Quality of Service everywhere

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***Abstract*— Applications provided in the Internet of Things can generally be divided into three categories: audio, video and data. This has given rise to the popular term Triple Play Services. The most important audio applications are Voice over IP (VoIP) and audio streaming. The most notable video applications are Video Telephony over IP (VToIP), Television over IP (IPTV), and video streaming, and the service World Wide Web (WWW) is the most prominent example of data-type services. This paper elaborates on the most important techniques for measuring Quality of Service (QoS) and Quality of Experience (QoE) in Triple Play Services.**

Keywords-Triple Play Service; QoS; QoE; VoIP; IPTV.

I. INTRODUCTION

Quality of Service (QoS) is of crucial importance to modern digital networks, not least in the Internet, which is increasingly going under the name Internet of Things (IoT). The term QoS is becoming a household phrase, and has long been anchored in the definition of Next-Generation Networks in ITU-T Standard Y.2001 [1]. The International Telecommunication Union defines QoE as "The overall acceptability of an application or service, as perceived subjectively by the end-user" [2]. In November 2009, the European Parliament and the European Commission adopted the so-called Communications Packet, their directives 2009/136/EC [3] and 2009/140/EC [4] underlining the importance of QoS. Both QoS and QoE are to be monitored continually, and preferably automatically, in modern networks, and that means in the Internet of Things (IoT) too. EU research projects, such as Leone [5] and mPlane [6] and standardisation organisations, such as the Internet Engineering Task Force (IETF) [7], have been hard at work to achieve this. Monitoring the quality of service throughout the EU is, however, proving to be an especial challenge, given the dynamic structure of the Internet. New services are forever being introduced and older ones restructured. The IETF seeks to meet these challenges with the all-embracing Framework for Large-Scale Measurement of Broadband Performance (LMAP [7]) and, in keeping with the EU research project mPlane [6], promotes a flexible all-purpose solution.

Whilst these frameworks do contain fundamental concepts and specifications for the diverse areas of a distributed measuring system, such as the exchange and storage of acquired measurement data, by no means are they intended as complete systems. First of all, the suitable measuring equipment, storage units and results analysis software of various providers must be pieced together. In keeping with the trend of shifting more and more services into the cloud [8], the individual components of big-data systems have been designed to work flexibly in the cloud. Alongside these large-scale, complex yet adaptable systems there is a demand for specific, complete quality-assessment solutions that are easy to implement and use. Existing systems for monitoring Triple Play Services might benefit from the new possibilities of cloud computing. Since cloud-based solutions can usually be implemented without complicated precommissioning at the user's end, and the costs incurred through on-demand solutions are lower than long-term investments, the entry threshold will fall, and the use of indispensable measuring technology will become more appealing. For, despite the unequivocal recommendations, continuous measurement of quality of service is still not a universal practice, owing to the lack of suitable QoS/QoE measurement techniques for measuring environments.

Section II begins with an overview of QoS and QoE measurement techniques; then in Section III the QoS/QoE in the VoIP service will be described. Section IV provides information about QoS/QoE in the VToIP/IPTV service. Following that, Section V discusses QoS/QoE in the WWW service. The paper concludes with a summary and an outlook on future work.

II. OVERVIEW OF QOS AND QOE MEASUREMENT TECHNIQUES

In order to determine the QoS/QoE in a network, two models are generally used: a) dual-ended model and b) single-ended model; cf. Figure 1 [9]. In the case of the dual-ended model, two signals are used: a) the original signal and b) the degraded signal. These two signals are available uncompressed. For this reason, measurements can be carried out for both Quality of Experience (a subjective evaluation) and Quality of Service (an objective evaluation). In the case of the single-ended model, only the impaired signal (compressed) is available. This allows only an objective evaluation of QoS to be made. QoS measurement is referred to as "intrusive measurement" (offline) in the case of the dual-ended model, and as “non-intrusive measurement” (online) in the case of the single-ended model.

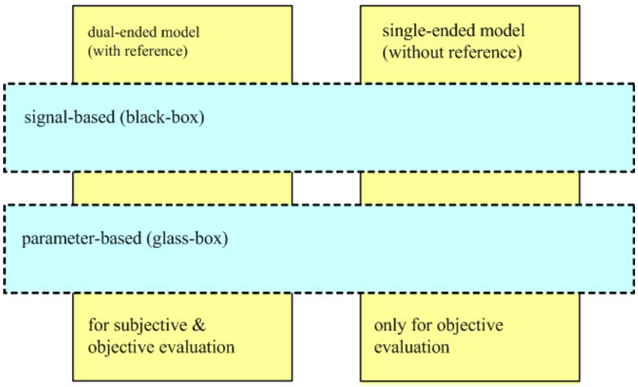

Figure 1. Overview of QoS and QoE measurement techniques.

Two measurement techniques can be used in the two models cited: a) signal-based and b) parameter-based measurement. The dual-ended model uses specialised algorithms to compare the input and output signals of signal-based measurements. In the case of the single-ended model, this comparison is made by using a reference signal. In both cases, the system to be assessed is treated as a “black box”. When carrying out parameter-based measurements, a distinction is made between two types: a) “glass-box” and b) “black-box”. In the first case, both the structure of the system to be assessed and the reaction of the individual system components to the reference signal are known. This knowledge is then taken into consideration in a suitable model. Additionally, the network parameters measured can be included in the calculation of the QoS. In the second case, not all details of the system to be assessed are known, so only the network parameters measured and the characteristic parameters for the respective service are taken into account.

The paper and the oral presentation at the Conference will review and discuss the application of common QoS/QoE measuring methods to Triple Play Services (audio/video/data).

III. QoS/QoE in the VoIP Service

Figure 2 represents current QoS/QoE measurement techniques for the VoIP service. It is noticeable that several international standards touch on this area. The signal-based QoE measurement techniques PESQ [10] and POLQA [11] are very accurate; they are, however, time-consuming and can often only be implemented with a licence. That is why parameter-based QoS measuring methods are usually preferred in practice. The E Model [12], which was originally developed for circuit-switched telephone networks, has recently been adapted for use in IP networks to produce the modified E(IP) Model, released as a patent [13] in 2014.

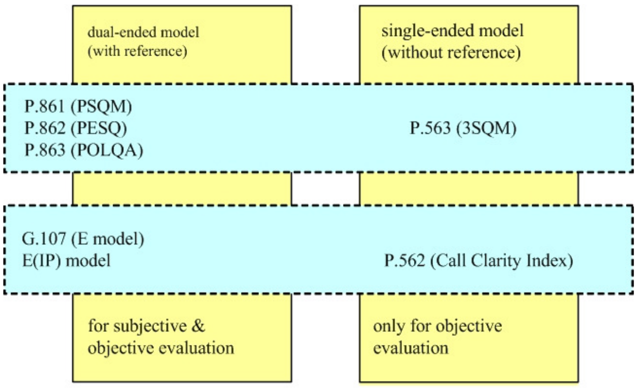

Figure 2. Overview of QoS and QoE measurement techniques for the VoIP service.

The modification in the E(IP) Model represents a restructuring of the two parameters *Ie* (Equipment Impairment Factor) and *Blp* (Packet-Loss Robustness Factor) to take account of impairment factors on the IP transport platform.

IV. QoS/QoE in the VToIP/IPTV Service

Figure 3 shows established methods for measuring the QoS/QoE of the video component of the VToIP/IPTV service.

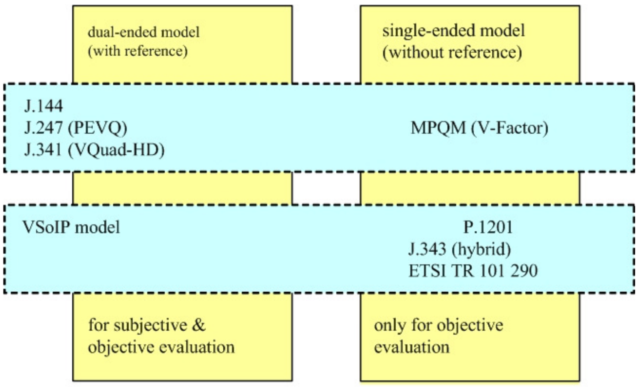

Figure 3. Overview of QoS and QoE measurement techniques for the VToIP/IPTV service.

Alongside several signal-based international standards there are also a few parametrised measurement techniques that work without a reference signal, not the least of these being the parametrised VSoIP Model [14], that is to be classified as a dual-ended model. Its make-up and mode of operation correspond to those of the E(IP) Model for the speech service. The parametrised QoS models are quick and easy to use, which is of great benefit in practice. In contrast, it takes minutes to measure the QoE of a HD video file using, say, the PEVQ [15] and the J.341 [16] method. Besides, they belong to the group of active (intrusive) methods of measuring QoE, which means that a connection must first be established in an IP environment, and a reference signal must be sent and mirrored at the receiver's end. That is very time-consuming.

V. QoS/QoE IN THE WWW SERVICE

Figure 4 shows the most widely known techniques currently used to measure QoS/QoE in the WWW service.

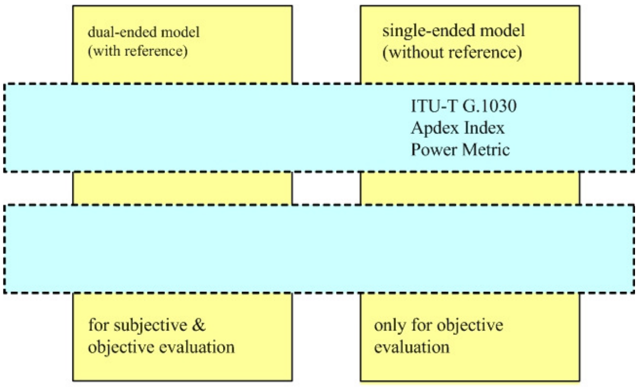

Figure 4. Overview of QoS and QoE measurement techniques for the WWW service.

It is immediately clear that there is only one standardised technique for measuring QoE in the WWW service: G.1030 [17]. There are two other QoS techniques in the single-ended model — Apdex Index [18] and Power Metric [19] — but they have not been standardised, meaning that there is an enormous need for further developments in this area, especially in view of the fact that the WWW service is one of the most widely used applications in the modern Internet of Things and accounts for the lion's share of traffic.

VI. CONCLUSION AND FUTURE WORK

This paper has reviewed and discussed briefly the application of common QoS/QoE measuring methods in Triple Play Services (audio/video/data). The strengths and weakness of the individual QoS/QoE measurement techniques have been spelt out. In practice it is highly beneficial to work with parametrised QoS models.

In the course of the related presentation in the track SERVQUAL [20], it will be demonstrated how the QoS measuring techniques that were described in the previous section are applied to the Triple Play Services. The results that were obtained from multiple series of QoS tests are presented in the form of graphs and then interpreted.

To summarise: a great deal of development work and practical implementation remain to be done in the field of QoS/QoE. New scientific concepts for QoS/QoE measurement techniques and systems are needed. Designers and engineers are faced with a mighty challenge!

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