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QUALITY OF EXPERIENCE MEASUREMENTS IN TELECOMMUNICATION NETWORKS

Abstract: *Considering highly diverse traffic in telecommunication networks, quality concepts play a crucial role in ensuring proper support for many types of applications with different Quality of Service (QoS) requirements. For the evaluation of telecommunication services from the users' perspective, Quality of Experience (QoE) has to be considered. In this paper, we have addressed various factors affecting QoE and we have analyzed complex relationships between them. We particularly consider the issue of measuring QoE in Next Generation Networks (NGNs). In addition, we propose several QoE dimensions assigning them absolute and relative qualitative and quantitative values.*
Keywords: *Quality of Service, Quality of Experience, Mean Opinion Score.*

1. INTRODUCTION

Concept of quality in telecommunications has been experienced great changes in recent years. Service providers are encouraged to consider not only technical aspects of quality but also users' expectations and experiences regarding a particular service. Requirements and perceived quality from a user's perspective are coverd by the term Quality of Experience (QoE).

QoE is a multidimensional concept with many factors affecting it. In this paper we discuss complex relationship between QoE and Quality of Service (QoS), as well as other important factors influencing QoE. We focus our research on methods of QoE observing and measuring. Mean Opinion Score (MOS) as the most frequently used measure of QoE is particularly considered.

The rest of the paper is organized in the following way. In Section 2 QoE concept and factors affecting it are discussed. In the same section a brief overview of QoE standardization is given. In Section 3 different MOS categories are considered along with the appropriate examples of evaluation in Next Generation networks (NGNs). Conclusions are given in Section 4.

2. QUALITY OF EXPERIENCE

QoS is mainly technical issue which is very important for supporting many types of applications with different QoS requirements in telecommunication networks. In general QoS model, given by International Telecommunication Union - Standardization Sector (ITU-T), in addition to technical considerations, QoS perceived by the user is included too [1]. The most common and time-tested tool to measure QoS is to use the performance management system that extracts data from measurements within a network element or elements in a telecommunication network

in order to perform evaluation of various network elements in the network. However, this method does not guarantee acceptable QoE for individual applications, or user sessions.

Requirements from the users' perspective depend on a particular service but are independent of the applied networking technology. Therefore, users' requirements should be defined in a way meaningful to them. QoE concept provides the basis for this.

QoE is subjective category, meaning that it depends upon user actions and subjective opinions. QoE, also referred to as "perceptual QoS", is defined as "a measure of the overall acceptability of an application or service, as perceived subjectively by the end-user" [1].

The perception of quality initially depends on the source quality. QoS, Grade of Service (GoS) and Quality of Resilience (QoR) parameters will also influence QoE.

QoE strongly depends on QoS and it is influenced by all elements of the system involved in the end to end service, including: network equipment, codecs, techniques, protocols, terminals, etc. GoS describes all phenomena occurring during connection setup, release and maintenance [2]. GoS may also be used in the context of handling new requests in networks with direct implication on QoE. QoR, traditionally perceived as one of the dimensions of QoS, in NGNs is defined as a separate quality segment. It includes network survivability against failures [3]. The approaches related to QoR describe the influence of failures on a network and client service, taking into account different survivability mechanisms.

Total QoE is affected by many other factors in the environment, psychological and sociological factors, including users' expectations, their experience with similar services, the opinion of other users, pricing policy etc [4]. The secondary factors are also very important for QoE evaluation by users, especially in the case of voice and

video services. Some of the supporting factors are independent of the service type, for example, user profile (occupation, education, age, etc.) or pricing policy (free, pre-paid and post-paid). Factors that affect voice quality could be noise, type of equipment (headphones, speakers) and type of content (music, news, telephone conversation). Rating of video quality is affected by lighting and screen size, viewing distance and the content (video call, movie, etc.). Moreover, the same service will be assessed differently if it is free or if is charged. Users are more likely to accept the degradation of QoS if it is free of charge. QoE encompasses the issue of the user decision on retaining the service or giving it up.

The relationship between QoE and the various factors that affect it is shown in Figure 1.
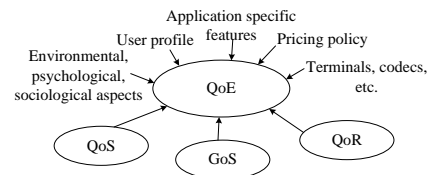

Figure 1: Factors affecting QoE

Since QoE encompasses user experience, it is best to include it on the border between perceptual and evaluated quality in the general QoS model [1].

2.1 QoE standardization

The concept of QoE has been studied by various organizations. Within the ITU-T, Study Group 12 is responsible for QoS and QoE. Some of their recommendations are as follows:

- ITU-T G.1010 provides guidance related to key factors of QoS that affect users [5]. It focuses on delay, delay variation and information loss and gives the target performance for a variety of applications that need to meet user expectations. For example,

the SMS service is classified as a low-priority service, so that the delay of approximately 10s is acceptable. The purpose of this recommendation is more as a guide than to state the final requirements. The actual target values of the parameters would be left to the operator.

- ITU-T G.1030 provides a model for assessing application data performance over IP networks [6]. This model consists of three steps: 1) evaluation of network performance, 2) assessment of application performance and 3) evaluation of perceptual performance. The last step implies geting insight into the idea of users' experiences i.e. their perception. This model can be observed as a "model of opinions" like e-model, which maps the end-user experience from the network layer to the application layer. The recommendation includes a model for search and other applications.

- ITU-T G.1070 provides a model for calculating QoE of video telephony based on a number of speech and video parameters [7]. The model consists of three functional steps: 1) assessment of video quality, 2) evaluation of speech quality, and 3) quality of multimedia integration functions.

3. MEASURING QoE

3.1 Mean Opinion Score

The most frequently used measure of QoE is MOS. Basic definition of MOS states: "The mean of opinion scores, i.e., of the values on a predefined scale that subjects assign to their opinion of the performance of the telephone transmission system used either for conversation or for listening to spoken material." There are absolute and relative indicators of QoE. The value of MOS is usually estimated

based on media flow characteristics and a particular telecommunication network [8]. In absolute QoE indicators, the results are displayed in five-point scale, i.e. a scale of 1 to 5, where a score of 5 indicates the highest quality. A relative scale must take into account comparative indicators and this scale usually includes positive and negative values. Scales may be based on different categories depending on a purpose. The quantity evaluated from these scores are represented by the symbol MOS.

3.2 Absolute and Relative Measurements in NGNs

Evaluation of QoE in NGN should be incorporated in an interdisciplinary approach, related to the multi-dimensional conceptuality of QoE. Such an approach includes the following steps:

1) Study of users' behavior based on a combination of qualitative and quantitative methods in order to identify the most important dimensions of QoE.

2) Examination the extent to which service meets users' requirements which can be interpreted through absolute QoE indicators.

3) Comparison of users' expectations and their satisfaction with a particular service with the aim of identifying differences between expected and actual experiences. This can be interpreted through relative QoE indicators.

As it can be observed, insight into the expectations and requirements is the starting point in the QoE measurement process. However, users' involvement should be simple and not disturbing for users. To get accurate results, users have to spend a lot of time, which often results in abandonment of their further participation. Thus, the balance between users' participation and accuracy of user tests is an open issue in measurement procedures

of QoE. In other words, there is a need for simple and sustainable QoE measurement, which can be applied to any type of NGN services.

Table 3. Absolute QoE indicators

QoE dimension	QoE indicator	MOS
Understandability	Excellent	5
	Good	4
	Fair	3
	Poor	2
	Bad	1
Learnability	Excellent	5
	Good	4
	Fair	3
	Poor	2
	Bad	1
Ease of use	Excellent	5
	Good	4
	Fair	3
	Poor	2
	Bad	1
User error protection	Excellent	5
	Good	4
	Fair	3
	Poor	2
	Bad	1

We propose following QoE dimensions:

- Understandability implies whether the information on the service is provided transparent enough, so users can recognize the appropriateness of the service for their needs. This can include demonstrations, tutorials, documentation etc.
- Learnability is the degree to which the service enables users to easily learn how it operates, i.e. whether the service is intuitive enough to be learnt easily.
- Ease of use refers to the degree to which the service facilitates users to operate and control.
- User error protection refers to the degree to which the service protects users against making errors.

Absolute and relative QoE indicators for each defined QoE dimension are given in Table 1 and 2, respectively. In both tables, the first column represents QoE dimensions, as it is defined above; QoE indicators are given in the second column; The quantity evaluated from QoE indicators are represented by MOS, in column 3.

Table 4. Relative QoE indicators

QoE dimension	QoE indicator	MOS
Understandability	Much Better	3
	Better	2
	Slightly Better	1
	About the Same	0
	Slightly Worse	-1
	Worse	-2
Learnability	Much Better	3
	Better	2
	Slightly Better	1
	About the Same	0
	Slightly Worse	-1
	Worse	-2
Ease of use	Much Better	3
	Better	2
	Slightly Better	1
	About the Same	0
	Slightly Worse	-1
	Worse	-2
User error protection	Much Better	3
	Better	2
	Slightly Better	1
	About the Same	0
	Slightly Worse	-1
	Worse	-2

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4. CONCLUSION

Service providers have traditionally focused only on the identification and management of QoS. Nowdays, there is a need for development of alternative frameworks. In this respect, comprehensive QoE considerations are of great importance.

Since QoE is a multidimensional concept, we firstly have discussed complex relationship between QoE and QoS. We have also explained other factors affecting QoE. Secondly, we have considered the issue of measuring QoE in NGNs. We have proposed several QoE dimensions assigning them absolute and relative QoE indicators and MOS values.

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