

PAPER 29 – ACHIEVING QUALITY OF EXPERIENCE IN TELECOMMUNICATION SERVICE

Abdulrasheed Umar¹, C. O. Alenoghena², S. Zubair²

Telecommunication Engineering Department, Federal University of Technology Minna, Nigeria

umar.pg915182@st.futminna.edu.ng

carol@futminna.edu.ng

zubairman@futminna.edu.ng

ABSTRACT

This paper presents a perspective view into network performance achievement via quality of experience (QoE) improvement of telecommunication service in Nigeria. Monitoring the quality of experience undergone by mobile network operators (MNO) has become paramount for policy makers who need to ensure high quality levels to limit customer annoyance due to quality dissatisfaction. The components of QoE and mechanisms of analyzing and evaluating them are discussed. The paper also identifies the important key performance indicators (KPIs) for QoE achievement. Telecom operators have recently faced the need for a crucial change from technical quality requirements to user experience guarantees. An abstract framework for achieving end-to-end QoE provisioning is proposed and described in detail in terms of its design, its constituents and their interactions, as well as the key implementation challenges. An evaluation study serves as a proof of concept for this framework, and demonstrates the potential benefits of implementing such a quality management scheme on top of current or future generations of mobile cellular networks. The paper is concluded with recommendations on how to achieve and improve the QoE in telecommunication service of the Nigeria.

Keywords – *Quality of Experience (QoE), key performance indicator (KPI), Mobile network operator (MNO).*

1.0 INTRODUCTION

Over 75% of all mobile network traffic will be exhausted and generated by smartphones by 2019 (Cisco online, 2020). As such there is an ever-growing interest from mobile network operators to better understand and assess the performance of their networks as viewed by end-users directly. The wide usage of internet based services has been traced down to the emergence of high-speed mobile network situated on Universal Mobile Telecommunication Systems (UMTS), Long Term Evolution (LTE) and other telecommunications standards. Equally, the availability of higher data transmission speed (throughput) enables mobile internet users to go beyond internet surfing, by enabling services such as file transfer, file download, video streaming and voice over internet protocol (VOIP). However, the Mobile network operators (MNOs) tend to limit the existing data-rate achievable by the users because of the high cost involved in acquiring spectrum (Tsiaras, et al, 2011). At the same time, the increase in the rate of subscribers have enhanced competitive advantage and provision of affordable services, thereby imposing additional challenge on the MNOs in providing a satisfactory level of service performance to the mobile internet users (Ibarrola et al, 2011), (Shaikh et al, 2010). Specifically, mobile networks are vulnerable to channel availability (such as decreased channel availability) that dynamically changes overtime because of the local congestion, which often result into compromising the user session (Goleva et al, 2012). The stated instances, increase in limited data rate and local congestion can seriously have impact on network telecommunication service experienced by users. Quality of experience is used in achieving evaluation of telecommunication service because it gives customers and service providers a comprehensive understanding of how users experience the service. Quality of experience metrics allow service providers to identify areas that require improvement and take action to ensure the highest levels of customer satisfaction. Quality of experience metrics also provides valuable insights into customer trends, behaviors, and preferences that can be used to optimize services and improve the customer experience. Quality of service (QoS) focuses on technical performance metrics such as network latency and packet loss, while quality of experience (QoE) focuses on the subjective experience of customers such as how satisfied they are with the service and how easy it was to use. QoS measures the technical performance of the service, while QoE measures the customer experience of the service. QoS is typically measured by service providers, while QoE is usually measured by customers. Both customers and service providers benefit from QoE evaluation of telecommunication service. Customers benefit from improved service experiences, as service providers use QoE data to identify areas for improvement and optimize services. Service providers benefit from greater customer satisfaction, as well as insights into customer trends and behaviors that can be used to target campaigns and services more effectively. In this paper we look at ways to achieve QoE in telecommunication networks.

1.1 QoE Measurement for Analysis on Telecommunications Network

Barakovic et al, (2013) defined QoE “as the degree of delight or annoyance of the user of an application or service. It results from the fulfillment of his or her expectations with respect to the utility and / or enjoyment of the application or service in the light of the user’s personality and current state.” QoE definition connects user perception, expectations, experience of the service application and network operators. User perceived QoE is often affected by varieties of influence factors. QoE influence factors are the characteristics of the service provided by the MNOs such as system (throughput, delay, jitter, loss, and security), human (gender, age, background, and education) and context (location, movement, time of the day costs and subscription type) influence factors (LeCallet et al, 2012). Quantified QoE influence factors allow the estimations of QoE as perceived by the users (Barakovic et al, 2013). The most studied QoE influence factor is the system factors constituting the Quality of service (QoS) parameters (throughput, loss, bandwidth, delay, and jitter). Because some parameters like bandwidth can be adjusted to increase the end user’s satisfaction (Alreshoodi et al, 2013). While there exist many studies that examined throughput measurement for wireless applications for web traffic (Rugedj et al, 2014), (Singh et al, 2013), few studies used user experience measurements obtained from the mobile network traffic, as most studies focus on collecting basic network information and performance data in a laboratory experiments through the desktop applications. Measurements obtained from the desktop in laboratory experiment are less useful because of the fixed contextual factor. Therefore, it is imperative to examine specific service-related throughput in mobile network traffic in relation to expectations, mobility (location and time), and different services like file transfer protocol (FTP) and Hypertext Transfer Protocol (HTTP). It is therefore imperative to take QoE measurement from the mobile network traffic to understand the experience of the user from both the network and user’s perspectives. Although crowd sourced data could also be used in measuring the extent of a user’s experience as to services provided by MNOs. The data gotten from the users are then collated, analyzed and interpreted in order to get a better first-hand comparative report as to MNP’s service and how well to suggest improvement to services rendered.

There are mainly two types of perceived QoE measurements, - subjective and objective measurements. The subjective measurements are based on customer perception of the services delivered to the customers, while objective measurement is the means of estimating subjective quality solely from the measurement obtained from the network traffic (Barakovic et al, 2013). The subjective measurement is the standard and most reliable way of assessing the QoE. Subjective measurement has been used in several studies to analyze the mean opinion score (MOS) in the form of numeric value ranging from 1 to 5 (from poor to excellent) (Singh et al, 2013). The limitation of subjective measurement is time consuming, expensive, lacks repeatability and not effective in real-time (Alreshoodi et al, 2013). In contrast to the subjective measurement like a survey measurement, mostly conducted in a laboratory experiment, objective measurement aims at predicting the subjective assessment methods based on the estimated MOS. Objective measurement requires a meaningful mapping function into the predicted subjective measurement (Shaikh et al, 2010). Objective measurement is a preferred measurement tool for analyzing network service because of its ability to be implemented and be embedded into the network using software applications and the capability to allow researchers model the relationship between the expectation and perceived influence factors to determine the MOS (i.e. perceived QoE) (Apajalahti et al, 2018).

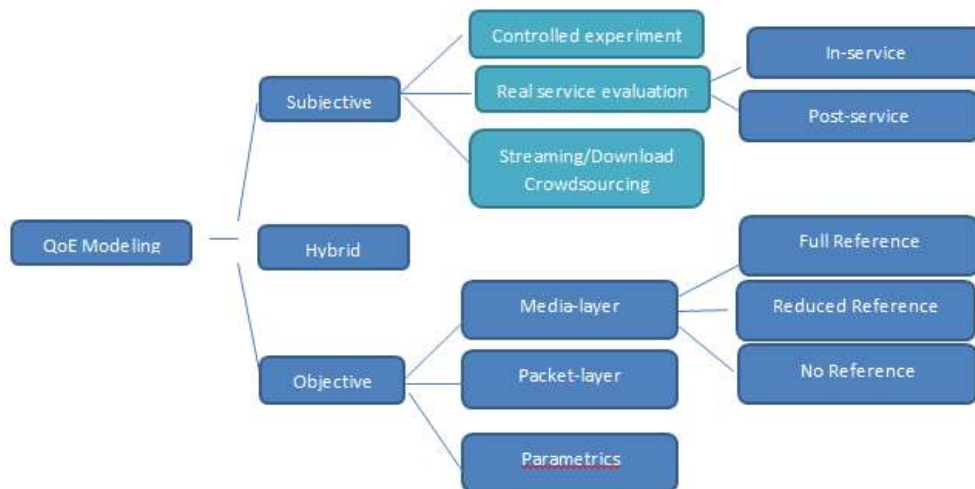


FIGURE 1: Classification of QoE modeling approaches (Dimitris *et al*, 2017)

1.2 KPI/QoE Metrics in Telecommunication Network

An increasing number of new network based application are entering the market and each application causes difference in performance objective. Application often evaluates the success of their objectives using KPI and QoE metrics. KPI and QoE metrics help application in telecommunications network to determine how effectively the application is achieving its performance objectives. The network as a driving force of such application plays a vital role in the end-to-end performance of application. Therefore, the performance of application highly depends on how well the network understands and serves the application requirement. The table below shows the performance metrics of the select KPI for QoE as against other methods of QoS. Some characteristic parameters were taken into account to better narrow down the test and also evaluate results.

A possible framework for achieving end-to-end QoE provisioning in telecommunication service would include the following elements:

1. **Quality of Service (QoS):** to ensure that the data is delivered with the required quality, the network needs to have adequate capacity and be able to manage traffic in an efficient manner. This would include ensuring adequate bandwidth and latency, as well as ensuring that traffic is properly routed and prioritized.
2. **End-to-end Monitoring:** to ensure that QoE is met, the network needs to be monitored for any performance issues or disruptions. This could be done through the use of monitoring tools such as packet sniffers, network probes, and application performance monitors.
3. **Service Level Agreements (SLAs):** to ensure that the QoE is maintained, SLAs should be established between the service provider and its customers. These SLAs should specify the expected performance levels, as well as any penalties or rewards that will be imposed if these performance levels are not met.
4. **Automated Fault Detection and Resolution:** to ensure that any performance issues are identified and addressed quickly, the network should have automated tools for fault detection and resolution. These tools should be able to detect any performance issues, alert the service provider, and then automatically take corrective action to resolve the problem.
5. **Customer Feedback:** finally, customer feedback is essential for ensuring that the QoE is being maintained. This can be done through surveys, feedback forms, and other customer feedback mechanisms. This feedback can then be used to further refine and improve the service.

Table 1: QoE KPI evaluation matrices as against others

Performance Characteristics	Drive Test	Using Data Centers	Crowdsourced Applications
Required equipment	Special test phones, RF scanners	Special hardware and additional server	Smart phones
Cost availability	Expensive and hardware are not readily available	Very expensive and requires permission	App is free
Target users	Team of network specialist	Usually used by academicians	Anyone that installs the application
Measurement level	Radio level measurement, service level measurements	Radio level measurement, service level measurements	Radio level measurement, service level measurements and QoE (Quality of Experience)
Measurement Size	Measurements are only during the test drive	Measurements are only for a certain period	Measurements are continuous
Position accuracy	GPS, current cell	Current cell	GPS, current cell
Traffic Overhead	Little or no overhead traffic	High overhead	No overhead traffic
Requires human intervention	Trained users required (active)	Yes	No (passive)
Scalability	Reduced, more drive test requires more specialized equipment	Difficult, technology dependent	Handles all sizes of traffic/measurements

2.0 PROBLEM STATEMENT

The problem of achieving quality of experience in telecommunication networks is a significant challenge faced by network operators and service providers. Despite advances in technology, network congestion, latency, and other factors can negatively impact the perceived quality of service by the user. This can lead to dissatisfaction, increased churn, and reduced revenue for service providers. Additionally, ensuring consistent quality of experience across different devices, applications, and locations presents a complex challenge. The problem requires careful consideration of factors such as network architecture, resource allocation, and user behavior to ensure that users receive high-quality service and have a positive experience with the network (Calle et al, 2015)

3.0 RELATED WORKS

A lot of study has been conducted on the subject of QoE in relation to telecommunication service, according to Timothy et al (2017) on service quality and customer satisfaction in Nigerian mobile telephony, The Nigerian Telecommunication industry has developed to be very competitive, as different Telecommunication companies jostle for the attention of subscribers. One of the key challenges confronting these Telecommunication companies is how they manage their service quality, which holds a great deal to customer satisfaction. Service quality and customer satisfaction are very essential in maintaining customer loyalty. Quality of Experience (QoE) in emerging mobile social network by Mianxiong et al (2015), The paper comprehensively surveys recent advances in MSNs and QoE issues addressed in various types of applications networks. From the lessons learned from the literature, it was found that most of the research proposals are dedicated to specific applications, network models and service scenarios. Regarding QoE monitoring studies in telecommunications network and mobile devices, there is an assorted list of tools to measure network performance in order to achieve a satisfactory QoE; some examples are MobiPerf (Xu et al, 2017), Mobilyzer (Kousias et al, 2017), Netalyzer (Apajalahti et al, 2018), in (Akpabio et al, 2020), (Fida et al, 2018) authors introduced YomoApp, an app to categorically monitor YouTube QoE related characteristics in mobile phones. QoE Doctor measures mobile application QoE using active measurement at both the application and network layers. While majority of the aforementioned only focused on QoE relevant objectives metrics such as rebuffering, page load time and interaction latencies, they lack a direct reference to user feedback e.g. mean opinion score (MOS). Where feedback is taken directly from real users and collects network measurements to provide a holistic perspective to the problem of QoE monitoring in network telecommunication and mobile network. This paper builds on past works on QoE achievement for telecommunications network in smartphones.

4.0 CONCLUSION

In this paper we have addressed QoE assessment, evaluation and achievement in network telecommunication. Also looking at how user end feedback can be exploited to achieve a desired and satisfactory QoE in mobile telecommunication network. All-in-all, the assessment, evaluation and implementation of QoE to better understand network telecommunication will provide future availability for other cellular users to have access to better telecommunications network provided by mobile network operators. A frame work to achieve QoE in telecommunications network was also discussed and looked into to enable achieving a desired QoE for better network.

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