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Mamadou Tourad Diallo, Nicolas Maréchal, Hossam Afifi

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# A Hybrid Contextual User Perception Model for Streamed Video Quality Assessment

Mamadou Tourad DIALLO, Nicolas MARECHAL  
Orange Labs  
Internet Delivery Acceleration  
Paris, France  
{mamadoutourad.diallo, nicolas.marechal} orange.com

Hossam AFIFI  
Institut Mines-Télécom  
Security and Mobility  
Evry, France  
hossam.afifi@mines-telecom.fr

## Abstract:

Users' satisfaction is the service providers' aim to reduce the churn, promote new services and improve ARPU (Average Revenue per User). In this work, a novel hybrid assessment technique is presented. It refines known mathematical models for quality assessment using both context information and subjectives tests. The model is then enriched with new features such as content characteristics, device type and network status, and compared to the state of the art. The effect of application parameters (startup time and buffering ratio) on user perceived quality is also analyzed in this article.

**Keywords-component:** Quality of Experience; QoE measurement; QoS; video streaming;

## I. INTRODUCTION:

Quality of experience is a determinant factor for the end to end evaluation of applications and services. There is a need to understand human quality requirements, and QoE appears as a measure of the users' satisfaction from a service through providing a simple (single index) assessment of human expectations, feelings, perceptions and acceptance with respect to a particular service or application [1]. An important challenge is to find means and methods to measure and analyze QoE data with accuracy. QoE is measured through three main means: i) objective means based on network parameters (e.g. packet loss rate and congestion notification from routers), ii) subjective means based on the quality assessment by the users giving his exact perception of the service and iii) hybrid means which consider both objective and subjective methodologies.

Consequently, we investigate in this paper the influence of content characteristics, device type and network context on perceived video quality. This investigation targets at providing inputs to decision tools for the service adaptation at both the application layer (e.g. choice of the compression parameters such as bit rate, frame rate and/or resolution, choice of the codec ...) and the network layer (e.g. delivery means such as unicast or multicast, access network, source server, delivery from the cloud...).

This article is organized as follows: Section II provides observed results and our mathematical model. Conclusions and highlights on perspectives are provided in Section III.

## II. CONTRIBUTION

In order to investigate the effects of context parameters (content type, device type, user throughput...), we set up videos experiments where

users are asked to give their scores about their perception of videos. Experiments consist in letting users to watch different contents (sport, music, news and animation) on different devices and with different network bandwidths. After each watch, end-users are asked to give their own opinion about their satisfaction according to ITU-T recommendations, i.e. according to a five point quality scale ranging from bad (1) to excellent (5). We show that content type and device type are more impacting than expected. This is visible in Fig.1 and Fig.2. As a consequence, content adaptation & recommendations systems can strongly benefit from knowledge about these two parameters. In this section we will study the effect of network throughput in order to predict QoE so as to reflect the results obtained from our extensive field test evaluations. The effects of application parameters (startup time and buffering ratio) are also analyzed.

### A. Impact of network parameters in QoE:

Before presenting our model based on subjective tests and evaluating it, we first provide a non-exhaustive short state-of-the-art on existing models & proposals. In [2] and [3] authors introduce the IQX hypothesis to make the bridge between QoE and QoS (network): QoE appears as a solution to some differential equations and the expressions are functions of QoS parameters. In particular packet losses and packet reordering are studied, but the link between MOS and bandwidth is not depicted. In this section, we reuse the exponential shapes from [3], but the novelty stands in the making use of bandwidth as a parameter to MOS, and by showing the dependence of constants in the model with content type and device. In our model, the satisfaction for user  $i$ , is measured by the formula (1) where: i)  $D_i$  is the observed throughput for user ii)  $D_{ref}$  is a reference value for throughput, meaning that when  $D_{ref}$  is reached the satisfaction is considered as maximum, iii)  $S_{max}$  is the maximal observed satisfaction which is only function of the content type, device and intrinsic video quality and iv)  $\alpha$  and  $\beta$  are regression parameters to be adjusted and compared according to content type and device. As a consequence,  $D_{ref}$  depends on the used device and video content type. For low demanding content like news and cartoon, this value is close to the encoding video bitrate. For more demanding content, this parameter is slightly higher than the video encoding bitrate.

Figure 1: Mean QoE with standard deviation in the desktop

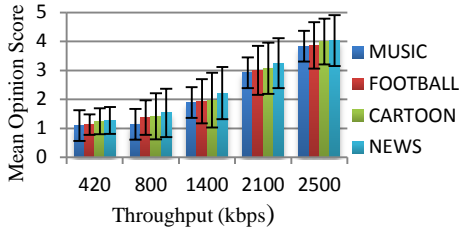
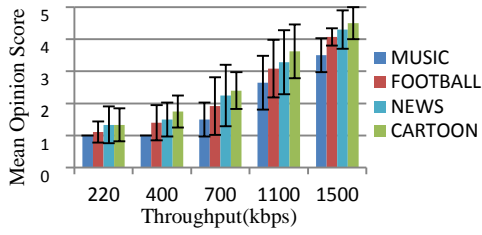


Figure 2: Mean QoE with standard deviation in the smartphone



$$QoE(D_i) = \begin{cases} S_{max} & \text{if } D_i \geq D_{ref} \\ \alpha * e^{\beta * D_i} & \text{otherwise} \end{cases} \quad (1)$$

Please note that  $S_{max}$  can be easily extracted from experiments by looking at thresholding effects in high throughput regime, and that  $D_{ref}$  is obtained via the following relationship:

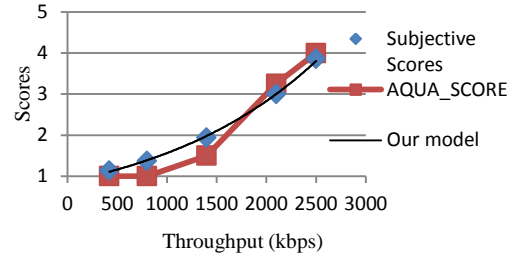
$$D_{ref} = \frac{1}{\beta} \ln\left(\frac{S_{max}}{\alpha}\right) \quad (2)$$

The variable which characterizes the used terminal is  $\beta$  (same value for all content type associated to a terminal). The parameter  $\alpha$  depends on the content type and used device also. The values of  $\alpha$  and  $\beta$  are obtained by least squares regression for each content type and each considered device. The exponential model fits well the subjective scores (see Fig. 3).

#### B. Impacts of application parameters in user perceived quality :

To analyze the impact of application parameters on the general perception, another set of important perceptual parameters were collected and rated by end-users: video startup time and the buffering ratio (see definitions here after). We define *video startup time* as the delay between playback command and playback begins. On its side, *Buffering ratio* is defined to be the ratio of the cumulative time during which the video was blocked (by lack of data in buffer) over the total video duration. Our goal is to answer questions such as: How startup time and buffering ratio reduce the user perceived quality ? Experiments show that startup time metric is less critical for users than buffering ratio, and that video startup time is more negatively correlated to general user satisfaction in the case of smartphone than desktop. However, for both desktop and smartphone whatever the content type, buffering ratio is a critical

Figure 3. Performances comparison



metric. As experimental results can not be included in this article because of the lack of space, we invite the reader to contact the author for obtaining this data.

#### C. COMPARISON:

To validate the performance of our model, the CUPM (Contextual User Perception Model), we compare the performance with a video quality metric computed by using Aquatool, a professional Orange Labs R&D tool (see Fig. 3). However, the reader shall keep in mind the differences: i) subjective scores are obtained by human-based assessments ii) AQUA\_SCORE is obtained by a production tool used on observation of streamed video iii) Our model is a proactive approach taking overall and general parameters. Moreover, it provides an easy parametric model to characterize end-user satisfaction, and can take into account context information for an accurate prediction, as long.

#### II- CONCLUSION:

In this article, we have analyzed the impact of throughput, used device and streamed content type on users' satisfaction. Video stalling phenomena has appeared as a critical parameter which impacts a lot end-user satisfaction whatever the used device. Moreover, our results prove that context information's have to be considered to monitor and provide an adequate user experience. As a consequence, media and delivery adaptation must take these contexts into consideration. We also provided a simple model that accurately captures MOS by mean of a simple exponential function in which the studied parameters have been introduced somehow naturally.

As a perspective, the authors are about to extend these conclusions by considering additional context information, and the way to exploit them robustly.

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