ELECTRONICS AND ELECTRICAL ENGINEERING
ISSN 1392 – 1215 2011. No. 5(111)
ELEKTRONIKA IR ELEKTROTECHNIKA

T 180 TELECOMMUNICATIONS ENGINEERING
TELEKOMUNIKACIJŲ INŽINERIJA

Autonomous System for Observation of QoS in Telecommunications Networks

A. Kajackas, V. Batkauskas, A. Saltis, D. Gursnys
Telecommunications Engineering Department, Vilnius Gediminas Technical University,
Naugarduko str. 41, LT-03227 Vilnius, Lithuania, e-mails: algimantas.kajackas@el.vgtu.lt, v.batkauskas@omnitel.net, arunas.saltis@el.vgtu.lt, darius.gursnys@el.vgtu.lt

Introduction

Quality of service (QoS) in telecommunications networks is analyzed by many authors in various aspects. Modern telecommunications systems, that were created according to ITU-T rec. E.800 and defined by QoS conception, are described as "The collective effect of service performances that determine the degree of satisfaction of a user of the service." Telecommunications systems, methods and means that are created in pursuance of this conception have a *fairly medium* level of the defined service quality. The chain of the overall quality monitoring mechanism on the level of "service provider – customer" according to ITU-T rec. G.1000 consists of four links: *Customer's requirements* – QoS_r, *QoS offered by the service provider*–QoS_o, *QoS achieved or delivered by the service provider, QoS perceived by the customer* – QoS_p. These links form a closed loop of managing. Although, the loop reflects the main processes of service quality monitoring provided by telecommunications systems, it not always manages to evaluate the real quality of the service that is received by the individual customer.

Formerly, when fixed line connection systems were mostly in use, technical conditions were similar for all users. Therefore, indicators for quality of services provided for various users were also basically the same. That made the measurement of *moderate quality* methods the most acceptable. The data received from these measurements were used, for example, to correct technical features of the network.

Currently, modern telecommunications systems such as mobile networks and Internet, are much more popular and more in use. These systems create entirely different connection conditions for each of their users. These conditions may be good, fair and even abstruse or bad; therefore the real quality of service received by an individual consumer (QoS_p) is not uniform for everybody and always fluctuates. In each case the quality of service depends mostly on overall intensity of network load or location of the costumer.

Regrettably, modern telecommunications systems do not apply any measurements to evaluate the quality of service received by the customer. Actually, customers themselves have no means to estimate or rate the quality of service as well. In other words, the fourth link that was mentioned above – QoS_p – in modern telecommunications systems is simply missing.

Nevertheless, the real perceived quality of service may be determined if individual quality of service (iQoS) of a single customer is measured and analysed [1]. The conception of the individual quality of service module is widely explained in the article [2]. This iQoS module obtains all the necessary information regarding the services received by the customer. It also can be used to insure the implementation of conditions that are provided in the service level agreement (SLA).

The group of scientific institutions from the project EuroNGI [3] strongly supports the conception of individual quality of service: "personalisation of individual QoS (iQoS) [2] attracts a lot of attention recently, as new opportunities are spotted for innovative billing solutions as well as better managing of the provided quality in general".

This article presents a research that is meant to fill in the existing alcove of the specific service quality measurement. The main goal of this project is to analyse the possibilities of creation of an autonomous system for monitoring and evaluation of QoS in the multiple environment. This system receives primary information about the quality of service perceived by the customers from their own terminal devices with special programs, called iQoS modules.

These measurements that enable evaluation of the real quality of service perceived by the customer are carried out in the interest of customers themselves. It also allows fulfilling the goals of the applied science that is to determine whether the performance level of the network, that is meant for control or monitoring of various objects, answers to special requirements. For instance, independent service providers, transportation systems and other objects are under enlarged security and liability requirements.

System Architecture

The basic concept of the telecommunications service quality management is shown in Fig. 1. It explains the architecture of the project. The idea consists of four main parts:

- Mobile Networks that are analysed;
- User Terminals with Software agents – iQoS modules;
- Trusted Third Party Server and Database;
- Subsystem for transmission of Quality Measuring Messages.

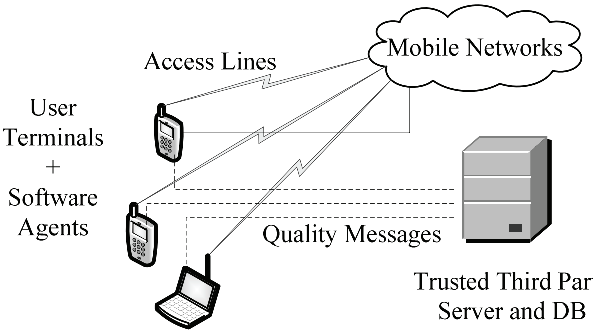

Fig. 1. The Architecture of QoS Observation and Evaluation System

This system has several basic functions: to perform service quality tests, to collect information from user terminals and make conclusions regarding overall network conditions, territorial sections of service quality, users' distribution and dispersion.

When customers speak on the phone or transmit information to different destinations using services from several network providers the iQoS modules, that are implemented in their terminals, perform passive quality tests and collect data about the perceived service quality. This data, called *quality messages,* is then transmitted to an independent trusted third party server.

This information that is accumulated in the server is then analysed by special software that afterwards produces conclusions and recommendations.

Additionally, the server safeguards the tests software and generates signals for special evaluations.

Related projects

The topic of network and service quality verification and monitoring is very wide and extensive. Most of the scientific work done in this field might be divided into two groups. One of them mainly concentrates on analysis and verification of service quality of separate telecommunication networks.

The other group pays attention to creation of similar service quality monitoring systems. This includes articles that analyse the means for verification of *network performance,* for example [4]. The paper [5] presents a service-oriented monitoring framework that allows service performance verification in contractual agreements between providers and users. The presented monitoring system is the one that was developed in the IST ENTHRONE II project.

There are also articles that intend to create special means that would help to verify the index of service quality according to the service level agreement [6, 7]. Similar concepts are discussed in the article [8], which presents a QoS monitoring mechanism based on quality ratings from the customers.

The above discussed projects and articles indicate that so far none of the existing measuring means are appropriate/ qualified enough to verify the real perceived service quality.

Quality of service and quality indicators

Firstly, it has to be mentioned that the definition of quality of service as such or as an index or a rate is not correctly defined. There are objective MOS methods based on verification of experts. Objective QoS measuring methods have been created using the experience from the studies of subjective evaluation of QoS. These algorithms analyze the input signal (voice or video) and evaluate the achieved level of QoS. Most of the commonly specialized QoS measurement tools nowadays use PESQ for voice and PEVQ for video. These tools are widely analysed and described in various articles, they are even officially recognized as protocols by ITU-T recommendations, P.862 and J.247 accordingly. When these tools are applied special rules, special procedures and special algorithms must be followed during all measurements. Furthermore**,** PESQ and PEVQ algorithms are invasive and give evaluation only when the original (reference) signal is available. Therefore, current measurement tools such as PESQ and PEVQ cannot be applied for service quality monitoring in real-time. A similar conclusion can be drawn while analysing the quality of other services such as web browsing.

In order to summarize the ideas discussed in this article and with reference to previous papers [9, 10] such conclusions could be drawn:

- the existing methods of verification cannot be applied in real-time, because the real service does not follow the basic requirements, that are identified by measurements;

- it is not possible to evaluate/verify the real quality of the service perceived by the user;

- the definitions for evaluation/verification of service quality perceived in real-time conditions must be corrected and new verification principles should be created.

The concept, which is proposed in this article, is based on the following:

- During a communication session *QoS offered by the service provider* (QoS_o) cannot be improved, only reduced;
- The quality of service is reduced, when signal distortion/corruption appears in the communications line or when scheduled conditions for service rendering are declined;
- While analysing the performance of the network (channel, system) it is possible to indicate when the quality of service perceived by the user is reduced;

The following factors are important in reducing the quality of service in mobile networks: variable bandwidth, data packet loss and packet delay as well as packet delay variation.

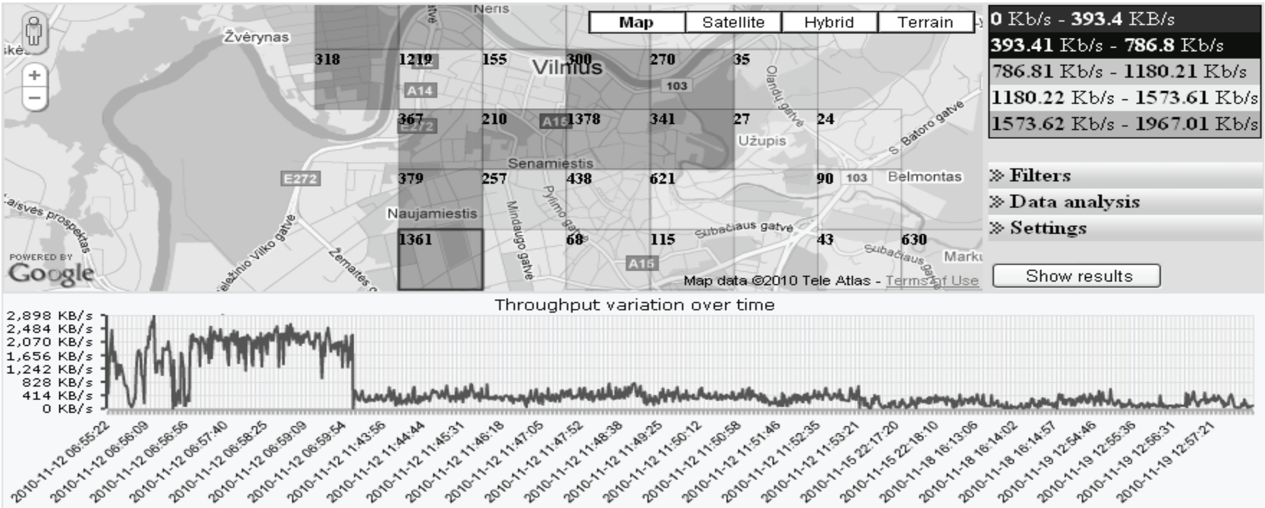

Fig. 2. Example of server results in Vilnius city

Collecting of the initial data

For example the customer i in the mobile network k at the coordinates $\{x_i, y_i\}$ in the moment in time t_j starts a communication session and use, service Π^l (voice, data or video service [12]). The communication session takes a T_j time period. The iQoS module evaluates the quality of the received service and calculates the quality estimator $\Theta(\Pi^l, i, t_j, T_j)$. It also builds the quality report $M\{\Theta(k, \Pi^l, i, t_j, T_j, x_i, y_i)\}$. The quality report, that is sent to the server, includes the quality estimator and other data of the user: type of the user device, the subscribers code, start time and duration of the communication session, the network code and location of the user (coordinates $\{x_i, y_i\}$, received from a GPS receiver or estimated from the mobile network [13]).

During the communication session the user can change his position in the network and QoS can change as well. In this case the session time will be divided into shorter periods and the quality estimator will be calculated for every period. The iQoS module calculates short term quality estimators and accumulates them for the determination of the achieved user quality.

The algorithm of the iQoS module evaluates if the achieved quality conforms to the determined quality criteria. The selected criteria usually are the criteria declared by the mobile network providers in the optimal or good radio conditions [14].

Quality reports M{...} could be saved in the user terminal or directly sent to the Trusted Server. The accumulated quality reports M{...} from the user terminal are uploaded to the server during a separate data session. Accumulation of the measurement results minimises the amount of the transmitted data and prevents data transmission from bad coverage areas.

Peculiarity of processing of collected data

The Trusted Server receives measurement results collected by iQoS modules. Peculiarity of the collected data is that the data is collected from accidental users, from random locations $\{x_i, y_i\}$, with random session start time $\{t_i\}$ and different lengths of session times $\{T_i\}$. Service quality varies during the measurement time. Collection and processing of the indeterminate data requires special algorithms.

The problem of variable coordinates $\{x_i, y_i\}$ is solved in the server sub-system during data saving process. Coordinates of all reports M{...} are rounded down to the discrete grid d.

When a defined number of measurements is collected from a particular sector $\{x_i, y_j\}$, the initial data analysis begins. The algorithm verifies if the reported QoS in different reports M{...} is similar or not. If measurement results are not controversial the calculated average value is rounded down to the discrete QoS grid in the particular sector.

If the calculated average quality is bad a report to the network operator is automatically created.

If measurement results from a particular sector are controversial, it is checked if older reports are not outdated. In such case data collection continues and QoS reports are not crated.

The collected data is analysed using the **user – centric** conception. The database collects the users' who received the lower or bad quality services IDs. What percentage of the received services was with lower quality is also calculated.

When the required amount of measurements for a particular service is collected reports are generated. They include a list of users who received the services with lower quality IDs and coordinates of the territory where the services with lower quality where provided.

Accumulated measurement results for Vilnius city are presented in Fig. 2. Vilnius city is divided in the coordinate grid and the colour of the sector represents the average value of the quality metrics.

Conclusions

The system that is being developed creates a possibility for continuous monitoring of mobile networks and quality characteristics of mobile services from a user's point of view. It complements the existing network and service quality measurement systems with measurement data from user terminals.

After the creation of the system it could be used for quality reporting services to the mobile users. It could inform users about QoS of different telecommunication services in a particular place. That could be done by providing quality reports to the user or the user could request the information about reliability of services in particular places.

Places of lower service quality are location–aware: and quality of services of different network operators could differ in different places. Taking in to account their living and work location and using this system, customers could select the most suitable mobile network operator.

Acknowledgement

Research was supported by the Research Council of Lithuania. Project Contract No. AUT-01/2010.

References

1. **Kajackas A., Batkauskas V., Medeisis A.** Individual QoS Rating for Voice Servines in CellularNetworks // IEEE Communications Magazine, 2004. – P. 88–93.
2. **Kajackas A., Anskaitis A., Guršnys D.** Individual Quality of Service concept in Next Generations Telecommunications Networks // Electronics and Electrical Engineering. – Kaunas: Technologija, 2005. – No. 4(60). – P. 11–16.
3. Studies of user–perceived Quality of Service within EuroNGI. Deliverable D.WP.JRA.6.1.2. Online: eurongi.enst.fr/archive/127/JRA612.pdf [2005–01–22].
4. **Ipatovs A., Petersons E.** An Experimental Performance Evaluation of the Wireless Network for Mobile Users // Electronics and Electrical Engineering. – Kaunas: Technologija, 2009. – No. 5(93). – P. 21–24.
5. **Sidibé M., Mehaoua A.** QoS Monitoring for End–to–End Heterogeneous Networks Configurations Management // IEEE International Conference on Automation, Quality and Testing, Robotics (AQTR '2008), 2008. – Vol. 1. – P. 364–368.
6. **Guo N., Gao T., Zhang B.** A Trusted Web Services Assessment Model Based on Six Dimensional QoS Framework and End–to–End Monitoring // IEEE International Conference on Service Operations and Logistics, and Informatics (SOLI '2008), 2008. – P. 695–699.
7. **Zeginis Ch., Plexousakis D.** Monitoring the QoS of Web Services using SLAs // Technical Report 404, ICS–FORTH, 2010. Online: www.ics.forth.gr/isl/publications /.../technical_report_404_May_2010.pdf.
8. **Jurca R., Faltings B., Binder W.** Reliable QoS Monitoring Based on Client Feedback // Proceedings of the 16th international conference on World Wide Web (WWW'2007), 2007. – P. l003–1012.
9. **Kajackas A., Vindašius A., Šaltis A.** User Access Link Impact on Web Browsing Quality // Electronics and Electrical Engineering. – Kaunas: Technologija, 2010. – No. 4 (100). – P. 59–64.
10. **Anskaitis A., Kajackas A.** The Tool for Quality Estimation of Short Voice Segments // Electronics and Electrical Engineering. – Kaunas: Technologija, 2010. – No. 8(104). – P. 97–102.
12. **Paulikas Š.** Estimation of Degraded Video Quality of Mobile H.264/AVC Video Streaming // Electronics and Electrical Engineering. – Kaunas: Technologija, 2010. – No. 2(98). – P. 49–52.
13. **Brida P., Machaj J., Benikovsky J., Duha J.** An Experimental Evaluation of AGA Algorithm for RSS Positioning in GSM Networks // Electronics and Electrical Engineering. – Kaunas: Technologija, 2010. – No. 8(104). – P. 113–118.
14. **Batkauskas V., Kajackas A.** Quality of Heterogeneous Mobile Data Services: Capabilities and End–user Achievements // Electronics and Electrical Engineering. – Kaunas: Technologija, 2010. – No. 5(101). – P. 43–46.

Received 2011 01 05

A. Kajackas, V. Batkauskas, A. Saltis, D. Gursnys. Autonomous System for Observation of QoS in Telecommunications Networks // Electronics and Electrical Engineering. – Kaunas: Technologija, 2011. – No. 5(111). – P. 15–18.

A project of creation of a multi-dimension and autonomous QoS evaluation and monitoring system is presented in the paper. The initial data for evaluation of the QoS is collected from users using specially created software programs – iQoS modules. Singularities of the initial data collection are discussed. Test results of the prototype system are presented. Ill. 2, bibl. 14 (in English; abstracts in English and Lithuanian).

A. Kajackas, V. Batkauskas, A. Šaltis, D. Guršnys. Autonominė telekomunikacinių paslaugų kokybės stebėjimo sistema // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2011. – Nr. 5(111). – P. 15–18.

Straipsnyje pristatomas projektas, kuriuo siekiama sukurti autonominę daugialypės terpės gautų paslaugų kokybės stebėjimo ir analizės sistemą. Šioje sistemoje pirminė informacija apie gautų paslaugų kokybę surenkama iš vartotojų galinių įrenginių, naudojant specialiai sukurtas programas – kokybės modulius. Aptariami pradinių duomenų rinkimo ypatumai. Pateikiami eksperimentinės sistemos bandymų rezultatai. Il. 2, bibl. 14 (anglų kalba; santraukos anglų ir lietuvių k.).