Systematic Analysis of Quality of Experience (QoE) Frameworks for Multimedia Services

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Abstract
Quality of Experience QoE frameworks were proposed and developed to provide quality of service to end users according to their needs and improve user experience. This paper presents survey of recently proposed QoE frameworks based on certain features such as monitoring support, data analysis, reporting to administrator, policy change and parameters for data collection and monitoring. During the survey it has been erudite that mainstream QoE frameworks have limited scope. Few of them do not support client side monitoring, policy change and both subjective, objective QoE combined approaches. QoE data analysis is also concern for negative and positive QoE is not available, which needs to merge to find robust QoE framework.

Index Terms
Quality of Service (QoS), QoE, Multimedia Framework, User needs, Monitoring

1. Introduction

The advancements in mobile technology and availability of high speed Internet have increased the usage of multimedia services [1]. User access multimedia services like video tutorials, news, movies, VOD and IPTV through PCs, smart phones, tablets and iPads. Users having different devices and networks access multimedia services from particular server or cloud. Due to heterogeneous devices and networks, users do not receive Quality of Service (QoS) from service providers [2]. Service Level Agreement (SLA) is a document between the user and service provider which defines what quality of service is expected from the service provider. If the user does not get the QoS as mentioned in the SLA then he will switch the cloud service provider and will blame the cloud provider for violating the promised SLA [3]. So to avoid SLA violations, organizations use QoE for eliciting user requirements. A user account is created where complaints about the cloud service which the user has subscribed to are registered, to know about the problems user is facing and to improve the service according to user requirements. Quality of Experience QoE is user perception about the services or product received at user end. QoE is defined as "Quality of Experience is a measurement of customer satisfaction or customer performance depends on objective or subjective measure of using any service or product" [4]. There are different definitions of quality of experience provides by academia and industry. The International Telecommunication Union ITU-T defines QoE [5] as "The overall acceptability of an application or service, as perceived subjectively by the end-user". Laghari and Connelly defines [6] QoE as "QoE is a blueprint of all human subjective and objective quality needs and experiences arising from the interaction of a person with technology and with business entities in a particular context".

Vendors of products use QoE to get user needs and their ever evolving demands. They use interviews, web based surveys and questionnaires to get subjective information from users about product or service. Two types of QoE are used to observe user perception; one is subjective and second is objective [6]. Web surveys, interviews, questionnaires and complaint boxes are used to collect subjective QoE. Objective QoE can be captured by using two methods (i) technical QoS data and (ii) cognitive systems and Human physiological tests [8].

The delivery of multimedia services with QoS to end user is cumbersome for service providers because multimedia services depend on the network conditions, user device performance and also multimedia contents which user selected for viewing. Network traffic is dynamic [9], sometimes it is very slow due to high load of users' traffic and sometime very speedy. Multimedia contents depend on the frame rate, codec and bit rate. Therefore, user device support for multimedia contents is also an issue. To overcome these problems and to improve QoS for multimedia services researchers developed a QoE framework for assessing users' satisfaction for video quality and delivery of services. The robust QoE frameworks contain web based form where users' subjective QoE can be submitted. It also monitors QoS (objective QoE), multimedia contents, network parameters, and data analysis of collected data for validation of services according to SLA.

This paper presents a review of some existing QoE frameworks for multimedia services and also for networks

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services. The rest of the paper is organized as follows. Section 2 presents a brief description of various QoE frameworks. Section 3 presents a comparative analysis of various QoE frameworks and section 4 concludes the paper.

2. QoE frameworks

Quality of experience (QoE) management frameworks were developed to provide quality of service QoS to end users in the client server architectures. A QoE framework for video streaming was given by MintMoS [10]. The framework evaluates the subjective QoE submitted by the users for network level QoS (packet loss, reordering and delay) and application level parameters (bitrate, codec and frame rate per second). This framework only provides quantitative analysis of monitored QoE data but does not provide qualitative analysis. MintMos scope is limited since it does not collect objective QoE, there is no policy change support on users' feedback and also does not report the degradation of services.

No Reference Video-Quality-Assessment Model for video streaming services based on the assessment of subjective QoE was proposed by Kawano et al. [11]. This framework evaluates video quality by using blockiness and blur derived from decoded video signals. The framework did not support objective QoE and only provided support for Quantitative analysis of subjective QoE. This framework did not contain reporting function on the degradation of services where policy remains fixed until administer does not change that.

QoE2M framework was presented by MuMu [12] and was based on agent technology. Agents run from server to client for monitoring the network performance such as packet loss and delay and collected information stored in DB for further management. The management framework analyzes the network and user needs; if network performance is low then it decodes the original video in low quality video and forwards it to the user for providing quality of service. Niche vendors provide QoE tools using objective QoE collections methods such as PESQ (Perceptual Evaluation of Speech Quality) and PNSR (Peak Signal to Noise Ratio). Niche vendor's tool does not contain runtime policy change mechanism and reporting tools [13, 14].

QoE framework for Multimedia services (QoM) was proposed by Laghari et al. [15]. The framework is based on the subjective and objective QoE evaluation and supports Quantitative & Qualitative analysis of collected data. This framework monitors NQoS (Network QoS) and AQoS (Application level QoS) using subjective and objective QoE methods which are stored in DB (database) for analysis. When services degrade with respect to the SLAs then reporting tool generate alerts on the user status on event of QoE and network services degradation [15].

EQoM (Enhanced Quality of Experience framework for Multimedia services) is a framework for multimedia services based on the agent technology for monitoring subjective and objective QoE. Active agents monitor the environment from server to end user and capture QoS data of user device (configuration and resource utilization) and on-going network traffic. This framework estimated Network level QoS and Application level QoS while showing results to end user about network degradation. If user feels degradation in services than at any time he can submit subjective QoE, which will be stored in the database of user profile. The framework automatically monitors objective QoE after submission of subjective QoE from the user. The system will then analyze both user submitted and framework collected QoE and compare services according to SLA. The comparison of user submitted QoE and framework collected QoE is also aimed at monitoring the user behavior. It may be possible that the user submits wrong user experience for getting more resources from the server. If framework finds that user did not received services according to the promised SLA then user services will be upgraded to provide him QoS according to SLA. EQoM framework supports functionality such as QoE monitoring, evaluation, reporting, run time policy change mechanism and service quality assurance according to the user needs [16].

Crowdsourcing System on Measuring Quality of Experience for Internet Video Streaming was proposed by Lin and Shih [17]. This framework is based on the subjective and objective QoE assessment. Crowdsourcing application was developed to capture objective QoE of user devices such as RAM utilization and CPU usage. Subjective QoE capture metrics based on the Mean Opinion Score (MOS) and dichotomous method. The accuracy of measured QoE was 81-100% during the experiment but this framework did not support reporting tool on the degradation of user experience and also it did not support user policy change.

A Quality-of-Experience Index for Streaming Video model was proposed by Duanmu et al. [18]. Duanmu et al. conducted subjective QoE experiment by encoding different video contents on the same bit rate and building database of streaming video. Subjective QoE of users was measured on initial buffering, combined effect of video compression and video stalling. Streaming QoE Index (SQI) was proposed for assessment of objective QoE, which accounts for the playback stalling events, instantaneous quality degradation due to perceptual video presentation impairment and the instantaneous interactions between them. The SQI model has limited scope; it does not support reporting function on the degradation of user experience and has limited monitoring parameters.

Wu et al. presented QoE framework for crowdsourcing multimedia assessment based on the subjective QoE [19]. Users can watch video by web interface and assign MOS for audio and visual quality of videos. This framework supports cheat detection, economically viable QoE collection through crowdsourcing and support variety of multimedia contents. The framework scope is limited where it does not support monitoring of contents, network parameters and also objective QoE.

3. Performance for QoE Frameworks

This section presents a comparative analysis of the proposed QoE frameworks in terms of various characteristics such as deployment parameters, monitoring, data analysis, reporting and policy change support as described in Table 1. Deployment parameter is the core parameter of any framework (NQoS & AQoS, Video blur and blockiness). Monitoring function is based on the monitoring objective QoS e.g. data of user device, server, multimedia contents and network statistics during the services. Analysis support of framework describes the collected subjective and objective QoE data for current and future usage for management purpose. Reporting tool is for sending alert message to administrator on the degradation of users' QoE for multimedia services. Remarks present information of QoE type which is used by framework for user needs and satisfaction evaluation.
MintMos [10] and Kawano et al's [11] framework parameters are different for collecting QoE but rest of the functions are same like monitoring, data analysis, reporting, policy change and remarks. QoE2M [12] and Niche Vendors [13, 14] used only objective QoE/QoS for monitoring contents and have limited functionality compared to other proposed frameworks. Parameters for the frameworks presented in [18] and [19] are different. Both [18] and [19] use VQA and stalling and audio and visual quality while keeping rest of the functions same. [15] and [17] used same parameters and almost same functions for QoE evaluation but only difference was that QoM framework support reporting tool which was absent in the framework proposed by Lin et al. [17]. EQoM is more advanced as compared to other frameworks. It supports all functions which are supported by others
but is extended with policy change on the degradation of services

Table I. Comparison of previous QoE frameworks with different parameters and features

QoE Frameworks	Parameters	Monitoring Support	Analysis Support	Reporting	Policy Change	Remarks
MintMos [10]	NQoS & AQoS	Yes	Quantitative	No	No	Subjective Evaluation
Tiachi Kawano[11]	Video Blur & Blockiness	Yes	Quantitative	No	No	Subjective Evaluation
QoE2M [12]	NQoS & AQoS	Yes	Quantitative	No	No	Objective (QoS)
Niche Vendors [13, 14]	PSNR, PESQ VQM	Yes	Quantitative	No	No	Objective Evaluation
QOM [15]	NQoS & AQoS	Yes	Quantitative & Qualitative	Yes	No	Objective & Subjective Evaluation
EQoM [16]	NQoS & AQoS	Yes	Quantitative & Qualitative	Yes	Yes	QoS & Subjective Evaluation
Lin and Shih [17]	NQOS & AQoS	Yes	Quantitative & Qualitative	No	No	Objective & Subjective Evaluation
SQI [18]	VQA and stalling	Yes	Quantitative & Qualitative	No	No	Objective & Subjective Evaluation
Wu et al. [19]	Audio & visual quality	Yes	Quantitative & Qualitative	No	No	Subjective Evaluation

4. Conclusion

In this paper we analyzed and discussed some of the QoE frameworks for multimedia services. The proposed QoE frameworks have been analyzed in terms of certain characteristics such as deployment parameters, monitoring, data analysis, reporting and policy change support. During the research it has been witnessed that very few frameworks support both subjective and objective QoE assessment, monitoring, reporting and policy change on degradation of users' QoE, which are the key requirements of QoE multimedia frameworks. Only the EQoM framework supports all key requirements of QoE assessment for multimedia services. All the remaining frameworks lack few main functions like support for both

subjective and objective QoE and policy change on the degradation of services

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