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Quality of Experience Metric of Streaming Video: A survey

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Abstract

Technological development in the last years leads to increase the access speed in the internet networks that allow a huge number of users watching videos online.

Video streaming important type in the real-time video sessions and one of the most popular applications in networking systems. The Quality of Service (QoS) techniques give us indicate to the effect of multimedia traffic on the network performance, but this techniques do not reflect the user perception. Using QoS and Quality of Experience (QoE) together can give guarantee to the distribution of video content according to video content characteristics and the user experience .

To measure the users' perception of the quality we use Quality of Experience (QoE) metric . Here , in complete we display what the QoE and QoS mean and what the difference between them, list the techniques used to measured them ; then we display a study of the literature on different tools and measurement methodologies that have been proposed to measure or predict the QoE of video streaming services.

Keywords: Quality of experience (QoE), Quality of Service (QoS) ,video streaming

مقياس جودة التجربة على الفيديو المتسلسل: دراسة

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الخلاصة

التطور التكنولوجي في السنوات الأخيرة ادى إلى زيادة سرعة الوصول في شبكات الانترنت وبالتالي السماح لعدد كبير من المستخدمين بمشاهدة مقاطع الفيديو بشكل مباشر .

الفيديو المتدفق نوعًا مهمًا في جلسات الفيديو في الوقت الفعلي وأحد أكثر التطبيقات شيوعًا في أنظمة الشبكات. وتوضح لنا تقنيات جودة الخدمة (**QoS**) تأثير حركة الوسائط المتعددة على أداء الشبكة ، ولكن هذه التقنيات لا تعكس إدراك المستخدم .يمكن أن يؤدي استخدام جودة الخدمة (**QoS**) وجودة التجربة (**QoE**)معًا إلى ضمان توزيع محتوى الفيديو وفقًا لخصائص محتوى الفيديو وتجربة المستخدم.

لقياس إدراك المستخدمين للجودة ، نستخدم مقياس جودة التجربة (**QoE**) . في هذا البحث نعرض بشكل كامل ما يعنيه **QoE** و **QoS** وما الفرق بينهما ، قائمة بالتقنيات المستخدمة لقياسها ؛ ثم نعرض دراسة لبعض البحوث حول أدوات ومنهجيات قياس مختلفة تم اقتراحها لقياس جودة التنبؤ بجودة الفيديو أو التنبؤ بها.

1. Introduction

In future generation networks the video streaming gathering will be having contributed in our life experience and all personal activities key factor to attract and keep customers, by combining the Quality of Service (QoS) and Quality of Experience (QoE)[1].

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The service got by the user, it is affected by the network components and other factors like (infrastructure tools, network, client, terminal,…).

So, Quality of Experience (QoE) is considered as a user-centric metric that refer to the total acceptability of the service that have dealt with the end-to-end factors.

The QoE is used to measures the performance as the user can understand subjectively [2]. After all, we find the QoE is an expansion to QoS[3].

The network and service providers must have objective tools with high accuracy where it can compare them with the subjective mean opinion score of users [4].

Quality of Experience (QoE) depends on the Quality of Service (QoS) [1]. It indicates the degree to which the service meets user anticipation, especially from the user's point of view to the valuation performance of the service, Figure-1 show that QoE is an extension to the QoS. The evolving in the network infrastructure and e-commerce environment making the Service providers concern great weight to quality control and are associated with improving the quality of the user experience as one of the main competition methods [5].

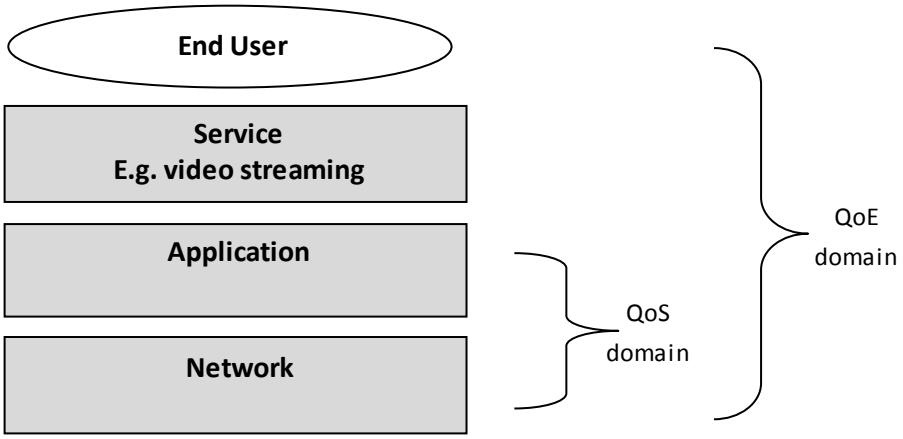

Figure 1- QoS and QoE architecture [6]

2. The Difference between QoS and QoE

The quality of service (QoS) define the overall characteristics of a service such as communication that affect the satisfied of user's service needs[5].From video streaming point, QoS indicated to the capability of the network to transmit packet in the best way possible, QoS represents the network-centric. However, the obvious question is how QoS control and measure the perception of user's service. In the pursuit of keeping the quality of user perception above than the acceptance threshold, service providers required to have a knowledge about network parameters QoS and express that into quantifying level represent the perception of user QoE and vice versa. QoS depends on parameters otherwise QoE calculate Mean opinion score (MOS) to measure user response. So , the relationship between QoS and QoE need to invite an efficient QoE mechanism to control the measurable parameters of QoS[3]. Table (1) show the differences between QoS and QoE[4,5,7,8].

Table 1-Differences between QoS and QoE

QoS	QoE
measured the effective of the network and its components	Measured the satisfaction and effective the quality of network and service.
It look From the perspective of telecommunication system performance and mechanism	From the perspective of user's, person's of Information and Communication Technology (ICT) service, application and systems
QoS measure are based on the experimental, technology-oriented or simulated assessment.	QoE measure are based on methodological approach and multidisciplinary.

Focused on telecommunication services	Focused on broader domain, not just networks
QoS metrics : coding parameters(bitrate, spatial and temporal features) and network parameters (packet loss, delay and jitter)	QoE metrics: subjective (MOS, DMOS,…) and objective: (viewing time, probability of return,…)

3. Factors affect QoE

The QoE metric distinct from the rest of the standards because its that parameters different from service to other . An example, playback start time of video has important role in services more than video and audio quality .The parameters impact on QoE can be classified into Three groups [4,9] :

1. Video content quality at the source. The quality of content depends on the characteristics of the original video on the source destination .The codec type, bitrate , MPEG-2, MPEG-4and etc.
2. The quality of services (QoS) considered about the how to deliver the content crosses the network, QoS features all about delay, jitter, packet loss and bandwidth.
3. The perception of human, the first two are easy to quantify, but this one isn't. the most common way to capture human perceptual is the Mean opinion score (MOS).
4. QoE Measurement Methodologies

The video QoE have three methodologies to measure it: Full Referenced (FR), Reduce Reference (RR) and No Reference (NR) [2,9,10].

- Full Referenced (FR) type we must have the origin video as reference and use it in the assessment process.
- Reduce Reference (RR) have no origin video but it used information about the origin video during assessment progress.
- No Reference (NR) are same RR because they have no origin video but the NR has no information about the origin video it will calculate QoE in real-time by take the QoS features or pixel-based features or both, for that reason it one of the practical QoE measurement for real-time video stream .

4.1 Full Referenced (FR)

This methodology measure the similarity with the original video file to determine the degree of distortion, in another word the impaired version compared to the high-quality undistorted original of the same video frame by frame.

The traditional metrics for signal fidelity such as Peak Signal to Noise Ratio (PSNR), Signal to Noise Ratio (SNR), Mean Square Error (MSE) and etc. However, FR still used widely and considered as the criterion standard, unfortunately, the accuracy suffered when used to quantify the perception of video content. Fidelity signal metrics used quality assessment to quantify the error or distortion level by comparing the reference video with the one being processed [1, 11].

The most delegated methods used in FR metrics are Mean Square Error (MSE), Structural SIMilarity (SSIM), Peak Signal to Noise Ratio (PSNR) , Virtual Information Fidelity (VIF) and Information Fidelity Criterion (IFC)[12], Figure-2 Explain the mechanism of Full Reference method work .

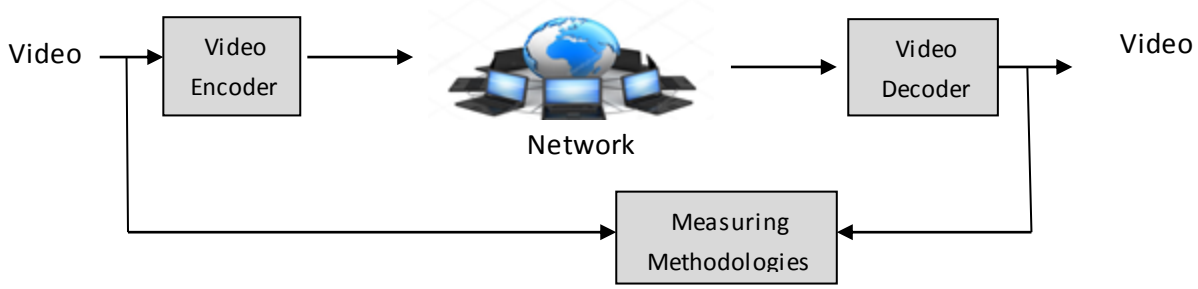

Figure 2-The mechanism of Full Reference method work

4.2 Reduced Referenced (RR)

RR based on the idea of extracting the original video feature or characteristics from the original (reference) video such as spatial and motion information and used it to measure video Quality at the end user side[12].

It convenient to use RR approaches when it hard to keep or transmit the original video. Also considered suitable in situation required Real-Time measurement [13].
Nevertheless, RR needs the information about the original video to transmit accurately to received side[14], Figure-3 Explain the mechanism of Reduced Reference method work .

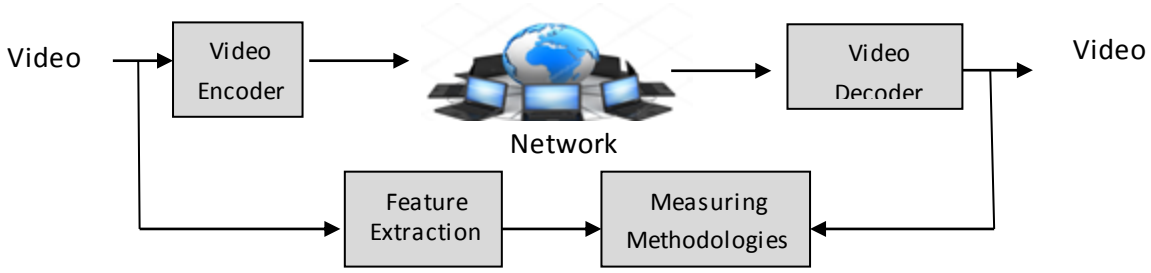

Figure 3-The mechanism of Reduced Reference method work

4.3 No Referenced (NR)

No reference does not need any knowledge about the reference video, NR Video quality assessment compared to FR and RR metrics is much more flexible due to the difficulties and even impossible sometimes to get the video reference[14].

Commonly NR used when required to measure the video quality in real time [9]. NR is more flexible than RR because it is suitable to any videos environment. Usually used to calculate the effect of network transportation error on videos, Figure-4 Explain the mechanism of No Reference method work

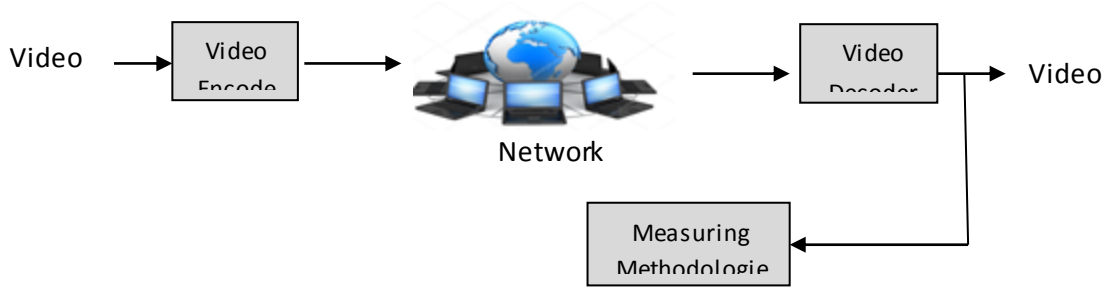

Figure 4-The mechanism of No Reference method work

5. QoE Measurements Types

The QoE metrics are classified into objective and subjective metrics according to measurement methods used [2].

One of the challenges of the executing subjective experiments, it is the time-consuming, so we need to create objective quality metrics, that have the ability to estimate Mean Opinion Score (MOS) automatically. Objective quality methods can be divided into two approaches psychophysical and engineering [15].

Psychophysical approach using different features like contrast and orientation sensitivity, frequency selectivity, spatial and temporal pattern, masking, and color perception to modeling the Human Visual System (HVS) [15].

The engineering approach employ a simple metrics depend on the extraction and analysis a certain features from a video [15].

5.1. Subjective measurements types

One of the perfect technique for measuring conception video quality is The subjective method where the Subjective metrics based on the data that are gathering from viewers this data effected by a factors such as viewer interest, content age , and internet quality, So this subjective metrics may be suffered from the bias that changing by change the subject.

To avoid this problem in Subjective metrics using a powerful method for collect data directly from users and feed its into statistical techniques (mean, Standard Deviation, Regression,...) [2]. The number of viewers used in a viewing and listening test is from 6 to 40. Four is the absolute

minimum for statistical reasons. In general, we need at least 15viewers subjects to give best result to the subjective metric and no more than 40 [16].

So that, the main goal of using such metric is to check accuracy of objective scores so can be used in video QoE prediction.

The more familiar subjective measurement is the Mean Opinion Score (MOS) where the viewers look videos in real-time and classify such as following: 1-worst, 2-poor, 3-fair, 4-good, and 5-excellent. This type of metric needs at least 15 viewers to give acceptable result , So the MOS consider as one of the an accepted scale for subjective assessment [2,6,16].

5.2. Objective Measurements Types

Objective QoE metrics can be measured using number of measurements tools but first we must know the common objective QoE metrics factors that affect on the user's QoE[2]:

1. Playback Start Time: is the time taken to download the HTML page, load the video player plug in.
2. Number of Interruptions: it happens when the playback of the video is briefly slowed down.
3. Duration of Interruptions: the interruptions count and the period of each interruption have great role effecting on the QoE of the user .
4. Quality of the Video File: The type of encoding rate has great effects on the quality of a video stream.
5. User Engagement: its measurement of the time that a user really spends viewing the video without getting far away.

5.2.1 Objective Video QoE Measurement Approach

1. Mean Square Error (MSE)

Used to calculate the amount of distortion in the video as FR metrics.

$$MSE = \left(\frac{1}{X \times Y}\right) \sum_{i=0}^{X-1} \sum_{j=0}^{Y-1} \left(p_{s(i,j)} - p_{d(i,j)}\right)^2 \quad (1)$$

Where $p_s(i,j)$ represents the location of the pixel in (i,j) of the original video , $p_d(i,j)$ represent the pixel location in (i,j) of the destination video, where (X ,Y) represent the rows and columns[17] MSE works as an arithmetic statistical tool used to measure and estimate the difference between the reference and distorted content.

2. Peak Signal Noise Rate (PSNR)

The most common full Reference metrics. In the video, PNSR experienced some limitation due to the low correlation to subjective quality measurement. At the sometimes the low complexity in implementation makes PNSR still widely used to assessment video/image quality. It's work by comparison pixels by pixels between the content of reference and distorted. The result comes out are appearing as the peak SNR figure does not represent the actual content[18].

$$PSNR = 10\, log_{10} \left(\frac{MAX^2}{MSE}\right)^2 \quad (2)$$

3. Structural SIMilarity index (SSIM)

Normally used for Image Quality Assessment (IQA), also used widely in Video Quality Assessment (VQA), SSIM used the structure of the frame image and notice the change in it. Three comparison used in SSIM, luminance, structure, and contrast.

4. Video Signal Noise Ratio (VSNR)

Considered as a Human Visual System (HVS) based metric. Video Signal Noise Ratio (VSNR) approach consists two stages, first, it detects distortion by measure contrast and checks if it below the contrast thresholds of human perception than no further analysis required if it not then the distortion can be touched by user perception [12]. Then the second stage operates which depends on the perceived contrast prosperity and the property of visual mid-level.

6. Quality of Experience and its application areas

There are many application areas that consider the QoE, among them [13]:

• Telecommunication services: covering a large variety of multimedia communications and classical fixed and mobile networks.
• Assistive technology: which goal is designed and develop assistive and Rehabilitative devices for people with inability to improve their QoE.
• Cloud Computing: this new technology must be clear for the user, the capacity to share, transfer and collaborate with the cloud must maximize the user's QoE.
• Multimedia learning: the use of multimedia contents must be easy and natural with

cognitive resources, simplify the access to information.
• Games: the quality of game software affects directly the user's QoE

7. Review of Video QoE Prediction Models

7.1. QoE measurement of HTTP video streaming models

In [11] Mok and authors studied the problem of QoE and affecting by HTTP video streaming where it divided into two parts:

- First: measuring the correlation between the network QoS and application QoS by using both analytical model and empirical evaluation and proposed three APM for HTTP video streaming .
- Second: measuring the correlation between application QoS and QoE by Balances between network throughput and re buffering frequency that have great effects on MOS variance .

In [19] Suh and authors proposed a new algorithm called QoE enhanced adaptation algorithm over Dynamic Adaptive Streaming over HTTP (DASH). This algorithm conserves the minimum buffer length to avoid interruption and reduce the changes in video quality in the playback time. The authors applied the DASH test in a large domain. Where The experimental results show that QAAD algorithm provides a smooth flow with stable video quality under unsteady network conditions.

7.2. Machine learning used in training models

In [14] Bao and authors proposed a new method of QoE estimation based on fuzzy clustering heuristic algorithm which is focus on calculation service score at the server side.The server side responsible for collecting network quality of service QoS parameter and other information. Then save this information in big data base and use it in heuristic rules model to predicts user score, this process called fuzzy clustering analysis and then they will generates service QoE score that will fed back to clients.

In [17] Li and authors used Decision tree algorithm as one of the machine learning classification that have the ability to analyze the correlation among the metrics performance and factors of QoE where they focused on analyzing the impact of rebuffering and other related parameters on user MOS using decision binary trees.

In [20] Mocanua and authors display a new metric that measure the user dissatisfaction which not always refer to averaged scores . Do that by using deep learning framework / deep belief networks and two modeled the averaged scores and user dissatisfaction levels.

8. Conclusion

The video streaming services represent especially challenge to measure the QoE. where this metric used from many of years but not yet have been standardized .

Building an efficient quality of experience metric is an important goal of the QoE predictions model. In this paper a survey on techniques of quality of experience metric system have been provided and show the major differences between the normal quality of the video and quality of experience , then show a different between QoS and QoE. The major method surveyed depended on calculating the QoS features and video features and use them in prediction system. Most researchers are different in machine learning method that use or different in the type of features.

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