INCORPORATING NETWORK AND SERVICE QUALITY INTO QUALITY OF EXPERIENCE MEASUREMENT FOR NETWORK SERVICES

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This thesis is dedicated to my parents, sisters, and my love for their endless support and encouragement.

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ABSTRACT

Measuring the quality of IP network services that users are experiencing and maintaining their loyalty towards these services are the most important factors that service providers consider. The existing evaluation methods for calculating the Quality of Experience (QoE) are categorized into two groups named subjective and objective. The subjective approaches are expensive and time consuming. The focus of this study is on objective measurement of QoE for VoIP application, but the main problem with these approaches is that they do not consider all the network and service details in their calculation models. During conducting the research, different questions has been focused on, how QoE measurement can help service providers in their business, and how objective measurement of QoE can be conducted to cover all the factors which are needed to measure the best and the most accurate quality from the user's point of view. The results of this research are based on a survey which has been done in UTM main campus (Johor) between three engineering faculties, experimental results and information from literature. At the end of this study a new model for measuring the QoE of VoIP application is proposed and based on this model a managing and monitoring framework for QoE is presented. This framework has 6 phases where in each phase different attributes and parameters are measured and calculated and then are utilized in the proposed model to repot the final level of QoE.

ABSTRAK

Mengukur kualiti perkhidmatan rangkaian IP bahawa pengguna mengalami dan mempertahankan kesetiaan mereka terhadap perkhidmatan ini merupakan faktor yang paling penting bahawa pembekal perkhidmatan dipertimbangkan. Kaedah penilaian yang ada untuk menghitung Kualiti Experience (QoE) dikategorikan ke dalam dua kumpulan bernama subjektif dan objektif. Pendekatan subjektif adalah mahal dan memakan masa. Fokus kajian ini adalah pengukuran tujuan QoE untuk aplikasi VoIP, tetapi masalah utama dengan pendekatan ini adalah bahawa mereka tidak menganggap semua detail rangkaian dan perkhidmatan dalam model perhitungan mereka. Selama melakukan kajian soalan berbeza telah terfokus pada, bagaimana pengukuran QoE dapat membantu pembekal perkhidmatan dalam perniagaan mereka, dan bagaimana tujuan pengukuran QoE boleh dilakukan untuk menutup semua faktor yang diperlukan untuk mengukur kualiti terbaik dan paling tepat dari user sudut pandang. Hasil dari kajian ini didasarkan pada kajian yang telah dilakukan di kampus UTM utama (Johor) antara tiga fakulti teknik, keputusan eksperimen dan maklumat dari literatur. Pada akhir kajian ini model baru untuk mengukur QoE aplikasi VoIP dicadangkan dan berdasarkan model pengurusan dan rangka pemantauan untuk QoE disajikan. Rangka kerja ini mempunyai 6 fasa di mana dalam setiap fasa atribut yang berbeza dan parameter yang diukur dan dikira dan kemudian digunakan dalam model yang diajukan untuk merepoting peringkat akhir QoE.

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LIST OF ACRONYMS

ACK	-	Acknowledgment
BSD	-	Bark Spectra Distortion
CN	-	Core Network
ETSI	-	European Telecommunications Standards Institute
FR	-	Full Reference
HTTP	-	Hyper Text Transfer Protocol
IETF	-	Internet Engineering Task Force
IP	-	Internet Protocol
IPTV	-	IP Television
iQoS	-	Individual Quality of Service
ITU	-	International Telecommunication Union
MGCP	-	Media Gateway Control Protocol
MNB	-	Measurement Normalizing Blocks
MOS	-	Mean Opinion Score
MTBF	-	Mean Time Between Failures
MTTR	-	Mean Time To Repair
NR	-	No Reference
PAMS	-	Perceptual Analysis Measurement System
PESQ	-	Perceptual Evaluation of Speech Quality
PSQM	-	Perceptual Speech Quality Measurement
PSTN	-	Public Switched Telephone Network
QoE	-	Quality of Experience
QoS	-	Quality of Service
RAS	-	Registration Admission and Status Protocol

RR	-	Reduced Reference
TIA	-	Telecommunication and Industry Association
UE	-	User Equipment
VoIP	-	Voice over IP

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

By introducing new approaches in network technologies and different ways of accessing network products, different methods of controlling quality of these network products have been proposed. One of the most common approaches which are deployed by nearly all of the service providers is Quality of Service or in acronym QoS. This approach just considers layers 2 and 3 of the OSI network model attributes to control the quality of the network services. By increasing the demands of the customers for better qualities and also the curiosity of service providers to find out how much the level of customer's satisfaction is, recently a new approach has been introduced named Quality of Experience. This approach controls the quality of the network product or service from the users' points of views. QoE has been deployed for many network services such as Voice over IP (VoIP), IP Television (IPTV) and so on.

In recent years the services of the mobile networks are increasing rapidly and because of this phenomenon keeping the loyalty of the customers and their satisfaction

towards these services is a challenging task (Nokia, 2004). QoE is a mechanism to measure the satisfaction level of the customers in using a target network service.

Different metrics interact to each other to provide an accurate measure for QoE. Quality of Service (QoS) is an important metric which helps service providers to guarantee their network quality and also helps them to measure their QoE. Two main definitions of the QoS are as follow:

- Based on Balasubramanian (2006) QoS is the capability of the service providers to provide a satisfactory level of their mobile services for customers which include quality of voice, the strength of signal, low level of call blockings etc.
- In Soldani (2006) QoS is defined as the capability and ability of the network to provide its services at an assured service level. QoS uses all procedures, functions and mechanism to provide the negotiated quality level between the user equipment (UE), and the core network (CN).

For Quality of Service (QoS), there are different metrics which are considered for controlling the quality of a network. Some of these metrics are (Jane, 2006):

- Throughput: the rate which the packets traverse through the network.
- Delay: The time that packets take to travel from one side to another.
- Packet Loss: The total number of the packets that are lost during communication.
- Reliability: When the service of a network is always available.

There are different approaches and definitions towards Quality of Experience (QoE). Below are some of these definitions.

Based on Patrick et al (2004) Quality of Experience can be defined as the total perception and opinion of the people when they interact with their environment, where this opinion can be pleasing and enjoyable, or annoying and frustrating.

In O' Neil (2002), QoE is defined as the overall performance of a system from a user's point of view. And in ITU-T Rec.109 the QoE is defined as the overall acceptability of a service from a user.

From all these definitions and approaches the author can understand that QoE focuses on the acceptability and satisfaction level of users towards network services. If we want to depict the relationship between QoS, QoE and the user's satisfaction it would be Figure 1.1.

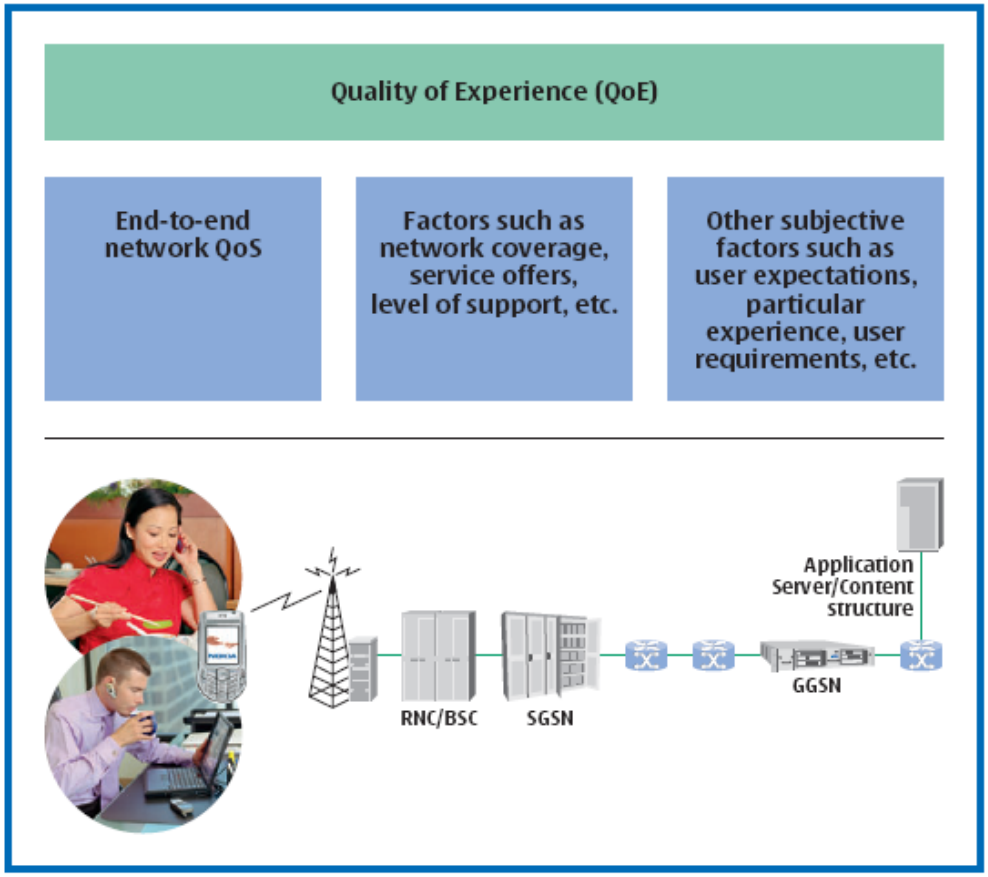

Figure 1.1: Relation between QoS/QoE and User's Perceived Quality (Nokia, 2004)

There are different approaches in measuring QoE. These models can be categorized under two major groups named subjective and objective. Based on ITU-T (1996), in subjective approaches service providers interact with real users and their data are collected in special labs and with special and technical equipments. But in objective ones they just use mathematical approaches and models to measure the satisfaction level of their customers.

In subjective approach they gather data from their users which are presented in numerical format from 1 to 5 which 1 presents the worst quality and 5 is the best quality. Then the average of the voted numbers is presented as the perceived quality. This value

is named as Mean Opinion Score (MOS). Table 1.1 presents the MOS values and meanings.

Table 1.1: MOS Values

Mean Opinion Score (MOS)		
MOS	**Quality**	**Impairment**
5	Excellent	Imperceptible
4	Good	Perceptible but not annoying
3	Fair	Slightly annoying
2	Poor	Annoying
1	Bad	Very annoying

Objective approached just use the technical parameters of the network to measure satisfaction level of users. Based on Sun and Ifeachor (2006) these approaches and models can be categorized under two groups named intrusive models and non-intrusive ones. In intrusive models, they utilize both the input signal and the received or degraded signal, and then they compare them to calculate and measure the received quality to their users. But in another group named non-intrusive, they just use the degraded or received signal. Table 1.2 summarizes intrusive and non-intrusive approaches of QoE measurement models.

Table 1.2: Intrusive and non-intrusive QoE measurement approaches (Sun & Ifeachor, 2006)

Approach	Characteristic	Advantage	Disadvantage
Intrusive	Utilizes both input and output signal to measure QoE.	More accurate	Not suitable for monitoring live traffics.
Non-intrusive	Utilizes just the processed or degraded signal to evaluate the quality.	Idle for monitoring live traffic.	Only uses degraded signal, so they are not as accurate as intrusive ones.

There are different models which are introduced for objective approaches that mostly concern technical aspects of the network and the service. The complete model is introduced by European Telecommunications Standards Institute (ETSI). This model presents the relation between QoE of a network service and different aspects of the network and service itself. Figure 1.2 depicts this model.

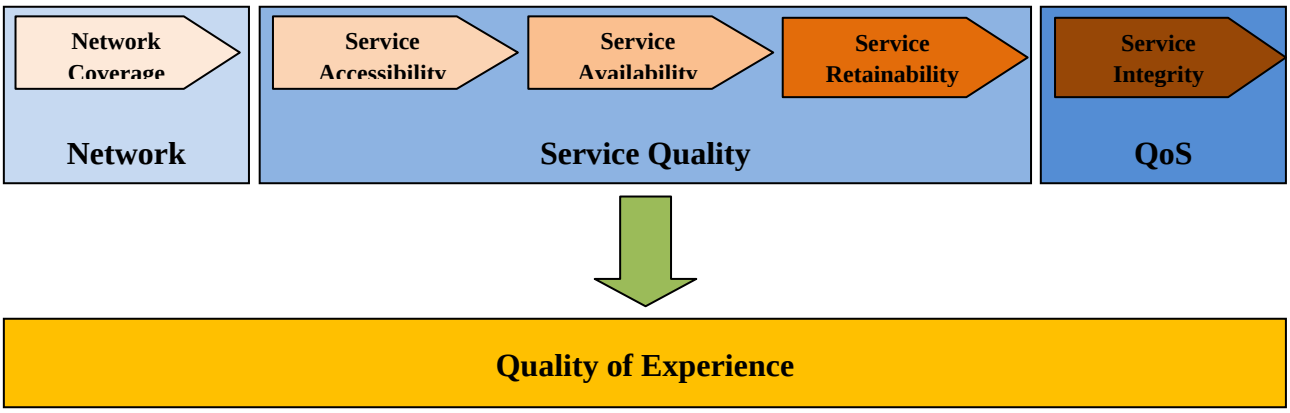

Figure 1.2: ETSI QoE Phase Model

Based on this model, the quality of experience of a network service is the result of having quality from three factors named network quality, service quality and quality from QoS. Each of these factors is affected from different phases. Network quality is presented in term of network coverage, accessibility, availability and the retainability of a service results its service quality, and QoS is presented in service integrity. Most of the existing approaches and models in measuring QoE of IP network services just consider the service integrity phase and do not cover other phases in their calculation and measurement models. So, we need a model which can integrate all these factors and phases to measure QoE of a specific service effectively and accurately.

1.2 Statement of the Problem

The main problem of proposing a new approach in measuring QoE for IP network services is *"How to consider all of the metrics that affect the service quality to measure QoE satisfaction level that is not only complete but also fast in utilization?"* Proposing a new approach based on the current approaches to make their results more realistic would be the main problem of this study.

1.3 Objectives/Purpose of the Study

The objectives of this study are:

i. To identify the usage trend of IP network users among UTM students.
ii. To study Quality of Experience approaches for the service that will be identified in objective 1.
iii. To improve the objective QoE measurement of identified service in objective 1.

1.4 Research Questions

- What is the usage trend of IP network users among UTM students?
- What are the QoE approaches for the identified IP network service?
- How to improve the objective QoE measurement of identified service?

1.5 Significance of the Study

A research by Accenture (Nokia ,2004) shows that the frustration and dissatisfaction of the customers over network services and the inability of service providers in dealing with them and make these services better cause 82% defection of the customers. This study also shows that this defection has a chain effect where one customer is not satisfied with a service he/she will inform other 13 customers about this dissatisfaction.

Operators and service providers cannot afford to wait for their customers to call or contact them to report about their services defection. A survey by Nokia (2004) shown that for every one customer who calls to complaint, 29 others will never call, and also this study found out that 90% of customers just leave them once they face a problem in their services without any complaint.

So, here the only way to cope with this situation and problem is devising a method to measure the satisfaction level of customers continuously and constantly. This study focuses on methods that are utilized to measure this satisfaction level objectively and also try to propose a new approach to make these current approaches more realistic in their values.

1.6 Scope of the Study

The respondents of the first phase of this study are students of UTM University. The users are randomly selected from master students of three engineering faculties of UTM University (Johor Main Campus) named FSKSM, FKE and FKA. For other phases the focus is on the literatures and proposed approaches in study field. For the second objective the scope of the study would be on objective measurement models of QoE and their advantages and disadvantages to find out their drawbacks.

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