Studying Quality of Experience (QoE) over Wireless Networks

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INTRODUCTION

Quality of Experience (QoE) provides an assessment of human expectations, feelings, perceptions, cognition and satisfaction with respect to a particular product, service or application. In wireless network communications, QoE is used to describe the user's perception in emerging multimedia applications and services, such as Voice over Internet Protocol (VoIP), video and audio streaming, etc. By using various metrics, QoE expresses user's satisfaction both subjectively and objectively, and is related but differs from Quality of Service (QoS). In particular, it describes the characteristics of the software and hardware services that are delivered, measured and guaranteed in terms of a contract. QoE is the most effective method to measure the user's gratification because it focuses on the human and not on the service.

In this article, the basic characteristics of QoE and the main differences to QoS are described. Moreover, a literature review of how QoE is associated with three different wireless network communication technologies (i.e. IEEE WiMAX, 3GPP LTE and IEEE 802.11) is presented and certain challenges are discussed.

BACKGROUND

As stated earlier, QoE is subjective, user-centric and content-dependent. Now is the time that QoS firstly, and more terms later come into foreground. Under QoS the idea is that transmission rates, error rates and other characteristics can be measured, improved and guaranteed in advance. By using parameters as bit rate, jitter, delay, packet loss, a service can be described and evaluated. Later in this article, the differences between QoS and QoE will be discussed in more detail.

In addition with QoS, the term Class of Service (CoS) can also be found in the literature in order to describe the semantics and parameters of a specific type of QoS. Applications and services are categorized as symmetrical or asymmetrical judging by the equality of the bandwidth in both uplink and downlink directions. Also elastic and non-elastic characterizations where used, based on the minimum level of bandwidth needed and finally interactive and non-interactive depending on the human contact with a service.

Grade of Service (GoS) describes all the phenomena occurring during connection setup, release and maintenance. It appears mostly in circuit switched optical services and is the probability of the service to be blocked or delayed for more than a specific interval due to the high traffic intensity and the lack of available resources.

Finally, Quality of Resilience (QoR) is perceived as one of the dimensions of QoS and covers the gray areas when a service is operational but not fully functional and is characterized as degraded. Approaches related to QoR are not well formalized as the ones in QoS, CoS, or GoS.

QUALITY OF EXPERIENCE

Definition

QoE includes all the previous terms. Sometimes, because the service quality field is still growing, the acronym QoX is used and contains all the above terms. A definition given by DSL Forum defines QoE as a measure as well as an indicator of a system fulfilling the

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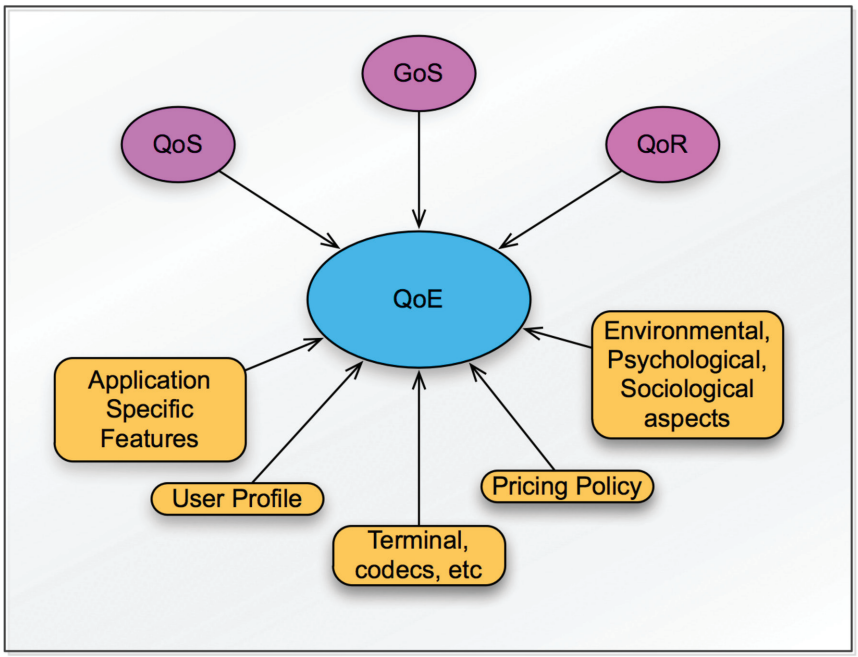
Figure 1. Factors influencing QoE



requirements of the customer: "QoE is a measure of end-to-end performance at the service level from the user perspective and an indication of how well the system meets the user's needs" ("Triple-play Services Quality of Experience (QoE) Requirements," 2006). Another definition may be found in ITU-T Rec. P.10/G.100 ("Vocabulary for performance and quality of service," 2012): "the overall acceptability of an Application or service, as perceived subjectively by the end-user." The quality of a service is influenced by many parameters, like hardware, protocols, techniques etc. Also, QoE is influenced by GoS, QoR, and QoS intrinsic parameters. QoE mostly relies on user survey and cores from the user. It is a more subjective approach of determining the quality of provided services.

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. (Figure 1).

In (Callet, Möller, & Perkis, 2013), influence factors are grouped in three categories. The first one is Human IF and describes any variant or invariant property or characteristic of a human user (demographic, socio-economic, age, gender, etc.). The second category (System IF) refers to properties/characteristics that determine the technically produced quality of an application or service and can be content-related, media-related, network-related and device-related. Finally, Context IFs are factors that embrace any situational property to describe the user's environment in terms of physical, temporal, social, economic, task, and technical characteristics (time of day, duration, frequency of use, existing interconnectivity of devices, etc.). Some examples of factors from all the categories can be seen in Figure 2.

QoS vs. QoE

The foremost difference between QoE and QoS resides in the following points: the former one focuses more on what the end user feels, whereas the latter concept is more a measure from the network aspect. Basically, the relationship between QoE and QoS can be concluded in two aspects: Firstly, QoE extends the concept of QoS (QoS actually encompasses only one part of QoE scope). Secondly, QoE needs the support from QoS, and inversely, QoS performance can impact QoE satisfaction.