Paper

New Tool for Examining QoS in the VToIP Service

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Abstract—This paper is dedicated to the subject of measuring QoS in the Video Telephony over IP (VToIP) service. QoS measurement models in general and then models designed specifically for measuring QoS in the VToIP service are presented. A new numerical tool for examining the quality of VToIP video streams VToIP is described. The tool's functionality is then put to the test in a number of analysis scenarios. The results and insights gained from the analyses are then presented in several diagrams, and interpreted. The paper concludes with a summary and an outlook on further areas of work.

Keywords—communication network, emulation tool, ITU-T G.1070, PEVQ, QoS measurement, Triple Play services, video streaming, VToIP.

1. Introduction

Quality of Service (QoS) plays a very important role in modern digital networks. The term has become a household word and can be found among other things in the definition of Next Generation Networks according to the ITU-T Standard Y.2001 [1]. In 2009, the European Parliament and European Council published directives for the standardization of networks and services [2], [3], placing great priority on quality of service.

The QoS in modern networks, and Quality of Experience (QoE) for that matter, should be measured continuously – preferably automatically. This makes specialized measurement methods and complete systems indispensable. There are, however, hardly any standardized QoE and QoS measuring methods for video-communications applications such as video-telephony. There are at present only two standards: ITU-T Rec. J.247 [4] and ITU-T G.1070 [5] to resort to. A third method for measuring the QoE of video services, the Perceptual Evaluation of Video Quality (PEVQ) Algorithm, has yet to be standardized [6]. It is one of the signal-based QoE measuring methods. According to the German license holders, the company Opticom [7], the PEVQ algorithm is in line with Recommendation J.247. So it seems it would make sense to work with this method to measure QoE in the VToIP service. However, the QoE measuring methods mentioned so far are very complex and the licenses are expensive. There are no simple, parameterized QoS measuring techniques that are quick and easy to use. Before any model can be developed, it will be necessary to clarify the relationships between QoS values and network and service parameters, admittedly using signal-based measuring methods. The analysis had to be conducted within clearly defined scenarios that yield reproducible and statistically irrefutable results. Quick analysis in meaningful, realistic environments are not possible without tools specifically designed to analyze QoS in emulations. At the moment there simply are no tools that can do that. This paper describes the design and development of such tool and its implementation.

The VToIP service operates according to Recommendation H.323 [8]. This Recommendation defines the encoding of audio and video signals. Codecs H.263, H.263+ and H.263++ are provided for video streaming. A VToIP connection can be established controlled and terminated using a range of signaling protocols. In practice, however, the SIP [9] protocol is by far the most widely used. Real-life measurements of the VToIP service have revealed that a refresh rate of 25 frames per second is usual. Common formats for the service are: CIF, QCIF, QVGA and QQVGA. From a practical point of view, this paper takes all these observations into consideration.

The paper will now present a classification of QoS measurement models in general and then those particularly designed for the VToIP service. The main impairment parameters of QoS are then presented briefly. The paper goes on to describe the newly developed numerical tool in Section 4. Following that, its functionality is tested in several various analysis scenarios (Section 5). The results and insights gained from those analysis are then presented in diagrams, and interpreted. The paper concludes in Section 6 with a summary and an outlook on future areas of work.

2. QoS Measurement Techniques for VToIP

In order to determine the QoS in a network two models are generally used: dual-ended model and single-ended model (see Fig. 1) [10]. In the case of the dual-ended model two signals are used: original and degraded. These are available uncompressed. For this reason, measurements can be carried out for both Quality of Experience (subjective evaluation) and Quality of Service (objective evaluation). When it comes to the single-ended model, only the impaired signal (compressed) is available. This allows only an

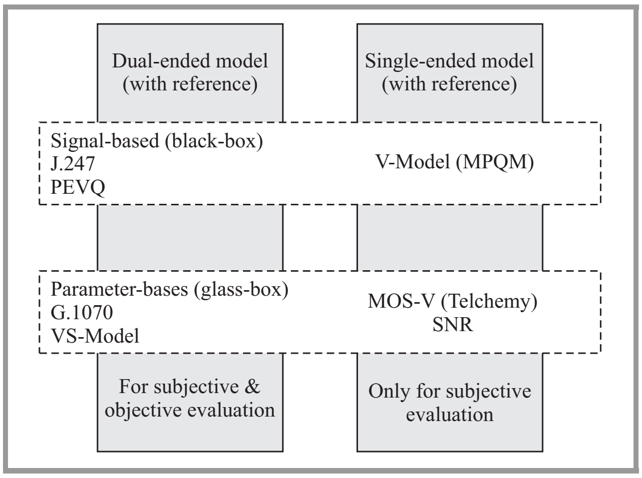

Fig. 1. Overview of QoS and QoE measurement techniques.

objective evaluation of QoS to be made. QoS measurement is referred to as "intrusive measurement" (online) in the case of the dual-ended model and as "non-intrusive measurement" (offline) in the case of the single-ended model.
Two measurement techniques can be used in the two models cited: signal-based and parameter-based. The dual-ended model uses specialized 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 under analysis is treated as a "black box". When carrying out parameter-based measurements, a distinction is made between two types: "glass-box" and "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 within a suitable model. Additionally, the network parameters measured can be included in the calculation of the QoS. In the second case, details of the system to be assessed are limited. For this reason, only the network parameters measured and the characteristic parameters for the respective service are taken into account.
Figure 1 shows the most commonly used measurement techniques for determining the QoS in a VToIP environment. The most important techniques are: the ITU-T Rec. J.247 [4], ITU-T G.1070 [5], Perceptual Evaluation of Video Quality [6] (Part of J.247) and a proprietary solution – the VS Model [11]. They yield QoS values on the so-called MOS (Mean Opinion Score) scale (from 5, being "excellent", to 1, "bad" [12]). The new analysis tool incorporates both the PEVQ method and the VS Model.

3. QoS Impairment Parameters

QoS impairment parameters can basically be divided into two groups: network parameters and service parameters. The most influential impairment parameters in networks include: delay, jitter, packet loss, burstiness, improper packet sequencing, communications pattern, available bandwidth [13], [14]. Some of these impairments can be countered by implementing jitter buffers in the terminal equipment, one of their parameters being their size, which has a significant influence on error concealment. The second group of impairment parameters is service-related. The following parameters are associated with the VToIP service: audio and video codecs, speech sample length, video format, image refresh frequency. All of these parameters affect QoS and accordingly must be considered in any assessment of QoS. In practice two methods are used to determine whether or not impairment parameters are actually exerting a direct influence on QoS values: measuring QoS in a real environment and examining QoS using a suitable tool albeit in an emulated environment. The first approach is resource-intensive and time-consuming. The results are generally marred by a very large distribution. The second approach is admittedly extremely time-consuming during the development stage, but as soon as the tool has been successfully implemented, it is quick and easy to use. And it delivers reliable and reproducible results for a given set of parameters. This is of particular value in practical applications. That is why this paper is dedicated to the second approach. The next chapters will address the concept behind the tool, its implementation and the practical benefits of using it.

4. The New Tool for Examining QoS in the VToIP Service

Figure 2 presents a block diagram representing the concept behind the tool to examine QoS in the VToIP service that was developed during the course of the work described in this paper. To be exact, it determines the quality of the video streams in the VToIP service. That is why it came to be called QoSCalc(VSoIP) (VS standing for video streaming).

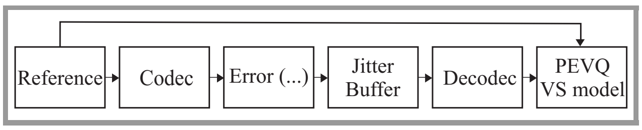

Fig. 2. Block diagram of the proposed Tool.

The following steps explain how the tool works:

- first the reference file is loaded;
- the reference signal is encoded according with the video codec selected;
- the encoded video samples are segmented and encapsulated in RTP packets in accordance with the selected settings of the parameters;
- the main impairment parameter, i.e. packet losses, is emulated in the block Error;

- the RTP packets containing the video samples are received and buffered in the jitter buffer, where they are processed. Whenever a packet loss occurs, the corresponding packet is discarded;
- once decapsulated the video samples are decoded in the next block according to the codec selected;
- finally, the received signal and the reference signal are led to the PEVQ algorithm, that then calculates the QoS as values on the MOS scale. It is also possible to input the parameters that are calculated on receipt of the RPT packets into the VS Model because it, too, is capable of determining QoS values on the MOS scale.

The tool QoSCalc(VSoIP) was developed using the programming language C Sharp. All of the steps outlined in the previous paragraph are performed on the computer. The transmission of RTP packets is done virtually within the tool itself. Figure 3 shows the tool's graphical user interface.

When using the tool QoSCalc(VSoIP), the first thing that must be done is to select a suitable reference file (see Video File panel in Fig. 3) for the video codec being used. The reference file must have a resolution that is supported by the video codec under analysis and fulfill further prerequisites (e.g., duration and content of the signal) set by the license holders in Germany of the PEVQ algorithm, i.e., the company Opticom [7]. Codec H.263 supports only the resolutions 16CIF (1408 × 1152 pixels), 4CIF (704 × 576 pixels), CIF (352 × 288 pixels), QCIF (176 × 144 pixels)

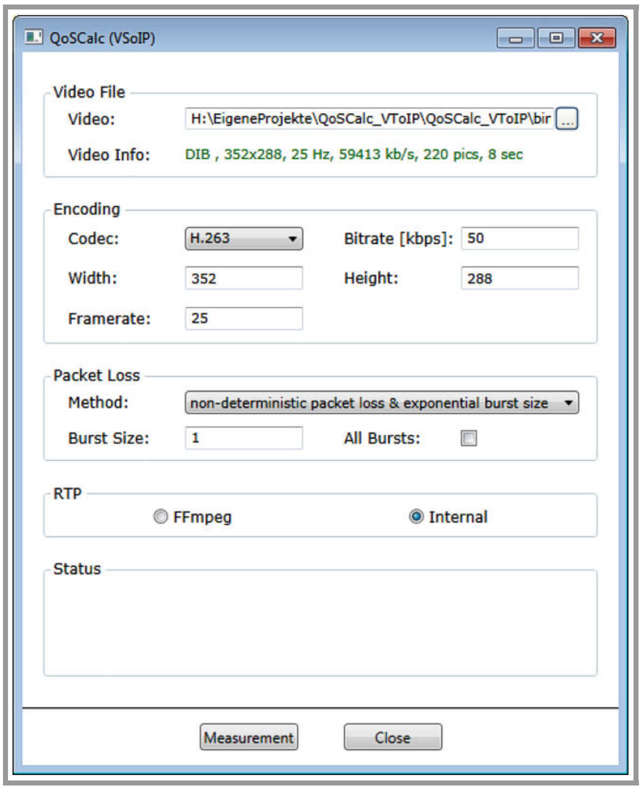

Fig. 3. Screenshot of the tool's graphical user interface.

and SQCIF (88 × 72 pixels), although more recent versions, H.263+ and H.263v2, do not limit resolutions and formats to quite such an extent. The selected signal is then analyzed and, among other things, its image refresh frequency, bit rate, duration and number of frames is detected. The user is asked whether height, width and image refresh frequency of the selected video should be used as a basis for a subsequent encoding. If this should not be the case, the user can enter alongside the chosen (H.263 or H.263+) alternative values and adjust the setting for bit rate (see Encoding panel in Fig. 3).

The user can choose between three different settings to calculate PEVQ values: deterministically distributed losses at constant burst size, binomially distributed losses at constant burst size; binomially distributed losses at exponentially distributed burst size (panel Packet Loss). As a consequence of the variable burst size a series of tests comprises 15 reading points, each consisting of 31 measurements. A CSV file containing the QoS values, packet losses and, if desired, burst sizes is created by default. Besides that, the arithmetical mean, standard deviation and confidence interval are calculated for each reading point. If transformation equations exist for the VS model for the selected parameter, then the QoS values calculated according to this method are contained in the file as well. As soon as a series of tests has been completed, a window appears informing the user along with other information as well, such as duration of the measurement tests and where the CSV file has been saved. A Visual Basic macro is used to present the values as Excel data sheets in which the corresponding curves are also shown.

The user can choose between two methods of encapsulating the encoded signals into RTP packets (panel RTP). Choosing Internal will prompt the tool to encapsulate the signals according to Recommendation RFC 2190 [15]. Choosing FFmpeg, however, will cause the corresponding software tool [16] to packet the individual RTP packets, one advantage here being the large number of codecs (H.264 as well) for which a corresponding RTP segmenting is supported and which must therefore not be separately implemented. The developers are working feverishly to provide this kind of encapsulation in future versions of QoSCalc(VSoIP). Finally, the panel Status displays the current status of test series in progress.

5. Analysis Scenarios

The numerical tool QoSCalc(VSoIP) has been tested in a number of analyses. It delivers reliable and reproducible results. Its functionality and efficiency will now be demonstrated in a number of representative measurement scenarios. The analysis scenarios exhibited the following parameters:

- video codec H.263+ with encoding rates of 1308 kbit/s and 4995 kbit/s;
- image format QVGA (320 × 240 pixels);

- image refresh rate of 25 images/s;
- binomially distributed packet losses of 0 to 20%;
- negative exponential distribution burst size with mean values of 1 to 5;
- 31 measurements per value of each of the variables (here: packet loss). This ensures that confidence intervals are achieved that are less than 10% of the mean values under analysis, with a probability of error of 5%;
- PEVQ and VS Model as the QoS measuring techniques;
- an AVI file PevqRef_qvga.avi from the company Opticom [7] was chosen as the reference video. The file is 8 seconds long.

Fig. 4. Screenshot of the reference video.

Figure 4 shows a screenshot of the reference video, and the results of the comparison study are presented in Figs. 5–8.

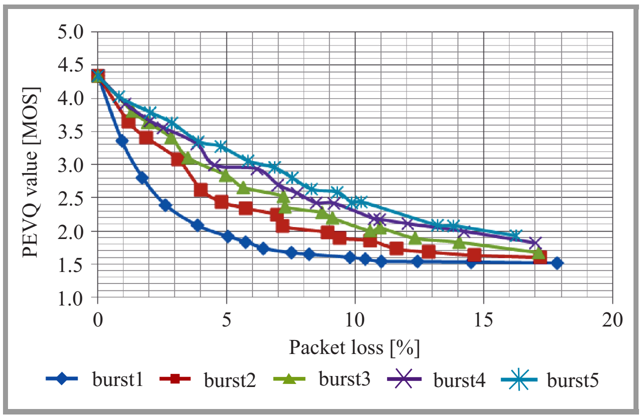

Fig. 5. PEVQ values as a function of packet losses and burst sizes at an encoding rate of 1308 kbit/s for the codec H.263+ and the image format QVGA.

Figures 5–6 show that all QoE curves develop exponentially. The curves also show that the encoding rate has a great influence on the QoE values. Burst size also has a significant influence on QoE. A burst size of 1 delivers the worst quality of experience in all three cases and improves with increasing burst size. Furthermore, the curves fall less steeply as burst size increases. The upshot of this is: it is far better for the service if fewer, larger bundles of packets are lost than lots and lots of smaller bundles. The reason for this lies in the properties of human vision. A set of curves like this could be used in the development of the parameterized QoS measuring model as was done, for example, in work [11]. In that scenario the suitability of the proposed tool, QoSCalc(VSoIP), for determining QoS in VoIP was proved beyond any doubt.

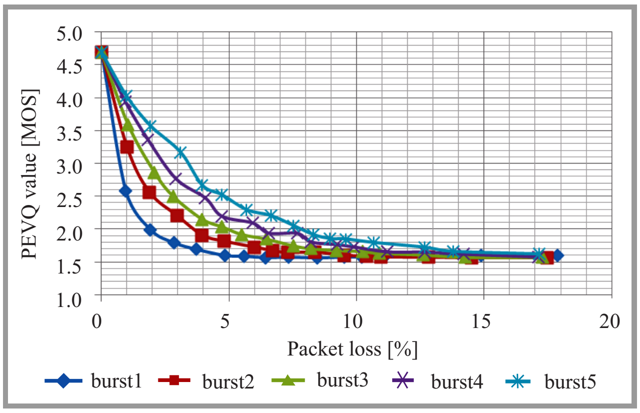

Fig. 6. PEVQ values as a function of packet losses and burst sizes at an encoding rate of 4995 kbit/s for the codec H.263+ and the image format QVGA.

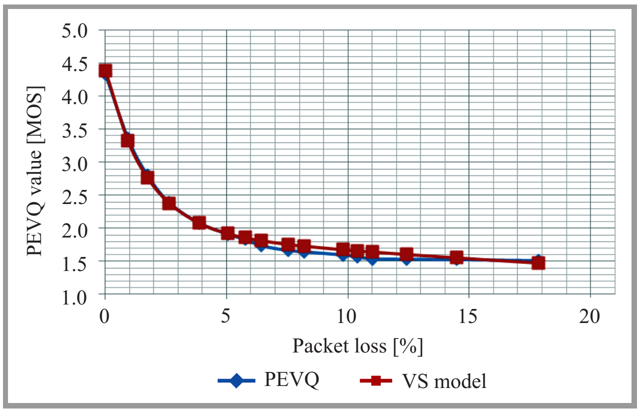

Fig. 7. QoS values as a function of packet losses gained from different measuring methods for the codec H.263+, the image format QVGA, burst size 1 and an encoding rate of 1308 kbit/s.

Figures 7–8 show that the quality of service deteriorates exponentially as packet losses increase. This is the case for both QoS measuring methods used here. The PEVQ and the VS Model curves proceed very close to each other, meaning that the numerical comparison study has proved that the VS Model is quite suitable for practical use. Whilst not forgetting that there are other various methods of measuring QoS, we have proved with this series of examinations

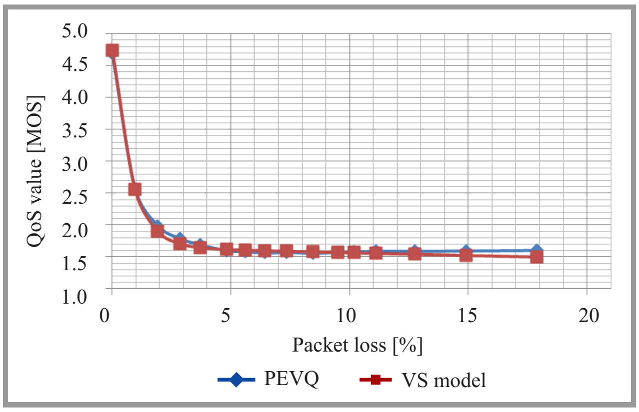

Fig. 8. QoS values as a function of packet losses gained from different measuring methods for the codec H.263+, the image format QVGA, burst size 2 and an encoding rate of 4995 kbit/s.

that QoSCalc(VSoIP), the tool developed here, is equally capable of quantifying QoS in the VToIP environment.

6. Summary and Outlook

The measurement of QoS in VToIP has been the central subject of this paper. It began with a classification of QoS measurement techniques in general before looking in more detail at those designed especially for the VToIP service. The main impairment parameters affecting VToIP were then discussed briefly. These parameters corresponded completely with the Recommendations of ITU-T [13] and ETSI [14], two leading authorities in the area. Following that, QoSCalc(VSoIP), the new numerical tool for analyzing the quality of the VToIP service was described in some detail. The design of the tool reflects recent developments in QoS measurement methodology for the VToIP service, which can only be of benefit in practical applications. The tool has room for proprietary solutions. Its user overlay is intuitive and easy to use. Several tests have proved the suitability of the new tool for examining the quality of service in VToIP. It functions impeccably and allows large-scale analyses to be configured quickly and then executed automatically. Comparable studies by other means would be both laborious and time-consuming, hardly automated as they are. This is where the new tool really shows its mettle.

In its present form the VS Model incorporated into the tool QoSCalc(VSoIP) supports the following image formats: CIF, QCIF, QVGA and QQVGA. It would make sense to expand the parameterized VS Model with further, widely-used image formats, such as: 2CIF (704 × 288), 4CIF (704 × 576), 9CIF (105 × 864), 16CIF (1408 × 1152), WQQVGA (20 × 120), WQVGA (40 × 240), VGA (640 × 480) and WVGA (800 × 480 pixels). To achieve this, further transformation formulas must be calculated for these formats, and the approach described in paper [11] can be simply taken over and applied as it is. The authors have already started work in this direction, the ultimate goal being to integrate the VS Model with the complete spectrum of image formats and the video codec H.264 within the QoS measuring system TraceView_Sim_VToIP from the company Nextragen GmbH [17] and to launch it on the telecommunications market.

The service VToIP is one of the so-called Triple Play services. It would be worthwhile developing and implementing similar QoS-analysis tools for the other real-time services, such as IPTV, since measuring QoS, especially in video services, can be quite a time-consuming endeavor, in some cases taking several minutes per measuring point. And that is where numerical tools can help. The authors intend to develop and implement a further tool that will analyze QoS in the service IPTV. The experience and insights gathered in the course of the work described in this paper will definitely be incorporated into future work.

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