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A tool for multimedia quality assessment in NS3: *QoE Monitor* ☆

D. Saladino [1], A. Paganelli *, M. Casoni [2]

Department of Information Engineering, University of Modena and Reggio Emilia, Via Vignolese 905, 41125 Modena (MO), Italy

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ABSTRACT

Nowadays, with the continuous rise of Internet-based multimedia services, such as video sharing websites, web radios and IP-based telephony, multimedia communications are gaining more and more popularity.

From the service provider's perspective, there is an increasing need in providing high-quality content; at the same time, from the network provider's view, the requirement is to design networks that can effectively support these services with adequate quality-of-service (QoS). In both cases, engineers and researchers need suitable planning tools exploitable for providing appropriate designs.

For all these reasons, we have focused our work on the design and implementation of a novel open-source tool, named *QoE Monitor*, which consists of a new module for the NS-3 simulator that can be used to perform objective and full-reference quality-of-experience (QoE) assessments in any simulated network. The goal of this tool is to predict the video and/or audio quality perceived by an end user through objective metrics. Moreover, its open-source nature foster its validation and promote knowledge sharing within the research community, while its modularity eases the implementation of additional software components to expand its capabilities (e.g., to account for new codecs and/or new QoE metrics).

In this paper, a detailed description of this tool is done and some numerical results about video streaming performance evaluations are presented, which show its effectiveness for the QoE analysis.

1. Introduction

Since there is a continuous growth of multimedia distribution over the Internet, it is increasingly necessary to guarantee the transmission of high quality video and audio content. For instance, regarding video streaming, the quality perceived by a viewer is subjective and depends not only on image proper features, like brightness, color, distortions, information contents, but also on other factors that involve the human vision perception. The latter one, in turn, is strictly related to image processing operations, like coding, compression/decompression, filtering, transcoding, and/or the adopted display features, like resolution, screen type, frequency, shared memory.

As video processing, and then transmission, may introduce some amounts of distortions or artifacts in both the received video and audio contents, the objective assessment of the quality perceived by a user, connected to a given network, is of

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* Corresponding author. Tel.: +39 0592056323.
E-mail addresses: daniela.saladino@unimore.it (D. Saladino), alessandro.paganelli@unimore.it (A. Paganelli), maurizio.casoni@unimore.it (M. Casoni).
[1] Tel.: +39 0592056323.
[2] Tel.: +39 0592056167.

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paramount importance. Based on this reason, our research is focused on the implementation of a complete framework that allows researchers and engineers to assess video and audio quality perceived by the end users, using numerical simulation tools. In more details, our goal has been to quantify the impact of a communication network, with a particular configuration, and of the employed codec on the quality of the received video and/or audio file.

The current stable version of our software tool (which is an open-source software released under GPL v.2 license, and can be freely downloaded from [1]) focuses on the QoE evaluation of a video stream transmitted through a network simulated by means of the Network Simulator 3 (NS-3) [2], by performing the Peak Signal-to-Noise Ratio (PSNR) and the Structural Similarity (SSIM) metrics, which are both objective (i.e., they are implemented by means of algorithms and do not rely on human evaluations) and full-reference (i.e., they require both the transmitted video file and the received one to predict the perceived quality). As currently there is no tool integrated into NS-3 that is able to provide this kind of outcomes, we have focused on the design and implementation of a new NS-3 module, taking into account an existing tool, called EvalVid [3], that has represented an effective starting point: we have carefully analyzed it and completely re-implemented its main features and modules, in order to have a tool directly integrated with NS-3 simulator.

Since this project is quite young, some advanced and specific features (e.g., application level FEC, reduced and no-reference quality assessments, *universal image quality index*), as well as those related to audio assessments, are still under development and will be part of our near future work. However, the present version of *QoE Monitor* is already usable and can provide helpful insights to the research community for the evaluation of video streaming services in any network implementable with NS-3.

The rest of this paper is organized as follows. Firstly, in Section 2 we describe the state-of-the-art of the currently available tools for the assessment of the video quality experienced by a viewer. Section 3 gives a short description of our reference framework and, then, describes in detail the proposed *QoE Monitor* architecture, together with its integration with NS-3; an overview of the main C++ classes composing the tool is provided, too. Section 4 presents the analyzed network scenarios and discusses the obtained simulative results, that demonstrate the validity of our tool, whereas Section 5 describes the first validation results we have obtained comparing our tool with EvalVid. Then, in Section 6 we suggest possible future works that could make this tool more efficient and usable in different contexts. Finally, Section 7 reports our main conclusions and highlights our final remarks.

2. Related works

As previously stated, the reference tool we have considered to steer our development is EvalVid, a modular tool-set, written in C, that allows to assess the perceived quality of a video stream transmitted through a network, which could be both realistically reproduced and/or experimentally simulated. The goal of this tool is not only to evaluate network parameters like jitter, loss and delay, which are typically referred to as quality-of-service (QoS) parameters, but also to assess the video quality really achieved through the computation of frame-by-frame PSNR. Moreover, it gives the possibility to change some configuration parameters like the video coding scheme or the adopted error model as well as the network parameters or the error correction strategy employed for the video reconstruction at the receiver side.

In [4], the authors describe a method to integrate EvalVid with the widespread Network Simulator 2 (NS-2) [5], to carry out realistic video QoE evaluations in arbitrarily simulated networks.

In [6], the "Research Group on Computer and Networks and Multimedia Communications – UFPA" implemented a successful port of the code-base of the original EvalVid project, to the NS-3 framework, to replicate the same functionalities provided to the NS-2 platform by [4]. However, it is important to underline that this tool makes use of trace-based evaluations (similarly to what EvalVid does), which means that only offline assessments are possible.

Furthermore, a widespread tool for video quality evaluation is MSU VQMT (Video Quality Management Tool) [7]. This tool supports different input formats, like AVI, YUV, MP4, WMV, VOB, and makes available different metrics to compare up to three video files, like PSNR, SSIM and Video Quality Measurement (VQM), and metrics for blurring and blocking measurement, too. It provides both full-reference (which requires both the sent and the received videos) and no-reference (which requires only the received video) comparisons.

A very promising tool that brings together a network simulator and a proper multimedia evaluation module is Open Evaluation Framework for Multimedia Over Networks (OEFMONs) [8]. Some of the most important features of this tool, which is based on QualNet (a commercial network simulator originally derived from GloMoSim [9]), are: modularity, which allows the system to be extended with novel codecs and/or network standards; real-time operation, which allows the simulation of realistic multimedia communications (e.g., real-time adaptation of coding parameters, usage of scalable video coding, etc.); real-time monitoring, i.e., the multimedia content at the output of the network setup can be monitored in real-time, thus allowing direct subjective quality assessment by the researcher.

Finally, another couple of proprietary and commercial tools is also available, i.e., Q-Master Video System [10] and Video Quality Analyzer [11]. The former measures the perceptual quality of both audio and video streaming, providing information about jerkiness, blurring, noise, besides the traditional Mean Opinion Score (MOS) values. The Video Quality Analyzer tool allows to analyze the perceived video degradation by employing an evaluation model very similar to the Human Visual System.