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DIFFERENT ASPECTS OF QUALITY IN NGN

Abstract: *Considering highly diverse traffic in next generation networks (NGNs), quality concepts play a crucial role in ensuring proper support for many types of applications with different quality of service (QoS) requirements. The provisioning of differentiated end-to-end service quality in NGNs will face a large number of challenges. In this paper we discuss relationships between different aspects of quality: grade of service (GoS), quality of resilience (QoR), quality of context (QoC), quality of experience (QoE) and quality of business (QoBiz).*

Keywords: *Quality of Service, Quality of Experience, Next Generation Network*

1. INTRODUCTION

Next generation network (NGN) should provide service differentiation with packets serviced depending on their value.

There are many different considerations regarding the service quality. In NGNs relation between pure technical aspects and non-technical aspects of quality tend to be dynamic. Quality issues encompass:

- tehnical aspects: modeling, design, operation, network control and inter-networking;
- economic aspects: management, cooperation with users, accounting and confidentiality.

This paper is organized in the following way: in Section 2 relationship between different technical and economic aspects of quality are disscused and conclusions are presented in Section 3.

2. QUALITY CONCEPT IN NGN

Quality concept in NGN encompasses both technical and non-technical aspects. Quality features as well as the definition of quality parameters and assessment criteria are covered by a Service Level Agreement (SLA) between a user and a provider. This agreement regulates a service price, responsibilities of all contracting parties and guarantees involved in providing and utilization of a service. SLA can cover many different areas, from business arrangements of offered service to setting the service price and penalties that may arise if the level of service falls below agreed.

To cover different areas and views on quality in NGN, several key terms should be distinguished: Network Performance (NP), Quality of Service (QoS), Class of Service (CoS), Grade of Service (GoS), Quality of Resilience (QoR), Quality of Experience (QoE) and Quality of Business (QoBiz). There is a tendency to use the term Qo*X* in order to cover some of the previously mentioned aspects of quality [1]. In this paper we extend the Qo*X* concept to include major economic measures of quality.

2.1 Network performance

Network performance refers to technical aspects of quality. It is defined independently of terminal performance and

user actions. NP is measured in terms of parameters which are meaningful to the network provider. Those parameters can be used for the purpose of system design, configuration, operation and maintenance [2]. This definition includes transmitting time and response time. Transmitting time is the time interval during which a packet is transmitted between two network nodes. Response time is the time interval between the requirement sending and the receiving of required data. NP ultimately determines the user observed QoS, but it does not necessarily describe that quality in a way that is meaningful to users.

2.2 Quality of service

QoS is mainly technical issue which plays a crucial role in ensuring proper support for many types of applications with different QoS requirements in NGN. It describes the ability of network to provide a service with an assured service level and is related to service performances that can be measured and controlled at the users' access point. The formal definition of QoS is as follows: "the ability of a network or network portion to provide the functions related to communications between users" [3]. QoS provides a valuable framework for network provider, but it is not necessarily usable in specifying performance requirements for particular network technologies (e.g. IP, MPLS, etc.).

Three levels of QoS in the general model were proposed: intrinsic, perceived and assessed [4] (Figure 1). Intrinsic QoS encompasses all service features determined by network efficiency, resources, provisioning, etc [1]. Moreover, intrinsic QoS is referred to as NP by ITU and ETSI as a strictly technical issue which is crucial for quality perceived and assessed by a user. The solutions used to support intrinsic QoS guarantees differ depending on the networking technique used in a particular segment of a network. Intrinsic QoS parameters are usually related to the networking technology used. The most common intrinsic QoS parameters in IP networks are: IP packet Delay Variation (IPDV), IP packet Error Ratio (IPER), IP packet Loss Ratio (IPLR), and IP Packet Transfer Delay (IPTD) [5].

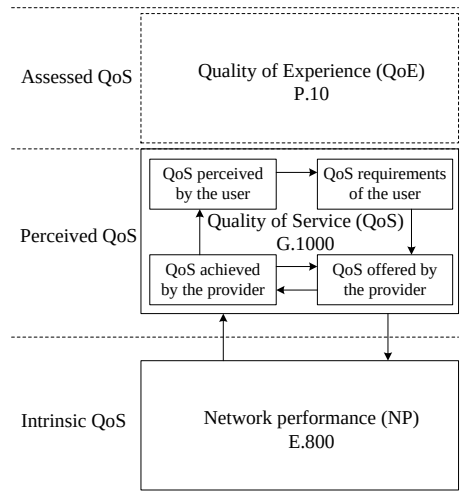

Figure 1. *ITU-T terminology and standards in relation to the general QoS model*

The perceived QoS reflects the user's experience of using a particular service, which is usually expressed in a non-technical manner. Perceived QoS is influenced by many factors, including the user's experience with a similar telecommunications service and other users' opinions. It is necessary for service providers to take into account these expectations while designing new business strategies and new services' offers in order to improve their position in NGN market. The effect of QoS offered by the provider (realized by using the appropriate network mechanisms and techniques) is observed as QoS achieved by the provider. Both are expressed in mostly technical terms. Finally, QoS perceived by the user can be determined (Figure 1) [6, 7].

The assessed QoS occurs when the user decides whether to continue using the

service or not [4]. This level depends on the perceived quality, service price, and provider's responses to submitted complaints and problems. Those issues specific to assessed QoS i.e. issues related to QoS requirements of a user and QoS perceived by a user (Figure 1) are covered by the term Quality of Experience (QoE), defined in [8].

Different sets of QoS parameters are used depending on which QoS level of the general model is considered. Requirements from the users' perspective are defined in a way meaningful to them. They are specific to a particular service and are independent of the networking technology.

2.3 Class of service

Telecommunications services and applications sharing several common features can be classified to a limited number of service classes. Class of Service (CoS) is defined as: "characteristics of a service such as described by service identity, virtual network, link capability requirements, QoS and traffic threshold parameters" [9]. Each service class is described by a specific set of parameters. Those parameters can be expressed qualitatively or quantitatively and usually these values are bounded according to application requirements and network level [6]. Application requirements are mostly related to traffic characteristics and network parameters. Therefore several QoS classes should be distinguished on the network level. The realization of them is supported by mechanisms at the layers 1 to 4 of the OSI-ISO model and is specific to the networking technology, protocols, and network architecture [1].

2.4 Grade of service

Grade of Service (GoS) applies to circuit switched networks i.e. telephone networks and describes all phenomena occurring during connection setup, release and maintenance [10]. Currently, it applies especially to circuit switched optical services. GoS parameters are, for example: connection set up delay, probability of endto-end blocking, delay in authentication, and probability of breaking an active connection and blocking probability (in case of applied admission control mechanism). GoS parameters are very important for service differentiation in WDM, ASON and GMLPS networks and are, in general, even more meaningful than QoS parameters. However, assurance of a high GoS as well as a distinction of several GoS classes (similarly to QoS classes) in optical networks is still under research [11]. GoS may also be used in the context of handling new requests in networks with the admission control mechanism, especially in NGN [12].

2.5 Quality of resilience

Resilience, i.e., network survivability against failures, has traditionally been perceived as one of the dimensions of QoS. So far, reliability-related metrics are agreed in SLAs under a general QoS umbrella. It concerns mainly the availability, i.e., the probability that a service is operational. Recently QoR distinguished itself as an independent aspect of quality [13]. The reasons lie in its importancy to society and in a wide range of survivability mechanisms providing variable QoS to a user, which makes resilience an area independent of transmission and transfer performance evaluation. The approaches related to QoR describe the influence of failures on a network and client service, taking into account different survivability mechanisms. The basic QoR measures such as the reliability function, availability, downtime and failure rate are determined [3]. The methodologies for quantification QoR in various environments are also developed e.g., for fiber optic systems, SDH systems, IP networks and MPLS connections [13]. Service class definitions based on resilience properties can be ground on users' QoR requirements or on

precisely defined quality metrics [14]. Common requirements are to meet resilience-related metrics that are averaged over a long time period [1].

2.6 Quality of experience

QoE is subjective in nature, i.e. depends upon user actions and subjective opinions. It includes the complete end-to-end system effects (client, terminal, network, services infrastructure, etc). 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" [3].

QoE is a multidimensional concept with many factors affecting it. Therefore it is difficult to be defined or measured in a simple unified manner. It takes into consideration not only a technology performance in terms of QoS, but also users' satisfaction with that technology, subjective evaluation, degree of their expectations fulfillment and in what context they use it or intend to [15].

The perception of the quality initially depends on the source quality and is influenced by all system elements involved in the end-to-end service delivery (e.g. network, equipment, codecs, techniques, protocols, terminals, etc.). QoS, GoS and QoR parameters will also influence QoE. The overall QoE evaluation is additionally affected by environmental, psychological, and sociological factors, including user expectations and experience with similar services, other opinions, pricing policies, features of the particular location where the service is received, etc. In fact, the side factors are very important in QoE evaluation by the user, especially in the case of voice and video services. Some of these additional factors are independent of the service type, e.g., user profile (occupation, education level, age, etc.) or pricing policy for the service (static, dynamic). Factors influencing the voice quality assessment are, for example, background noise, type of equipment (headphones, speakers), and type of content (music, news, telephone conversation). The rating of the video quality would be influenced by screen illumination and size (e.g., mobile phone or PDA, screen outdoor vs. large LCD TV at home), viewing distance, and content (video call, action movie, "talking heads"). Moreover, the same service in technical terms would be evaluated differently in dependence of the applied pricing scheme. Users are likely to accept some quality degradation of the service if it is free but would be strongly disappointed if they have to pay for such a service and consequently will give up the service. QoE encompasses the issue of the user decision on retaining the service or giving it up. Therefore, the QoE locates on the border between the perceived and assessed quality in the general model (Figure 1).

2.7 Quality of business

In addition to technical aspects of quality and users' perceived quality, profitability is of the most importance to providers. QoBiz in particular covers the service provider profitability. It deals with the financial aspect of service provisioning and refers specifically to measures such as service price, service provisioning costs, revenue from the service provisioning, revenue per transaction, lost transactions etc. QoBiz can be firmly connected to the SLA. As users' needs are constantly increasing, as well as competition between service providers, SLA becomes more complex. In general, QoBiz parameters are all those parameters that are expressed in monetary units. According to the more precise interpretation, it as a monetary value that matches the quality of delivered service, expressed through connection of QoS parameters with monetary value within the SLA [16].

In Figure 2 the service flow is depicted along with the connections between NGN providers and users. While

a provider is interested in bandwidth and in number of users supportable, an end user is interested in perceived response time. A provider receives requests from users for certain services and creates a service taking into account QoE and QoS parameters. Using QoE mechanisms provider monitors users' attitudes about the quality of delivered service and based on that he strives to improve delivered quality by means of QoS mechanisms. The right side of the Figure 2 gives the financial flow realized in the interaction between users and provider which directly relates to QoBiz metrics. The delivered service must be paid to cover the costs of providing certain QoS (as marked with the arrow from QoBiz to QoS box). If a provider delivers high QoE, the user's willingness to pay for the service increases (as depicted by the dashed arrows between the QoE and QoBiz box in Figure 2). Revenues from users are also used to assess QoBiz of specified service (as labelled by the arrow from the user to the QoBiz box in Figure 2). Evaluation of QoBiz must take into account both cost and revenue aspects.

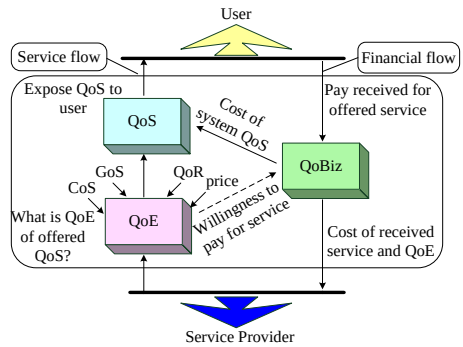

Figure 2. *Relations between different aspects of quality*

3. CONCLUSION

In NGN QoS differentiation will not provide a suitable economic framework for the trade-off between quality delivered by the SP and willingness to pay from users' side. Therefore there is a need for development of alternative frameworks. In terms of tehnical aspects of quality QoS, NP and QoR metrics need to be designed. For the evaluation of NGN services from the users' side QoE have to be considered. Finally, QoBiz, as an indicator of a service provider's business performances, have a significant role in provisioning service quality in NGN.

In this paper, we have addressed various quality aspects and we have analyzed complex relationships between them.

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