EVALUATION OF QUALITY OF SERVICE IN FOURTH GENERATION WIRELESS AND MOBILE NETWORKS

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ABSTRACT

Communication networks extend network capacity and coverage by leveraging network and resource architecture in a dynamic way. However, because of the different communication technologies and quality of service (QoS, managing and monitoring these networks are too difficult. All communication technology has its own characteristics while the applications you use have their own QoS requirements. The methods are based on the QoS analysis for each application or access network separately. However, these methods do not combine all performance and wireless access networks while reporting QoS quality to the group Arrangement. Therefore, it is difficult to obtain any aggregate performance results using these methods. In this project, a methodical method is applied for the QoS analysis of these types of networks. The method uses a fuzzy logic (FL), artificial neural network (ANN) and Adaptive Neuro-fuzzy Interference System (ANFIS) to evaluate and predict the performance QoS of networks. The proposed methods consider the significance of QoS-related parameters, the available network-based applications, and the available Radio Access Networks (RANs) to characterize the network performance with a set of three integrated QoS metrics. The first metric denotes the performance of each available application on the network, the second one represents the performance of each active RAN on the network, and the third one characterizes the QoS level of the entire network configuration. The obtained predicting output were compared to the actual data and to each other to test which system the best for this study. The results ANN model were the closed to the real data than outcome ANFIS model.

ABSTRAK

Rangkaian komunikasi memperluaskan keupayaan dan liputan rangkaian dengan memanfaatkan rangkaian dan arkitek sumber secara dinamik. Bagaimanapun, kerana teknologi komunikasi yang berbeza dan kualiti perkhidmatan (QoS) menilai, mengurus dan memantau rangkaian ini terlalu sukar. Semua teknologi komunikasi mempunyai ciri-ciri tersendiri manakala aplikasi yang anda gunakan mempunyai keperluan QoS sendiri. Kebanyakan semasa. Kaedah ini berdasarkan analisis QoS untuk setiap aplikasi atau rangkaian akses secara berasingan. Walau bagaimanapun, kaedah ini tidak menggabungkan semua rangkaian prestasi dan rangkaian tanpa wayar semasa melaporkan kualiti QoS kepada Pengaturan kumpulan. Oleh itu, sukar untuk memperoleh sebarang hasil prestasi agregat menggunakan kaedah ini. Dalam projek ini, satu kaedah teratur digunakan untuk analisis QoS jenis rangkaian ini. Kaedah ini menggunakan logik kabur (FL), rangkaian neural tiruan (ANN) dan kesimpulan Sistem (IDF) yang digunakan untuk menilai dan meramal prestasi QoS rangkaian. Kaedah yang dicadangkan menilai kepentingan parameter yang berkaitan dengan QoS, aplikasi berasaskan rangkaian yang tersedia dan Rangkaian Akses Radio (RANs) yang tersedia untuk mencirikan prestasi rangkaian dengan satu set tiga metrik QoS bersepadu. Metrik pertama menandakan prestasi setiap aplikasi yang ada pada rangkaian, yang kedua mewakili prestasi setiap RAN aktif di rangkaian, dan yang ketiga menandakan tahap QoS keseluruhan konfigurasi rangkaian Hasil yang diramalkan diperoleh berbanding dengan data sebenar dan satu sama lain untuk menguji sistem mana yang terbaik untuk kajian ini. Keputusan model ANN adalah tertutup kepada data sebenar daripada model ANFIS hasil.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

ANFIS	-	Adaptive Neuro-Fuzzy Inference System
ANN	-	Artifical Neural Network
ANS	-	Access Network Selection
CN	-	Core Network
CFM	-	Context Fusion Module
DFS	-	Dynamic Frequency Selection
FL	-	Fuzzy Logic
HSS	-	Home.Subscriber.Server
KPIs	-	Key Performance Indicators
LTE	-	Long Term Evolutio
MIMO	-	Multi-Input Multi-Output
MS	-	Mobile Station
OFDMA	-	Orthogonal Frequency Division Multiple Access
QoS	-	Quality of service
QoR	-	Quality of Resilience
RNS	-	Radio Network Subsystem
RTMM	-	Realtime Monitoring Module
VHO	-	Vertical Handover
WLANs	-	Wireless Local Area Networks
WWANs	-	Wireless Wide Area Networks

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

A network without appropriate QoS schemes may not be able to manage its parameters and as a result QoS of connections degrades. Consequently, it imposes a requirement on the network operators to re-dimension the network. It goals to report the gap between technical competences and excellence of service tackled by the worker. The analysis is based on live data collected on a commercial cellular network and compared to broadband wireless [1]. A methodology for QoS assessment based on a relatively small set of Key Performance Indicators (KPIs) is devised. The measured data are used to verify the proposed methodology. Multiple-input-multiple-output (MIMO) is an emerging technology which is capable of greatly enhancing the spectral efficiency by serving multiple users at the same time and frequency. The use of more antennas was first proposed for multi-cell multi-user cellular systems and since then, it has received much research interest [2]. It was shown that large multi-input multi-output (MIMO) has very large performance gains compared with the conventional MIMO provided that a sufficiently large number of transmit antennas per active user are employed at each base station (BS). Data services are changing our life in a profound way. Cellular providers make Internet connectivity available anywhere and anytime [3]. This allows for instantaneous access to social networks, employment Intranet, academic environments, shopping, Internet browsing and entertainment [4]. From the user perspective, it is important that regardless of the access platform, there is a guarantee of the QoS with respect to the experience. Cellular companies strive to improve service and provide better experience to their users [5].

The progression and expansion of new wireless and cell advancements have changed the way individuals work and convey [6]. As of late, the versatile information movement is relied upon to achieve 15.9 exabytes every month, and 69 percent of this will comprise of video activity. There will be more than 10 billion portable associated gadgets by 2018, which will surpass the world's normal populace around then. To manage this developing number of gadgets and this huge increment of movement, the remote systems are moving towards an all-heterogeneous engineering. A heterogeneous correspondence organize gives straightforward and self-configurable administrations crosswise over Wireless Local Area Networks (WLANs), Wireless Metropolitan Area Networks (WMANs), and Wireless Wide Area Networks (WWANs). Essentially, heterogeneous systems were foreseen as a coordination of IEEE 802.11 WLANs and different cell advancements [7], with versatile WiMAX as the real player in the center. Be that as it may, LTE-advance has added one all the newer innovation to the image, which would assume a pivotal job in this coordinated design, framing the (4G) or up and coming age of remote systems. The heterogeneous remote access, the elite all IP-based design and the propelled versatility bolster are the key drivers of this generation [8]. Research and development in various areas of cellular technologies has allowed for growth, and advanced development of cellular broadband services. Cellular telecommunication services became a valid alternative of traditional broadband landline connection service. Currently deployed advanced cellular standard is 4G Long Term Evolution (LTE) which allows cellular companies to provide even more advanced services in an efficient manner. With the development of LTE, the speed of the data transmission has increased with respect to the mobile and fixed broadband. The LTE offers support for more services such as voice, data, video and multimedia. It is based on OFDM/OFDMA (Orthogonal Frequency Division Multiplexing / Orthogonal Frequency Division Multiple Access) which is well suited to achieve high peak data rates in high spectrum bandwidth and multipath fading channel [9].

The exponentially increasing demand for high data rate and capacity in mobile communications has created a real challenge for wireless communication network operators, as a large percentage of indoor users suffer from a poor quality of service (QoS). The current mobile system should be equipped to cope with these demands. The third-generation partnership project long-term evolution-advance (3GPP-LTE-A) is a promising technology in this regard, whose objective is to increase spectral efficiency, coverage, capacity and offload traffic from the macro-cell. LTE-A is a progressively evolving technology that adapted generic and novel technologies of orthogonal frequency division multiplexing (OFDM) and multiple input, multiple output (MIMO), in order to accomplish future demands. The packet scheduler implemented in eNB plays a vital role to enhance the QoS [10]. This can be done by allocating time-frequency blocks known as Resource Blocks (RBs) to different users according to their current situations and priorities. Interference from the neighboring cell significantly affects the cell-edge user as well as the system performance. Therefore, inter-cell interference (ICI) has been studied previously to overcome the problems of poor QoS and low throughput of the cell-edge users [11].

1.2 Problem Statement

Communication technique of network has many properties. These networks have their own bandwidth, coverage area and operating frequencies. Quality of service (QoS) characteristics, such as delay, productivity, package loss, as well as usage and implementation costs, differ from each other. As a result, the adaptation of heterogeneous network-based architecture to provide different applications, especially multimedia applications face significant challenges. Among these challenges, quality-of-service issues, such as quality assurance, management and control, remain top of the list. The methods for QoS evaluation of heterogeneous wireless networks have been extensively studied [12]. The motivations for these studies can be categorized as: Access Network Selection (ANS), Joint Admission Control (JAC), Joint Scheduling Control (JSC), and Vertical Handover (VHO) in heterogeneous networks [13]. First, evaluate the quality of service for a single application or a radio access network in a heterogeneous environment to be delivered to a better network. Second, strategies to maintain the quality of service for the current network while accepting the new invitation [14]-[18].

The weights are both subjective and objective in nature. For example, the importance of network-related parameters such as RSS and bandwidth are objective in nature. Application-related parameters such as end-to-end delay, packet loss, and jitter seems objective in nature, some studies reveal that they could be subjective in nature too. For example, a study conducted in Tanzania shows that to evaluate the quality of a network, the users give moderate importance to end-to-end delay over packet loss. Another research study is conducted by the European Telecommunication Standards Institute (ETSI), which reveals that the users give strong importance to end-to-end delay over packet loss. Therefore, the importance of application parameters can vary based on the contexts, for example, between home and an industrial environment or between developed and developing countries.[16].

To assess the quality of service for any network, the available studies categorize each access network by combining different quality of service metrics. The most common parameters, which are considered during this ordering process, are primarily related to the service, the network, and the user [17] (e.g, conversation, streaming, interactive, background), minimum bandwidth, end-to-end delays, productivity, packet loss, bit error rate, cost, transmission capacity, traffic load, current battery status of mobile terminal, and user preferences [18]. To combine these parameters into a single value, initially, the weight of each of these parameters is set according to their relative importance

1.3 Objectives

1- To investigate the QoS evaluation and monitoring approach of heterogeneous communication networks and study a unified metric that will quantify the end-toned QoS of a heterogeneous network configuration.
2- To simulate the traditional QoS parameters into a unified value to quantify the QoS levels of these networks using fuzzy logic, ANN and ANFIS tools (MATLAB).
3- To evaluate results of QoS were comparison to the actual data under all applications used.

1.4 Scope of Study

The project primarily concerned with study fault-tolerant systems and improve network and service quality through proper investigation, monitoring, and management of the systems. The scopes of this research can be summarized as:

1- Study the QoS evaluation of both heterogeneous and homogeneous wireless and mobile networks. Here we use the term heterogeneous to signify the simultaneous presence of several access technologies.To explain further,the term heterogeneous is used when a network engages multiple access technologies for serving various traffic flows. On the other hand, the term homogeneous is applied if a single access technology is present in the network serving single or multiple traffic flows. The primary emphasize of this study is on multimedia applications over cellular and wireless technologies. We choose rural area of a developing country as our context.

2- Gather information from a specific "context and then recommend specific QoS settings based on that context-based information. This type of approach usually examines the values of each traditional QoS-related metrics separately to evaluate the QoS level of any network model.

3- Another "approach could be to determine a unified QoS value of any such model by considering all the potential constraints such as QoS-related parameters, number of users and configuration settings. This way of dealing seems more efficient, however, is rarely used in context of those areas.

4- Uses an entirely new evaluation method based on the fuzzy logic, ANN and ANFIS using MATLAB software concepts. The importance and the acceptable values of the key QoS-related parameters which are identified can change based on the user and network contexts. For instance, the acceptable values of these parameters may vary between a developing country and an industrialized one.

1.5 Outline of study

Chapter 1 explains the background, problem statement, aim, objectives, scope, and includes the report outline. Chapter 2 reviews the previous related works in the current solutions and their existing gaps for QoS evaluation in heterogeneous networks. Then it presents a detailed analysis of fuzzy logic in relation to QoS analysis. Chapter 3 method of evaluation and predict QoS and identify the parameters of the study. Explain the simulation method and input and output parameters using fuzzy logic, ANN, and ANFIS Chapter 4 results and discussion.Chapter 5 conclusion and recommendation

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The advancement and proliferation of modern wireless and cellular technologies have changed the way people work and communicate. By 2018, the mobile data traffic is expected to reach 15.9 exabytes per month, and 69 percent of this will consist of video traffic. There will be over 10 billion mobile-connected devices by 2018, which will exceed the world’s expected population at that time. To deal with this growing number of devices and this massive increase of traffic, the wireless networks are moving towards an all-heterogeneous architecture.The objectives of this chapter are to find the background in the available research on QoS analysis in heterogeneous networks. This review will also help lay the groundwork for the design of a systematic approach to assessing quality of service in this context [19]. Current situations will be analyzed for the latest wireless and cellular technologies, and various interoperability structures in heterogeneous networks. The QoS requirements for different technologies can be illustrated in terms of network-based applications. Current solutions, which propose QoS analysis of heterogeneous networks and detailed analysis of ambiguous logic in relation to QoS analysis are presented. Some of the multi-standard decision-making algorithms applied in the QoS methodology were discussed in this report. A description of the QoS tools and the quality of the available experience, such as the electronic model, was presented and detailed research was made to select a suitable simulation tool for this work.

2.2 Technologies of Wireless Communication

The current states of wireless technologies can be presented as the following:

2.2.1 Wireless Local Area Networks (WLANs)

Common standards for WLANs are 802.11a, 802.11b, 802.11g, 802.11n, 802.11ac and 802.11a. The spectrum available for WLAN is industrial, scientific and medical, from 2.4 GHz to 5 GHz [20]. Average access control (MAC) and physical properties (PHY) for WLANs are determined in 802.11 standards. 802.11 wireless LANs are suitable for creating a local wireless community and sharing resources. 802.11b is the most popular because it is cheaper and has the best signal range. Its frequency ranges from 2.4 GHz to 2.4835 GHz [20]. IEEE 802.11a uses OFDM modulation technology, which helps reduce multipath interference. Works in the 5 GHz band at a rate of up to 54 Mbps at a distance of 10 meters. 802.11g is an 802.11b extension that uses 2.4 GHz and supports a data rate of up to 54 Mbps. These WLAN standards do not contain QoS support. As a result, 802.11e has become a bridge to this gap. 802.11e implements the priority mechanism to support QoS. Priority is assigned to each type of data traffic based on their QoS requirements. 802.11n was proposed to increase productivity. Advanced techniques to increase data productivity in this standard are multiple inputs (MIMO), tire assembly, and channel binding [21]. Channel linking is applied to a set of standard 20 MHz and 40 MHz channels. As a result, 802.11n devices can use twice the width of the channel compared to other standards available in the standard 802.11 family. IEEE 802.11n allows up to four data streams. However, the maximum IEEE 802.11n performance is only possible in the IEEE 802.11n network only. If the network is mixed with IEEE 802.11a/b/g devices, performance will be much lower. The IEEE 802.11ac MIMO runs up to eight data streams for one user. IEEE 802.11ad is another Gigabit standard, operating in the unlicensed 60 GHz band [22]. IEEE 802.11af is essentially a regulatory standard, which intends to operate a WLAN network in a white TV space [23]. To determine usable white space, IEEE 802.11af will use RF technology. This knowledge technology is based on the approved location database. This database provides information on any frequency and at any time and under any circumstances that the networks may operate. The 802.11h standard seems to reduce interference and power consumption. Includes MAC layers, PHY for Dynamic Frequency Selection (DFS), and Power Transmission Control (TPC) [24]. IEEE 802.11i allows security in the 802.11 family, which was previously missing. It combines IEEE 802.11 and 802.1X and Extensible Authentication Protocol (EAP) to provide protection for wireless LANs. Figure 2.1 shows different radio parameters with frequency and data.

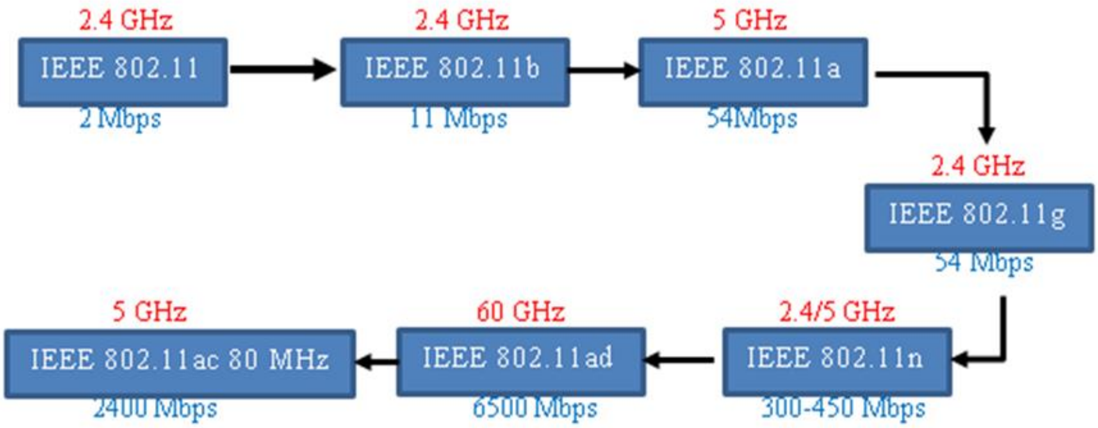

Figure 2.1: Frequencies and Data Rates for different Wireless LAN Standards

2.2.2 WiMAX

WiMAX worldwide interoperability is the marketing of IEEE 802.16, also known as Wireless Metropolitan Area Neatwork (WMAN). Can provide broadband wireless access in both fixed and mobile environments. Because of high bandwidth, it can reduce transmission delay for high quality images. The focus of the core working group was to develop the standard in a range of 10 to 66 GHz, but later changed to 2-11 GHz. It can work in both licensed and unlicensed bands. WiMAX coverage of 30 to 50 km with a data transfer rate of 100 Mbps in 20 MHz bandwidth [25]. The WiMAX network has three main components: Mobile (MS), Access Service (ASN) and Network Communication Services (CSN). ASN consists of base stations and ASN gates. The WiMAX CSN network provides IP connectivity and other core IP network functions. The key elements of the WiMAX network are the following entities [26]:

(A) Mobile Station (MS): The Subscriber Station (SS) is also known as Customer Location Equipment (CPE). There are two types of SS referred to as "internal CPE" and "external CPE". Users can install internal CPE. This may be in the form of a dongle for use on your laptop or computer. External CPE has a better antenna setting.

(B) ASN Gateway (ASN-GW): Gateway Service Access Network (ASN-GW) is responsible for aggregating second class traffic. It is primarily responsible for internal site management and migration, radio resource management and acceptance control, temporary storage of subscriber profiles and encryption keys [27]. ASN-GW is also responsible for the client function of authentication, authorization and accounting (AAA) server, the establishment and management of tunnel navigation with base stations, management of QoS policy, management of foreign proxy functions of mobile IP, and routing to the specified network service connection (CSN). Figure 2.2 illustrates the WiMAX reference model [28].

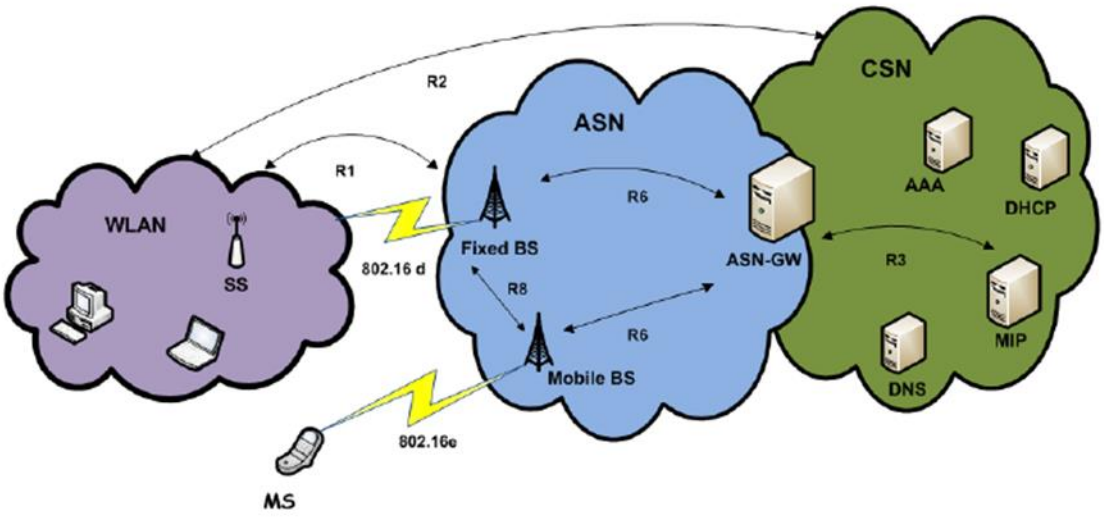

Figure 2.2: WiMAX Network Reference Model

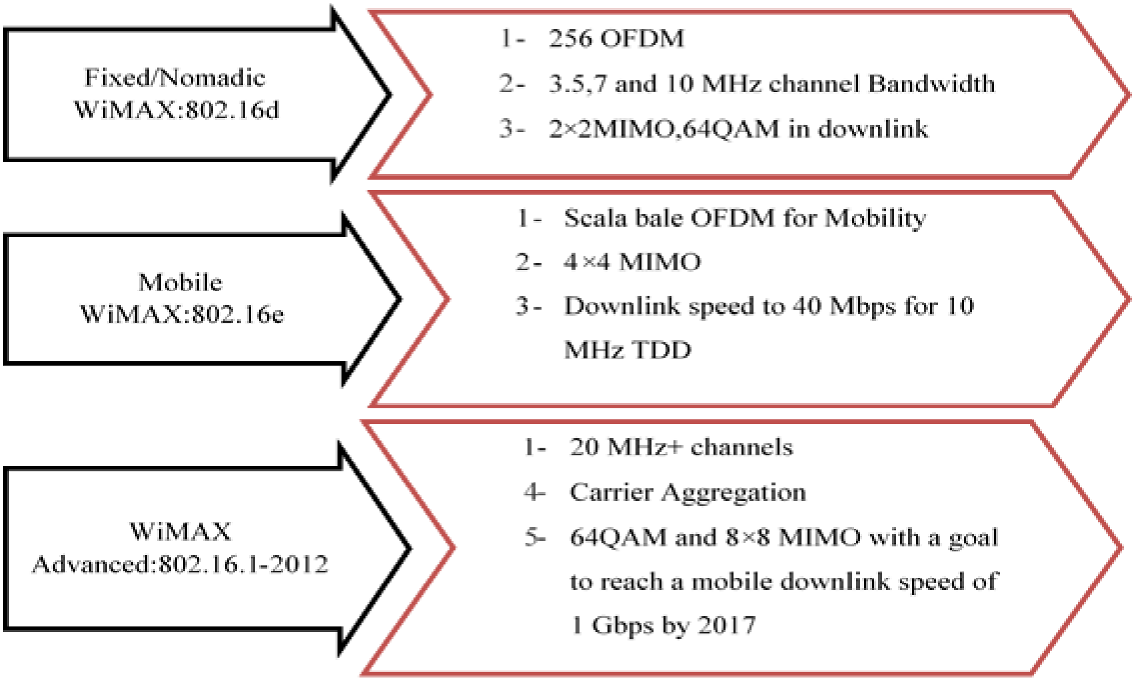

Figure 2.3: Outlines characteristics of different WiMAX technologies

Networks have higher data rates, greater system capacity, and improve spectrum efficiency compared to the second generation. Third generation technologies include UMTS, CDMA2000 and TD-SCDMA. These techniques are based on CDMA [29]. Most GSM / GPRS operators use UMTS as a 3G technology because it has the integrated GSM / GPRS infrastructure. The UMTS wireless interface is 3GCDP [30]. UMTS network consists of three main components: user equipment (UE)

2.3 Radio Network Subsystem (RNS) and Core Network (CN).

UE: The UE contains two separate parts; these are the portable devices (ME) and the UMTS service identification module (USIM).

RNS: The subsystem that controls radio access is usually called UTRAN. UTRAN is divided into several RNSs. The UTRAN radio element is called node B and is also referred to as a base station (BS). The controlling part is called the Radio Network Control Unit (RNC) [31]. RNC is located between Iub and Iu interfaces. It also has a third interface called Iur to maintain RNS bindings [32]. The open interface between UE and UTRAN is Uu and the open interface between IU is between UTRAN and CN. BS Station is located between Uu and UMTS interface. The Iub interface lies between

RNC and BS. UTRAN's primary mission is to create and maintain wireless access networks (RABs) for communication between UE and CN. The RAB mission is to meet the quality of service requirements required by CN.

CN: The core network manages all the network elements needed to switch and control the subscriber. CN manages Packet Switching (PS) and Circuit Switching (CS) domains. The recordset part in the CN is responsible for static subscription and security information. Figure 2.5 shows the UMTS reference structure.

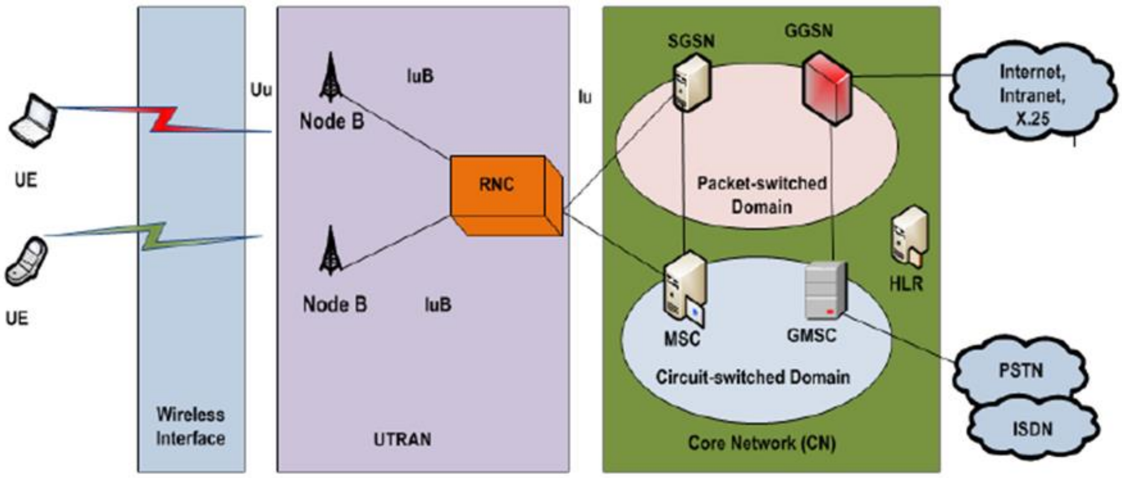

Figure 2.4: UMTS Reference Architecture

2.4 Fourth Generation (4G)

High Speed Packet Access (HSPA +): HSPA + is one of the leading 3G technologies. It is also called HSPA Evolution and Evolved HSPA. HSPA + enables enhanced support and performance for real-time conversation and interaction services, such as Push to Talk (VOIP), photo and video sharing, VoIP and voice over IP (VoIP) features such as multi- MIMO), continuous packet communication (CPC) and high-order combinations [33].

Long-Term Evolution (LTE): The first release of LTE, the LTE version 8, is referred to as exceeding 3G or sometimes as 3.9G [34]. In contrast to the circuit switched circuit model, LTE supports packet switching services only. LTE aims to provide seamless Internet (IP) connectivity between the UE and the packet data network (PDN). The LTE consists of three main components: UE, UTS and EPC. E-UTRAN and EPC together form the Advanced Package System (EPS). The high-level structure of LTE is illustrated in Fig. 2.5.

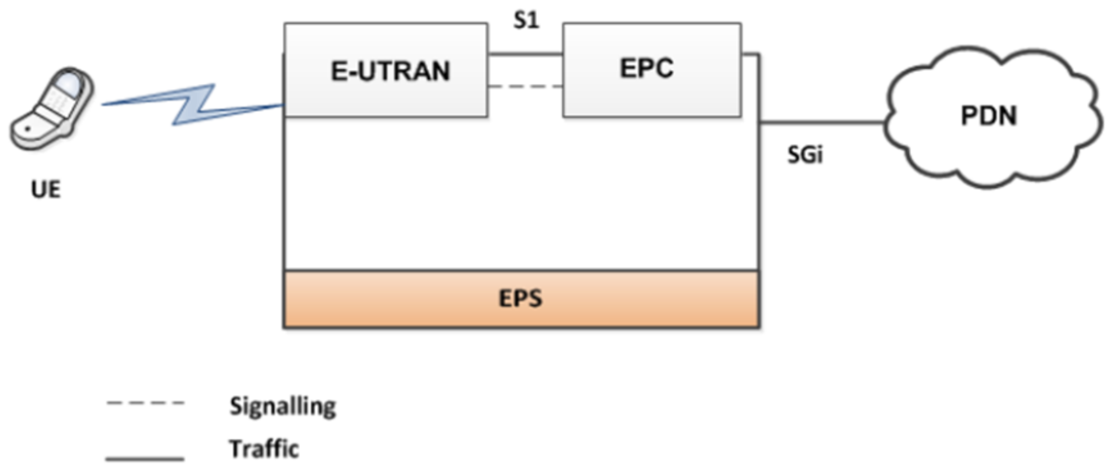

Figure 2.5: LTE High-level Architecture

The LTE core network referred to as EPC contains the following component: [59]

• The Home Subscriber Server (HSS) component is from UMTS and GSM. It is a central database that contains information about all the participants in the network operator.

• Data packet network gateway (PDN-GW) is responsible for communicating with other packet data networks using the SGi interface. Each network of data packets is defined by the access point name (APN). PDNGW plays the same role as GGSN and SGSN for UMTS.

• The Provisioning Gateway (S-GW) serves as a router that redirects data between eNodeB and PDN-GW.

• The Mobility Management Entity (MME) operates the phone at a high level using signalling and HSS messages.

• The PCRF function is responsible for decision-making in policy control as well as control of flow-based shipping functions in the Policy Enforcement Enforcement (PCEF) function. It is in the PDN-GW.

Figure 2.6 shows the global growth of LTE and UMTS according to the Statista report [35].

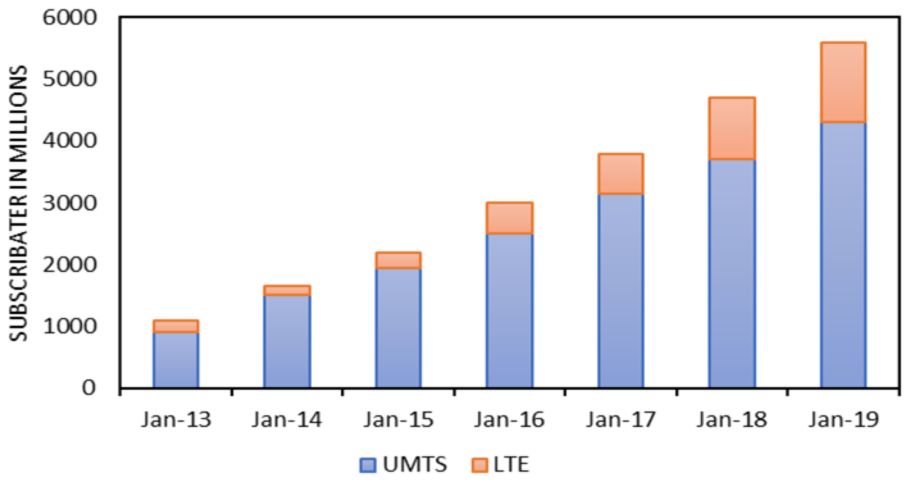

Figure 2.6: Global Growth of UMTS and LTE

2.5 Model of Quality of Service

According to the four-tier Quality of Service model proposed by [36], the QoS model in the network begins by setting customer expectations from the service providers, or more accurately than the core network they use. These expectations also help service providers determine network performance parameters, including packet loss, end-to-end delays, delay or jitter change, productivity, and the like. To achieve the specified values for these parameters, a set of mechanisms is available from the application layer to different network layers [37]. The final part of the model addresses the client's experience with network performance, and the model is related to QoE. Figure 2.7 illustrates the four-tier QoS model.

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