database at least two years.

b) **Applications:** It is expected to perform the measurements on popular operating systems/ platforms in fixed and mobile Internet networks (including WiFi and 3G/LTE interfaces). For PC/ laptop clients (Windows, Mac, Linux) as well as mobile platforms (Android, iOS and Windows Phone). It is suggested that the construction of the system web interface will use HTML5. A Web application for mobile platforms will be optimised for screen size and resolution. Optionally applications available online third-party suppliers (for example: Google, Windows, Apple)[4] are considered.

c) **Metrics**: The standards, test validation, result representation, tests scenarios, and time durations[5].

d) **Basic KPIs for web test client:** RTT (Round Trip Time), TCP Throughput, Jitter (packet delay variation), Loss (TCP retransmissions) and other parameters defined in ITU/ECC/CEPT/BEREC recommendations and decisions.

e) **Detailed KPIs for software preinstalled on client PC/device**[6]: RTT (Round Trip Time), MTU (Maximum Transmission Unit) or TCP MSS, TCP Throughput, TCP Retransmissions, Buffer Delay, TCP Window Size as per IETF RFC6349[7].

f) **Presentation of results in graphs:** QoS indicators such as Throughput, RTT, Retransmissions over time and extra parameters which to be agreed between AKEP and the contractor basing on ITU/ECC/CEPT/BEREC recommendations and decisions, specially such as ECC REPORT 195- Minimum Set of Quality of Service Parameters and Measurement Methods for Retail Internet Access Services, 17 April 2013 or FINAL REPORT for EC- Analysis of Broadband Speed, December 2015.

g) **Reporting and result visualization**: functions allow to:

- carry out the following functions: benchmark and analyse trends in quality of broadband services (supply and demand) in Albania, notably, yet not exclusively, the coverage and take-up of QoS Albania targets by AKEP regulations (the indicators of quality of service);
- assess correlations between various dimensions of QoS indicators and the indicators of Geographic Information System (GIS)[8] (e.g. regional and rural socio-economic data from Albania).

h) **Additional requirements**:

- Network address translation (NAT) and firewall transparency.
- Optimal test sample size configuration for fast and reliable test results across different operating systems (OS) and Internet access speeds.

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4 It is recommended to design the applications that provide the information about network problems from the point of view of the operator /client, including testing with capability of network segmentation; tests that enable the user to check that traffic from applications is being rate-limited (i.e., throttled) or blocked, in both upstream and downstream directions.

5 For example- based on RFC6349 standard and by using TCP protocol to do the test- the duration of the test depends on the device operating system, the speed of the Internet, the sample size; minimum period of time for this test by TCP protocol is about 60 seconds.

6 Since a Web test client exists the software preinstalled on client PC/device is not necessary. In addition, preinstalled software can generate test faults resulting from the specific environment of the client PC.

7 In the case of TCP protocol the transmission must be error-free; in case of packet loss, e.g. errors in the transmission, packets are transferred again, so theoretically binary rate/speed may be higher than the speed perceived by the user.

8 It is recommended to design the applications to capture, store, manipulate, analyze, manage, and present spatial or geographical data as well as to present the aggregated results on the maps.

- Test server selection algorithm based on: the server availability, localization, performance, the client platform/OS and the manual selection by end-user (client).
- CPU utilization and the tasks/processes list (resource control for end-client and the server side), the network interface cart type (client site)[9] is optional and requires the installation of software on client computer.

i) **Characteristic features**: covering the testing IAS (Internet access services), the data registry, calculation, analysis, evaluation, visualization, mapping and the reporting/publication of results.

j) **IT**: the structure and architecture of the tool hardware and software, as well as the structure of the data base system/s with the functionality of the database layer[10].

k) **Security and data protection**: the firewalls, profiling access, archiving, backup, mirror solutions, active reserve power supply.

6.2.3 Documentation and training

6.2.3.1 Documentation of project management

a. **Design of system**: title xxx, version xxx, accepted by xxx, date xxx, signed by xxx. The purpose of this document is to present, how the system will be implemented based on requirements gathered in the analysis phase, including reports, draft technical terms of reference (ToRs), etc. The document shows the technological aspects adopted for the implementation of the project named "QoS measurement tool",

b. **Project quality plan:** title xxx, version xxx, accepted by xxx, date xxx, signed by xxx. This document is intended to describe all aspects of quality management in the project. Quality management is to ensure that it will be achieved all the objectives of quality, especially the results and final production of the system as expected AKEP by the constant project activities[11],

c. **Project plan/schedule:** title xxx, version xxx, accepted by xxx, date xxx, signed by xxx. Plan defines the frequency and control practices and procedures. This plan sets out requirements on how to perform all operations and for co-operation between the teams. As the work progressed, the plan will be subject to periodic updating to reflect the results of the analysis, requirements specification and system design. It remains valid until the end of the project.

6.2.3.2 Project documentation

a. **Technical description, deployment and maintenance description**: title xxx, version xxx, accepted by xxx, date xxx, signed by xxx. Description of the design, construction, installation and implementation of the system and its maintenance, and warranty service.

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[9] The following information is useful:
- on the configuration of the client computer- because the security/firewall also affect the speed of the outside of CPU and it must be seen transparently in both directions,
- on how address translation is done on the router user in order to be able to perform the tests; the idea is to have access to a particular computer from outside of the network (must be the communication in two directions).

[10] The database layer provides an object view of database information by applying schema semantics to database records, thereby isolating the upper layers of the directory service from the underlying database system. The database layer is an internal interface that is not exposed to users.

[11] The document is divided into two main parts:
- **description of the quality system includes**: definition of the objectives, procedures used to guarantee quality assurance and determine the organizational structure; the roles, the rights and duties of the parties' representatives,
- **description of the project quality plan**: that is, the development of procedures, the preparation of the output sets of information and plans related to the system. The plan includes a list of which products (or individual product features) how, when and by whom will be checked for compliance with established acceptance criteria.

b. **User manual, administrator and design instruction**: title xxx, version xxx, accepted by xxx, date xxx, signed by xxx. Description of functionality, rights and profiles, access levels, administration and designing possibilities, including safety and emergency of system,

c. **Training dedicated to AKEP Team:** title xxx, version xxx, accepted by xxx, date xxx, signed by xxx. Plan of trainings on subjects: using the system, maintenance and development of the system- for designers, administrators and operation users from AKEP team, or to access for public clients.

6.3 Others requirements related to project implementation

This chapter contains related organisational/administrative requirements necessary to implement the project.

6.3.1 Requirements related to contract

a. **Development of project**: to ensure the technological sustainability, transfer of copyrights and licensing, the technical support and maintenance as well as addressing any derivative works (possibilities of the project extension, modularity**,** etc.).

b. **Experimental start-up phase before service:** the application system, as defined in the project, once deployed has to be operational. To operate in the environment of the country ISP (Internet service provider) network, the contractor will provide during 6 to 9 months of the system implementation:

- all installations and reinstallations of client applications, measurement probes or the referenced servers for efficient distribution to the access points (defined by AKEP) up to 20 client applications, 10 probes and 5 referenced servers;
- acceptance tests and the reports for each of the configuration of the network system (in accordance with above AKEP distributions).

c. **Service and Maintenance Agreement**[12]**:** The basic requirement is to obtain an adequate warranty and support. This is an accepted project standard for hardware supplies, and is a good practice with respect to any application system.

The required level of service should be indicated, for the purposes of enabling the contractor to estimate costs and the necessary resources. The agreement describes the required level of service, based on the requirements related to reliability and availability of the system, the experience-based estimate of frequency and nature of problems that might occur and some rule-of-thumb estimates of expected software quality. Lack of this information could be misleading if such service is required[13].

[12] Mainly the annual maintenance cost of such IT product is 25 – 30 per cent of the delivery system cost; contractors should be required to provide system upgrades under the contract especially in the scope of the latest version of browser (Firefox, Chrome, etc.).

[13] The contractor will provide for the first year of system implementation any consulting services in Albania, along with cost of repairs at the contractor's expense. General consultation time, made via phone, and in any case on system operations on-site will not exceed 600 hours. The contractor will be available for consultancy and receive any information concerning system malfunctions from 8 am till 4 pm on working days and from 9 am till 1 pm on weekends via telephone. The contractor will repair any serious defects in 24 hours, any other defects in 7 days, since the time the defect was reported. Service after these hours will be available on selected malfunctions or defects, when it is classified as critical, or the risk is classified as "high" or "very high",

d. **Transfer of Copyright Agreement:** which contains at least the rules on[14]:

- **Grant of exclusive ownership and use rights**

  The developer sells, grants, conveys and assigns to AKEP, exclusively for and throughout the world, in and for all languages (including but not limited to computer and human languages whether now existing or subsequently developed) all contractor rights, titles and interests in the contract materials, including but not limited to all rights of contractor under all Albania laws on intellectual property or derivative provisions in the country.

- **Derivative works**

  The developer acknowledges that AKEP has the sole rights worldwide and in all languages (human or computer, now or subsequently existing):

  (i) to prepare derivative works based on the contract software, documents and other deliverables (collectively "derivative works"),

  (ii) to reproduce, distribute, copy or display the contract software, documents, other deliverables and derivative works and all versions thereof,

  (iii) to sell or transfer ownership to, or to rent, lease, lend or license the contract software, documents, other deliverables and derivative works,

  (iv) to exploit through any and all means available the contract software, documents, other deliverables, derivative works and all versions thereof,

  (v) to authorize others to do any and all of the aforesaid; and

  (vi) to utilize contract materials and derivative works in combination with any other works, in and as part of any collective works, and to do so in any and all forms.

6.3.2 Delivery of tool specifications for hardware and software

a. **Test Server:** located at peering-gateway or IXP-gateway, alternatively both sites to terminate traffic load from web based clients (basic KPIs) or/and software clients (detailed KPIs analysis) to provide/detect the potential problem by the segmentation testing capabilities. Server with two interfaces: test interface 10 Gbit/s and management interface 1 Gbit/s[15].

b. **Database Server:** to store test results and provide geolocation on the maps (e.g. Google). They are supposed to be an ISP vendor and all KPIs stored in the database beyond test client location available. Access to results should be granted for different test system user privileges and test customers upon registration. Database capacity up to 100 000 tests per week.

c. **Web Based Test Client:** is delivering basic KPIs (listed above) test results, preferable HTML5 supporting measurements on all operating systems (ex. Windows, OSX, different Linux

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[14] **Grant of Exclusive Rights to Trademarks and Service Marks**: Contractor, grants, conveys, transfers, alienates and assigns exclusively to AKEP, for and throughout the world and in any and all languages (human or computer) and media, whether now existing or subsequently developed, all the contractor rights, titles, interests (legal, industrial, commercial, equitable, use, as an author and otherwise) in and to any and all: (i) trademarks and service marks which concern any contract materials.
Grant of Exclusive Rights to Copyrights and Patents: The developer, grants, conveys, transfers, alienates and assigns exclusively to the company, for and throughout the world and in any and all languages (human or computer) and media, whether now existing or subsequently developed, all the developer rights, titles and interests (legal, industrial, commercial, equitable, use, as an author or inventor and otherwise) in and to any and all: (i) copyrights and/or patents of any type or nature in the contract materials.

[15] Choice of the interface of server reference / test: 1 x 10 Gbit/s OR n x 1 Gbit/s. 1 x 10 Gbit/s is recommended, but use the access n x 1 Gbit/s, when "n" will rise along with the development of the test traffic by the clients; cards of server: using 10 Gbit/s dual; usage of SSD disk is risky and it does not report the error before the failure; use of the continuous RAM at least 128 GB is recommended; without the so-called n x cores,
Configuration of the machine – in case of over 100 tests at same time, it is recommended not to use the single machine, but several servers with 10 Gbit/s interface in each server.

distributions) including the mobile devices such as the smartphones and tables: iOS, Android, Windows with required GUI optimisation (because of a lot of "junk", redundant software). Web clients provides ability to perform test with registration (with ability to see historical results) and without.

d. **Software Application Test Client:** is delivering detailed KPIs (listed above) test results. This application requires test system user to create the customized test request with configurable throughput (upstream and downstream), the number of TCP connections and duration of the test. Test client receives an URL with link to download and install software on PC (Windows, Linux), and execute test. Results are stored into the Database Server. Test client PC and Test Server resources (CPU utilisation), the list of processes and NIC (network interface card) type, local IP address) are under control during the test and stored with results in the database to validate reliable results. Test system user controls, number of tests and expiration of the test URL as well as the test profile setup until URL is valid[16].

e. **Test System Administration Dashboard:** required to setup Software Application Test Client profiles, different user privileges etc.

f. **Dashboard for QoS analytical visualizations**: it is recommended to use in the tool[17]:

- starting from the loading of data through the selection of the variables and the hierarchical structures, by the analytical processing, one obtains the resultants of the visualization, filtering, zooming and drilling (sometimes called slicing and dicing), to identify the outliers, correlations and trends of QoS outcomes.
- reports:

(i) profiled for QoS indicators, operators, geographical regions, services, etc.

(ii) QoS indicators filtered by colour, value, size, shape, etc.

7. Conclusion

The Technical Specifications reflected in Chapter 6 of this document will be used as the building block of the tender document which will be floated by AKEP for the development and operation of the tool.

[16] To control the course of the test, e.g. when the URL is not reporting (e.g. is the overload, so the test cannot be maintain indefinitely).

[17] Choice:
- the technology relies on in-memory OLAP (Online analytical processing) cubes, which are displayed through a series of the visualizations including tree maps; the in-memory computing platform enables you to process massive amounts of the data in real-time so you can deliver the information at unprecedented speeds. It processes transactions and analytics in-memory against a single copy of the data for the real-time,
- the database server which uses a relational model to power transaction-based applications – on-site or the cloud,
- relational database management system built for the purpose of the project to ensure the data warehousing, reporting, and historical analysis,
- Web Intelligence (Webi) then Desktop Intelligence (Deski), realized in the category of business processes that are modelled as objects (for example by Business Objects).

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International Telecommunication Union (ITU)
Telecommunication Development Bureau (BDT)
Office of the Director
Place des Nations
CH-1211 Geneva 20 – Switzerland
Email: bdtdirector@itu.int
Tel.: +41 22 730 5035/5435
Fax: +41 22 730 5484

Deputy to the Director and Director, Administration and Operations Coordination Department (DDR)
Email: bdtdeputydir@itu.int
Tel.: +41 22 730 5784
Fax: +41 22 730 5484

Infrastructure Enabling Environmnent and e-Applications Department (IEE)
Email: bdtiee@itu.int
Tel.: +41 22 730 5421
Fax: +41 22 730 5484

Innovation and Partnership Department (IP)
Email: bdtip@itu.int
Tel.: +41 22 730 5900
Fax: +41 22 730 5484

Project Support and Knowledge Management Department (PKM)
Email: bdtpkm@itu.int
Tel.: +41 22 730 5447
Fax: +41 22 730 5484

Africa

Ethiopia
International Telecommunication Union (ITU)
Regional Office
P.O. Box 60 005
Gambia Rd., Leghar ETC Building
3rd floor
Addis Ababa – Ethiopia

Email: itu-addis@itu.int
Tel.: +251 11 551 4977
Tel.: +251 11 551 4855
Tel.: +251 11 551 8328
Fax: +251 11 551 7299

Cameroon
Union internationale des télécommunications (UIT)
Bureau de zone
Immeuble CAMPOST, 3e étage
Boulevard du 20 mai
Boîte postale 11017
Yaoundé – Cameroon

Email: itu-yaounde@itu.int
Tel.: + 237 22 22 9292
Tel.: + 237 22 22 9291
Fax: + 237 22 22 9297

Senegal
Union internationale des télécommunications (UIT)
Bureau de zone
19, Rue Parchappe x Amadou Assane Ndoye
Immeuble Fayçal, 4e étage
B.P. 50202 Dakar RP
Dakar – Senegal

Email: itu-dakar@itu.int
Tel.: +221 33 849 7720
Fax: +221 33 822 8013

Zimbabwe
International Telecommunication Union (ITU)
Area Office
TelOne Centre for Learning
Corner Samora Machel and Hampton Road
P.O. Box BE 792 Belvedere
Harare – Zimbabwe

Email: itu-harare@itu.int
Tel.: +263 4 77 5939
Tel.: +263 4 77 5941
Fax: +263 4 77 1257

Americas

Brazil
União Internacional de Telecomunicações (UIT)
Regional Office
SAUS Quadra 06, Bloco "E"
11º andar, Ala Sul
Ed. Luis Eduardo Magalhães (Anatel)
70070-940 Brasilia, DF – Brazil

Email: itubrasilia@itu.int
Tel.: +55 61 2312 2730-1
Tel.: +55 61 2312 2733-5
Fax: +55 61 2312 2738

Barbados
International Telecommunication Union (ITU)
Area Office
United Nations House
Marine Gardens
Hastings, Christ Church
P.O. Box 1047
Bridgetown – Barbados

Email: itubridgetown@itu.int
Tel.: +1 246 431 0343/4
Fax: +1 246 437 7403

Chile
Unión Internacional de Telecomunicaciones (UIT)
Oficina de Representación de Área
Merced 753, Piso 4
Casilla 50484, Plaza de Armas
Santiago de Chile – Chile

Email: itusantiago@itu.int
Tel.: +56 2 632 6134/6147
Fax: +56 2 632 6154

Honduras
Unión Internacional de Telecomunicaciones (UIT)
Oficina de Representación de Área
Colonia Palmira, Avenida Brasil
Ed. COMTELCA/UIT, 4.º piso
P.O. Box 976
Tegucigalpa – Honduras

Email: ituteguciglapa@itu.int
Tel.: +504 22 201 074
Fax: +504 22 201 075

Arab States

Egypt
International Telecommunication Union (ITU)
Regional Office
Smart Village, Building B 147, 3rd floor
Km 28 Cairo – Alexandria Desert Road
Giza Governorate
Cairo – Egypt

Email: itucairo@itu.int
Tel.: +202 3537 1777
Fax: +202 3537 1888

Asia and the Pacific

Thailand
International Telecommunication Union (ITU)
Regional Office
Thailand Post Training Center, 5th floor,
111 Chaengwattana Road, Laksi
Bangkok 10210 – Thailand

Mailing address
P.O. Box 178, Laksi Post Office
Laksi, Bangkok 10210 – Thailand

Email: itubangkok@itu.int
Tel.: +66 2 575 0055
Fax: +66 2 575 3507

Indonesia
International Telecommunication Union (ITU)
Area Office
Sapta Pesona Building, 13th floor
Jl. Merdan Merdeka Barat No. 17
Jakarta 10001 – Indonesia

Mailing address:
c/o UNDP – P.O. Box 2338
Jakarta 10001 – Indonesia

Email: itujakarta@itu.int
Tel.: +62 21 381 3572
Tel.: +62 21 380 2322
Tel.: +62 21 380 2324
Fax: +62 21 389 05521

CIS countries

Russian Federation
International Telecommunication Union (ITU)
Area Office
4, Building 1
Sergiy Radonezhsky Str.
Moscow 105120
Russian Federation

Mailing address:
P.O. Box 25 – Moscow 105120
Russian Federation

Email: itumoskow@itu.int
Tel.: +7 495 926 6070
Fax: +7 495 926 6073

Europe

Switzerland
International Telecommunication Union (ITU)
Telecommunication Development Bureau (BDT)
Europe Unit (EUR)
Place des Nations
CH-1211 Geneva 20 – Switzerland
Switzerland
Email: eurregion@itu.int
Tel.: +41 22 730 5111

International Telecommunication Union
Telecommunication Development Bureau
Place des Nations
CH-1211 Geneva 20
Switzerland
www.itu.int

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