Sudan University of Science & Technology
College of Graduate Studies

Performance Evaluation of Vertical Handover in Heterogeneous Networks

تقويم أداء الإنتقال الرأسى في الشبكات غير المتجانسة

This thesis is submitted as a partial fulfillment for the degree of MSc in Information Technology

Submitted by:

Arwa Mukhtar Abdallah Mohammed

Supervisor:

Dr. Fath Elrahman Ismael Khalifa

الأيـة

قال الله تعالى في كتابه الجليل

(أَمَّنْ هُوَ قَانِتٌ آنَاءَ اللَّيْلِ سَاجِدًا وَقَائِمًا يَحْذَرُ الْآخِرَةَ وَيَرْجُو رَحْمَةَ رَبِّهِ ۗ قُلْ هَلْ يَسْتَوِي الَّذِينَ يَعْلَمُونَ وَالَّذِينَ لَا يَعْلَمُونَ ۗ إِنَّمَا يَتَذَكَّرُ أُولُو الْأَلْبَابِ(9) قُلْ يَا عِبَادِ الَّذِينَ آمَنُوا اتَّقُوا رَبَّكُمْ ۚ لِلَّذِينَ أَحْسَنُوا فِي هَٰذِهِ الدُّنْيَا حَسَنَةٌ ۗ وَأَرْضُ اللَّهِ وَاسِعَةٌ ۗ إِنَّمَا يُوَفَّى الصَّابِرُونَ أَجْرَهُم بِغَيْرِ حِسَابٍ(10))

صدق الله العظيم

سورة الزمر الآيَة (9 – 10)

DEDICATION

I would like to express my deep gratitude to my parents for providing me continuous support throughout the period of this study.

My deep thank to my brothers (Mohamed and Mohamed Al-Samual) and my sisters (Enas and Afag) for their pragmatic supports in all aspects. I would like to send my deep supplication to my brother (Anas) who left us to meet his god in paradise if god wills. Lastly, I would like to thank all my family members for their valuable advice and encouragement during the period of this study.

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Abstract

Handover has a great significance to accomplish seamless connectivity in heterogeneous wireless networks. When existing connections in the Wi-Fi or UMTS network is deteriorated gradually or may not enhance service quality. In case of weak signal level, or unavailable network. Using a vertical handover to select the best network based on required service, application, and location. In this research, our main objective is to evaluate the Vertical handover between Wi-Fi and UMTS networks Using OPNET Modeler software, to know and understand more about the handover process. In this thesis Wi-Fi and UMTS networks different statistics are calculated based on several parameters such as throughput, delay, traffic received and sent, end to end delay for application such as VOICE and HTTP. With regard to this evaluation it found that in Global statistics the delay for UMTS network is decrease by the rate of 18% and throughput value for Wi-Fi network is increase by the rate of 10% the with-handover scenario was improved significantly compare to without-handover scenario. In Node statistics; the delay has decreased for user Wi-Fi by the rate of -63% and -55% for user UMTS, thus the user has been connected to the better network and improved Qos when user moves between Wi-Fi and UMTS.

المستخلص

إن للانتقال أهمية كبيرة لإنجاز الإتصال السلس في الشبكات اللاسلكية غير المتجانسة. عند عدم تحسين جودة الخدمة، نسباً لضعف مستوى الإشارة أو ان الشبكة غير متاحة يتدهورالإتصال في الشبكتين المحلية اللاسلكية والنظام العالمي للاتصالات المتنقلة تدريجيًا . يتم استخدام الانتقال الرأسي لتحديد أفضل شبكة استنادًا إلى الخدمة والتطبيق والموقع المطلوب. في هذا البحث، هدفنا الرئيسي هو تقييم للانتقال الراسي بين الشبكتين المحلية اللاسلكية و النظام العالمي الاتصالات المتنقلة باستخدام برنامج أداة هندسة الشبكة الأمثل، لمعرفة وفهم عملية للانتقال الراسي في الشبكة المحلية اللاسلكية وشبكة نظام الاتصالات المتنقلة العالمي، يتم حساب إحصاءات مختلفة بناءً على عدد من العوامل مثل الإنتاجية والتأخير وحركة المرور التي يتم إرسالها واستقبالها والتأخير من طرف إلى طرف في التطبيقات مثل الصوت و بروتوكول نقل النص التشعبي.

فيما يتعلق بهذا التقييم ، فقد وجدت أنه في الإحصائيات العالمية ، ينخفض التأخير في شبكة نظام الاتصالات المتنقلة العالمي بنسبة 18٪ ، وتزداد قيمة الإنترنت للشبكة المحلية اللاسلكية بمعدل 10٪ ، وبالتالى قد تحسن سيناريو الانتقال بشكل كبير مقارنة مع سيناريو ،الانتقال دون الانتقال. في إحصائيات عقدة فقد انخفض التأخير لمستخدم الشبكة المحلية اللاسلكية بمعدل -69٪ ولمستخدم نظام الاتصالات المتنقلة العالمي -17٪ وبهذا فقد تم اتصال المستخدم بأفضل شبكة وقد تحسنت جودة الخدمة عند انتقال المستخدم بين Wi-Fi و نظام الاتصالات المتنقلة العالمي.

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List of Abbreviations

1G	first generation
2G	Second generation
4G	Fourth Generation
AMPS	advanced mobile phone system
AP	access point
CDMA	code division multiple access
DES	global discrete event statistics
FTP	File transfer protocol
GGSN	gateway GPRS support node
GSM	Global System for Mobile Communication
HO	handover
HTTP	Hypertext transfer protocol
IMT	International Mobile Telecommunications
IP	Internet protocol
kBit	Kilo Bit
LTE	Long Term Evolution
MAC	Media access control address
Mb	Mega bit
MN	mobile node
OPNET	Optimized Network Engineering Tool
Qos	Quality of service
RNC	radio network controllers

RSS	Received Signal Strength
SGSN	serving GPRS support node
TDMA	time division multiple access
UCN	UMTS core network
UE	User equipment
UMTS	Universal Mobile Communication System
UTRAN	UMTS terrestrial radio access network
VHD	Vertical Handover Decision
VHO	Vertical Handover
WLAN	Wireless Local Area Network
Wi-Fi	wireless fidelity
WIMAX	Worldwide Interoperability for Microwave Access

CHAPTER ONE

INTRODUCTION

INTRODUCTION

1.1 Preface

Wireless technologies such as Wi-Fi, WIMAX, 3G, etc. were developed by different standards to provide seamless connectivity with Qos support. These technologies offer variety of services, different data rates and diverse area of coverage. [1]

The limitations of these wireless access networks can be overcome by joining these technologies through Vertical Handover (VHO) interworking architectures which is essential to provide everywhere wireless access ability with high coverage area, high data rate and low cost. [2]

A heterogeneous network here means that a combination of 3G (UMTS) and Wi-Fi network technologies and access to these technologies when needed, taking into account different kind of communication requirements at specific situations and user needs.

Vertical handover, in heterogeneous networks can be initiated for convenience rather than connectivity reasons. A decision algorithm gives a better performance when several parameters are considered, more so when a combination of static and dynamic parameters are considered. But the tradeoff is with the increase in decision time and complexity of the algorithm. The decision may depend on various groups of parameters such as Network- Related Parameters, Terminal Related Parameters, User-Related Parameters and Service Related Parameters.

One of the most important parts of any wireless network is Handover process. And it is the process of maintaining a user's active sessions when a mobile terminal changes its connection point to the access network for example a base station or an access point. Handover can either be horizontal or vertical. A horizontal handover takes place between point of attachment supporting the same network technology, for example between two neighboring base stations of a cellular network or two access points. Vertical handover takes place in heterogeneous wireless networks [3].

1.2 Problem Statement

When existing connections in the Wi-Fi or UMTS network was deteriorated gradually or may not enhanced service quality in case of weak signal level or in case of no available network. That lead mobile user directly search for high performance connection in other access network. The Presence heterogeneous networks coverage (4G, 3.5G, 3G, and Wi-Fi).

1.3 Proposed Solution

Using a vertical handover to select best network based on required service, application, and location. Using two parameters received signal strength and available Bandwidth. On other hand the proposed model enable the user connected to the better network.

1.4 Objectives

General aim of this research is to

Evaluate the Performance of vertical Handover in Heterogeneous Networks

The Specific objectives include:

- To simulate the vertical handover in heterogeneous wireless networks using OPNET simulation.
- To improve the Quality of Service (Qos) and Increase throughput for calls.
- To reduce delay for mobile users in networks.

1.5 Methodology

The Vertical handover model have been implemented to trigger handover at the optimal time to the optimal network Based on received signal strength and available Bandwidth of network parameters that will increase performance of these heterogeneous networks in terms of throughput for call and reducing delay in multi networks. In this research there are two types of heterogeneous networks; Wi-Fi and UMTS that they were implemented and tested by using OPNET modeler simulation, to create an environment to simulate both scenarios with-handover and without-handover scenario and assess performance. Then we will evaluate the performance of these heterogeneous networks in terms of overall network and specific node for user mobility. Finally, two scenarios are compared to show the results and draw conclusions of Vertical handover.

1.6 Research importance

The research focusing on vertical handover between Wi-Fi and UMTS network to solve the limitation problem of network coverage.

1.7 Thesis Outline

This thesis composed of five chapters their outlines are as follow:

- Chapter Two: Is the Literature Review

  Introduces the evolution of mobile communication system, Different wireless technologies such as WLAN and UMTS, the heterogeneous wireless network and mobility management.
- Chapter Three: Simulation Model

  Is presented the vertical handover between Wi-Fi UMTS and the system model of the research.
- Chapter Four: Results and discussion

  This chapter is provides the results of work done and discussion the results.
- Chapter Five: Conclusion and Recommendation

  This chapter concludes the work done in this thesis and gives the recommendation for future work.

CHAPTER TWO

LITERATURE REVIEW AND RELATED WORK

LITERATURE REVIEW

2.1 Background

2.1.1 Evolution of Cellular Mobile Technologies

Recently, communication technologies have become an integral part of people's daily life [2]. Mobile radio has been in use for about 80 years, but it took 40 years for mobile phones to have full duplex channels. Mobile communications play a big role in terms of voice/data network arena. With increasing in the demand of communication and number of mobile subscribers, telecommunication companies are working to bring new technologies into existence with better features so as to meet up the user requirement. Mobile systems are divided into generations according to their data rates and services as illustrated in Figure 2.1.

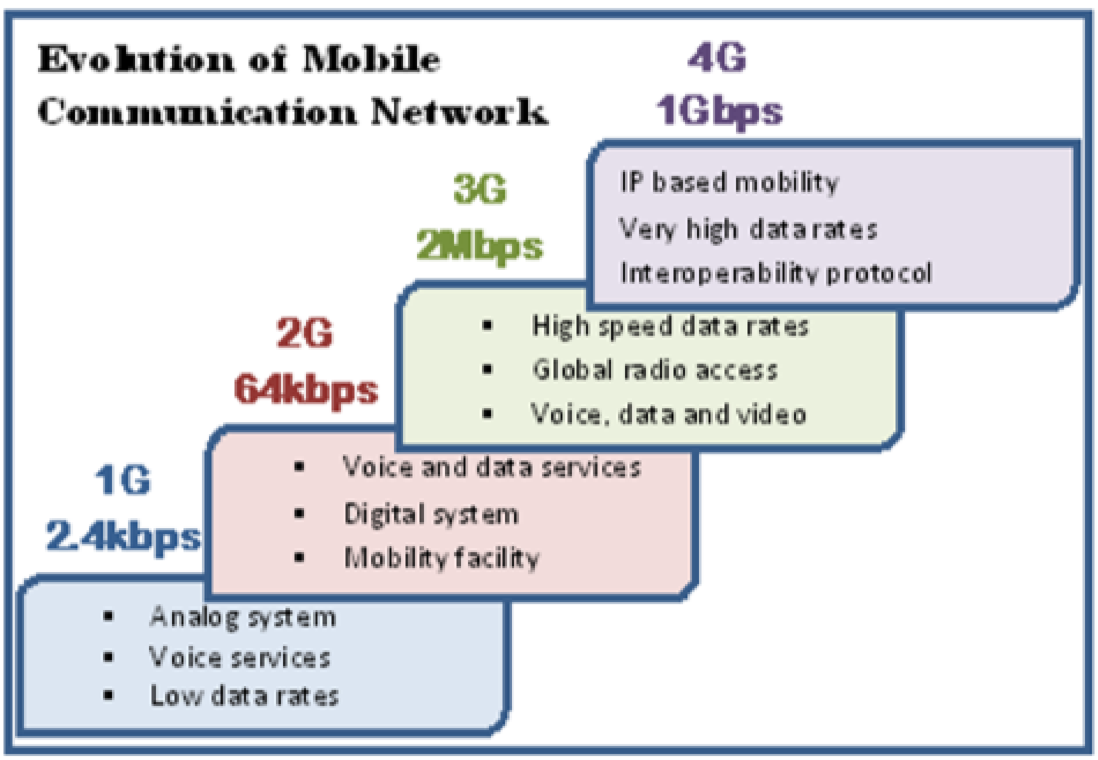

Figure 2.1 Evolution of Mobile communications from 1G to 4G [8]

The first generation (1G) mobile communication was based on the analog system. The most popular analogue 1G systems were advanced mobile phone system (AMPS). All of the standards in 1G use frequency modulation techniques for voice signals. The spectrum within cell was divided into number of channels which was not efficient in terms of the available radio spectrum, and this placed a limitation on the number of calls that could be made at any one time. Analog systems were based on circuit switching technology and offers only voice communication and no data communication. After the introduction of 2G technology mobile communications have undergone significant changes and experienced enormous growth and the number of subscriber reached nearly 20 million by 1990 [8]

Second generation (2G) mobile systems use digital multiple access technology, so that the analog technology was replaced by Digital Access techniques such as TDMA (time division multiple access) and CDMA (code division multiple access). Consequently, compared with first generation systems, higher spectrum efficiency, better data services, and more advanced roaming were offered. The GSM or Global Systems for Mobile Communications is most popular in 2G wireless technology also GSM, uses TDMA technology to support multiple users. The TDMA breaks down data transmission, such as a phone conversation, into fragments and transmits each fragment in a short burst, assigning each fragment a time slot. With a cell phone, the caller does not detect this fragmentation. During development over more than 20 years, CDMA uses spread spectrum technology to break up speech into small, digitized segments and encodes them to identify each call. The CDMA distinguishes between multiple transmissions carried simultaneously on a single wireless signal. It carries the transmissions on that signal, freeing network room for the wireless carrier and providing interference-free calls for the user. The CDMA breaks down calls on a signal by codes, whereas TDMA breaks them down by time. The result in both cases is an increased network capacity for the wireless carrier and a lack of interference for the caller. [8]

Third Generation (3G) networks are characterized by Faster data rates, Supports multimedia applications such as video and photography, video call and video conferencing, High speed mobile internet access and increased capacity. The 3G fulfils the specifications of International Mobile Telecommunications-2000 (IMT- 2000), the official International Telecommunication Union which intended to provide wireless access to global telecommunication system. The most important IMT-2000 proposals are the Universal Mobile Telecommunications System (UMTS) as the successor to GSM [8].

Fourth Generation (4G) networks is an emerging technology in the field of communication. As the data requirements increased, efforts were made to improve the downlink and uplink throughput rates by employing higher modulation techniques. Third Generation Partnership Project (3GPP) launched the Long Term Evolution (LTE) project in November 2004 in order to ensure the continued competitiveness of the UMTS in the future. As LTE is considered as the evolution of universal mobile telephone system (UMTS), hence LTE's equivalent components are thus named evolved

LTE is completely an all IP based system. Since there are provisions in LTE for inter-operation with existing systems, there are various paths available to connect to LTE. Due to this increased flexibility, LTE is the choice of majority of operators worldwide. Moreover, it provides better mobility, efficient radio usage, high level of security, flexible spectrum utilization, reduced delay/latency, cost efficient deployment and various other advantages which makes LTE more reliable and user friendly [8]

2.1.2 Wireless Technology Evolution

The wireless technology such as Wi-Fi or UMTS attempts to bring broadband applications to users on the move with the functionality of portability and mobility [2].

2.1.2.1 WLAN/Wi-Fi Networks

WLANs based on the IEEE 802.11 (Wi-Fi technology) specification family have gained popularity as being low-cost solutions that are easy to install and provide broadband connectivity, and such networks are being widely deployed in private spaces (e.g. homes and workplaces and as hotspots in public spaces, waiting areas and hotel lobbies). In wireless network communication, nodes communicate with others using wireless channels. Two important issues are employed in the wireless networks, the spectrum frequency ranges and different data rates. For example IEEE 802.11a/g use 54Mbit/s where IEEE 802.11b used 11Mbit/s. The signal strength in a wireless medium decreased when the signal travels further beyond a certain distance, the strength reduced to the point where reception is not possible. Traditional networks require re-configuration of IP address used by these host or subnet at the new location. An interface enables with Mobile IP allows these hosts or subnet to move without any manual address re-configuration. In an attempt to conclude the different IEEE 802.11 standards are listed in Table 2.1. [14]

Table 2.1 Summary of IEEE 802.11 standards description [14]

Standard	Description
IEEE 802.11a	Supports rates of up to 54 Mbps in the 5 GHz ISM band
IEEE 802.11b	Supports rates of up to 11 Mbps in the 2.4 GHz ISM band
IEEE 802.11c	Supports wireless AP bridge operations
IEEE 802.11d	Supports internationalization
IEEE 802.11e	Supports Qos enhancement mechanisms
IEEE 802.11f	Addresses interoperability of Apps from different vendors
IEEE 802.11g	Supports rates of up to 54 Mbps in the 2.4 GHz ISM band
IEEE 802.11h	Supports power control for 5GHz range requirements
IEEE 802.11i	Deals with security issues
IEEE 802.11n	Supports high data rates up to100 Mbps

2.1.2.2 Universal Mobile Communication System (UMTS)

The universal mobile communication system is one of the third generation technology .UMTS provide fully integrated digital communication with maximum data throughput up to 2Mb/s .high data transfer and data compression make possible high quality video streaming, and comfortable access to web server. UMTS become perfect tool for providing video conference .UMTS used packet switch connection [2].

The architecture of UMTS core networks is an adaptation of its GSM predecessor. The release'99 architecture depicted below contains all the traditional GSM core network components with the addition of two packet handling nodes – The SGSN and GGSN. These two nodes work collectively enabling UMTS networks to exchange information with external data networks.

- The SGSN is the central element in the packet switched network. The main SGSN functions are mobility management, traffic routing and user information and authorization. In addition to this, it provides a number of functionalities such as ciphering and compression. The SGSN location register stores location information (e.g. Current cell, current VLR) and user profiles (e.g. IMSI and temporary identities) of all users registered with this SGSN [13].
- The GGSN acts as an interface between the UMTS backbone network and external packet data networks. It converts packets coming from the SGSN into the appropriate packet data protocol (PDP) format (IP or X.25) and sends them out on the corresponding packet data network. In the other direction, PDP addresses of incoming data packets are converted to the UMTS address of the destination user. The readdressed packets are sent to the responsible SGSN. For this purpose, the GGSN stores the current SGSN address of the user and their profile in its location register. The GGSN is also responsible for charging and authentication. [13]

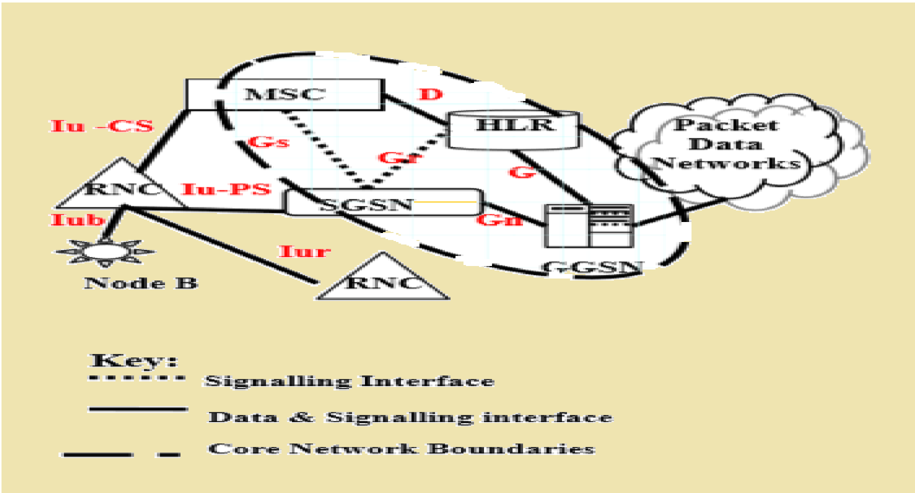

Figure 2.2 UMTS Network Architecture [13]

2.1.3 Heterogeneous Wireless Networks

The users of mobile communication networks has increased rapidly that is lead to increase of users demand for mobile services as well as the need to access information anywhere, anytime. No single wireless radio access technology will deliver all required services to all end-users anywhere anytime. It will also be, in each geographical area the wireless infrastructure forming from a variety of radio access technologies. Overlapping coverage is a typical feature where there is a choice for the end-user to connect to more than one radio access technology, either within the same Overlapping domain or across borders. Simply heterogeneous networks integrate several IP-based access technologies in a seamless way as illustrated in Figure 2.3. every network provide Qos in terms of higher data rates in selected areas at a lower cost to the end users in addition to that it increased wireless capacity and complexity of network components [2]

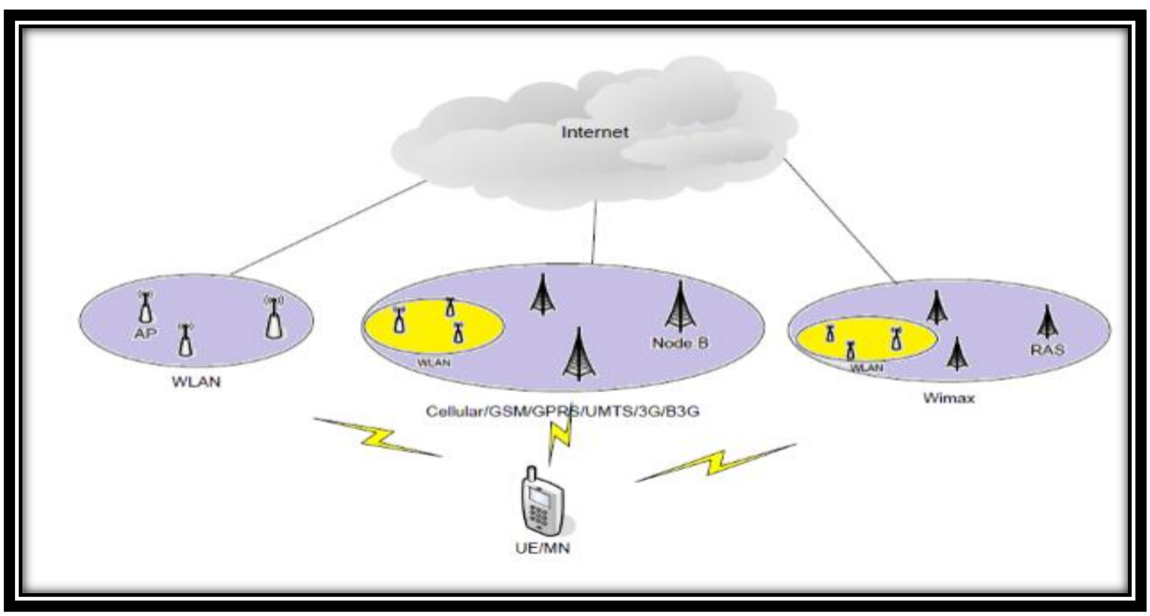

Figure 2.3 Integration of heterogeneous wireless access networks [11]

2.1.4 Handover Management in Heterogeneous Network

Heterogeneous environments are expanding and mobile devices often have built in support for multiple network interfaces. Seamless roaming or mobility is important and requires network management operations to avoid service degradation. Both location management and handover management constitute mobility management. Location management involves two processes. The first process is called location registration, or location update, in which the mobile terminal periodically informs the network of its current location, which leads the network mobility and mobility support procedures for wireless networks. Handover management includes wireless terminal handover management considerations within one network called horizontal handover and handover management across different wireless networks which could be based on different wireless access technologies termed vertical handover. [4] Handover management is divided into four part as in Figure 2.4.

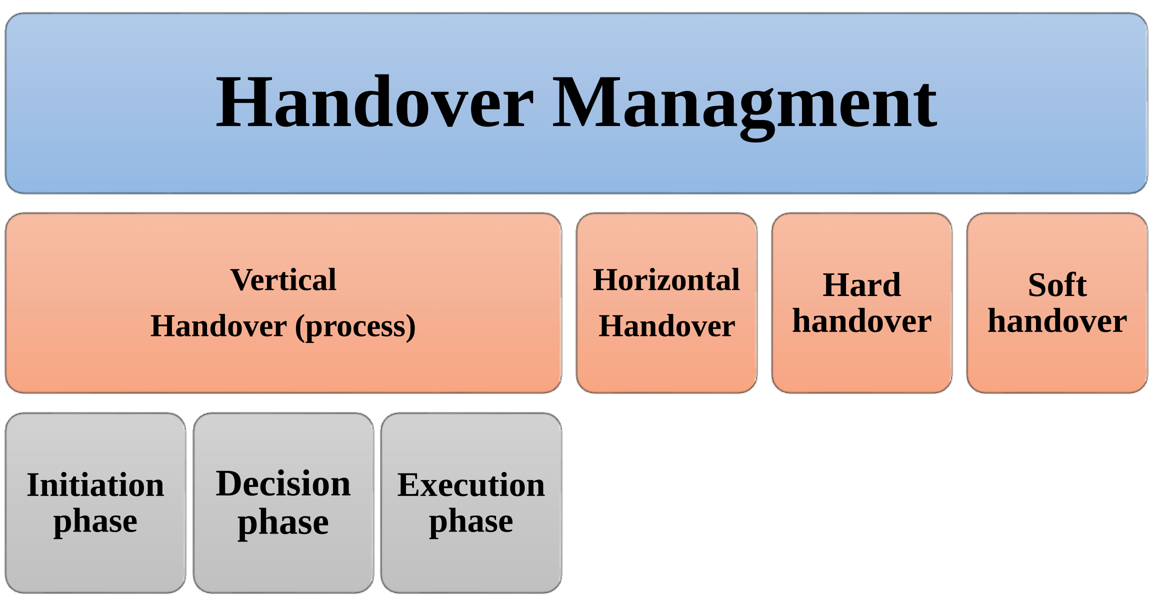

Figure 2.4 Handover Management Environment

2.1.4.1 Soft Handover

It is based on make-before –break handover which means that one or more radio links from the nearest base stations are established without losing the radio link of the current base station. At this point, a decision is not yet made to specify cell to which the mobile will be transferred. Also the mobile is always connected to at least one radio link that is why it was able to communicate with multiple access networks simultaneously at any time [5].

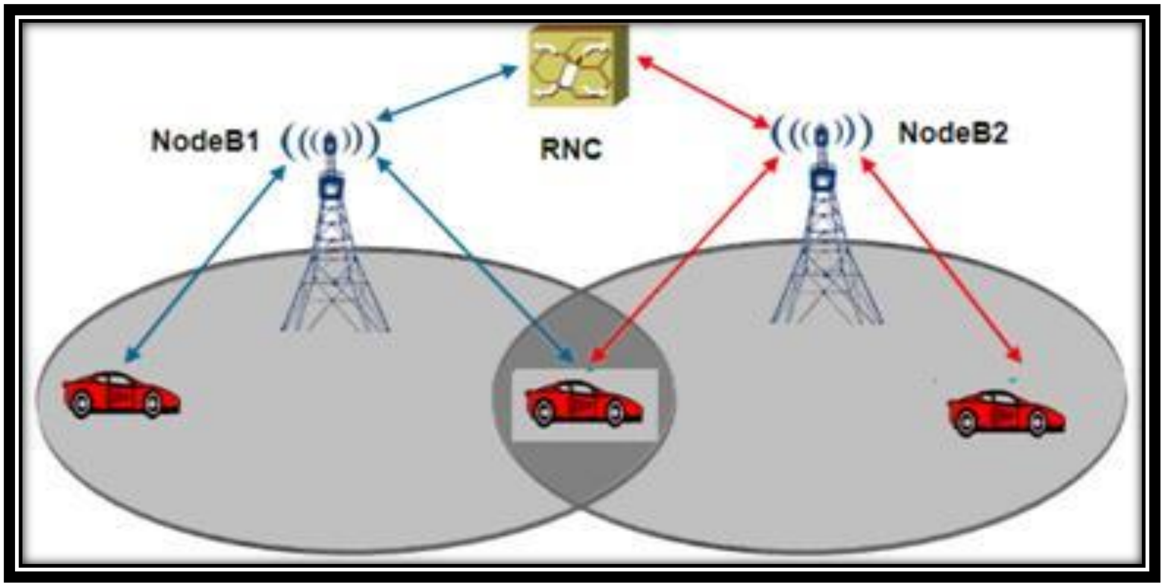

Figure 2.5 Soft handover [6]

2.1.4.2 Hard Handover

It is based on the break-before make handover which means that the radio links between the mobile and the base station in the old cell are released then, the new links in the new cell are established. The mobile has at most one set of radio links with one base station at any time. [5]

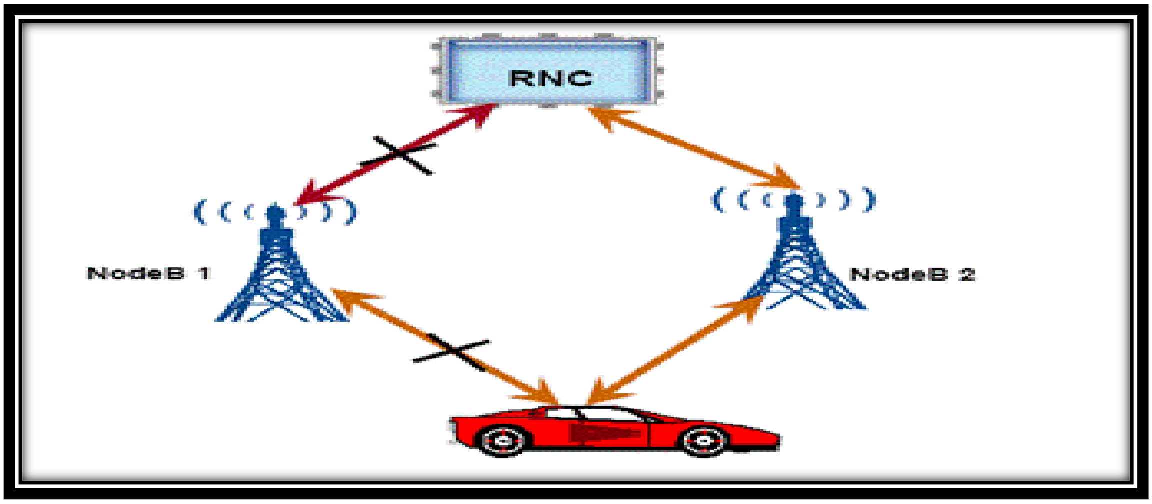

Figure 2.6 Hard handover [6]

2.1.4.3 Horizontal Handover

The handover take place between the cells of same wireless access technology [5] as in Figure 2.7. Here mobility is performed on the same layers. In this handover technique the on-going calls are to be continued, even though the IP address changes due to the mobile node movement. This handover may be categorized according to the direction of handover invocation. [12]

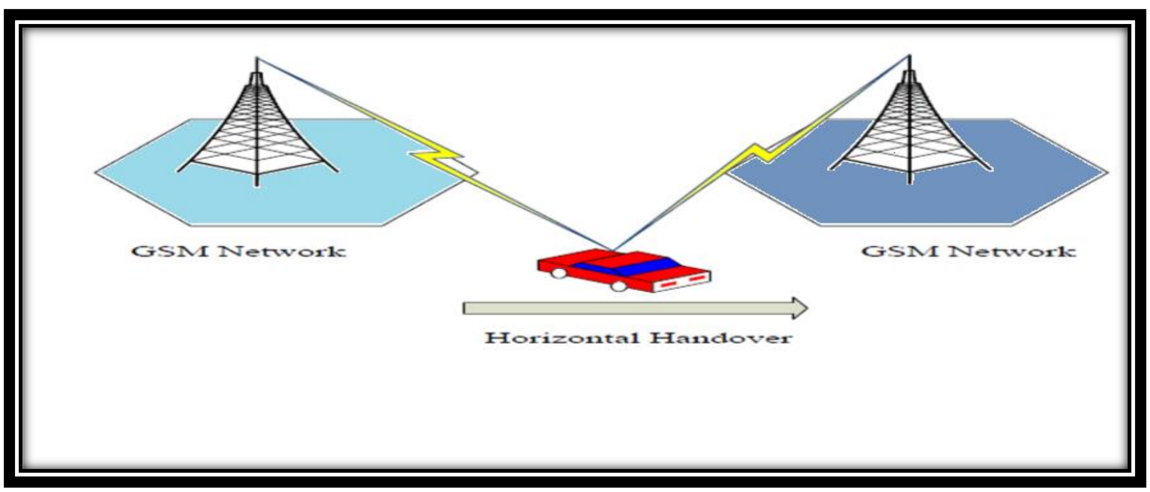

Figure 2.7 Horizontal handover [2]

2.1.4.4 Vertical Handover

The handover occurred between the cells of different wireless access [5]. As in Figure 2.8. In vertical handover the mobility is performed between the different layers and the users can move between different network technologies. In vertical handover the mobile travels across many heterogeneous networks and not only changes the IP address but also the Quality of Service (Qos) characteristics and even changes the network interface [12].

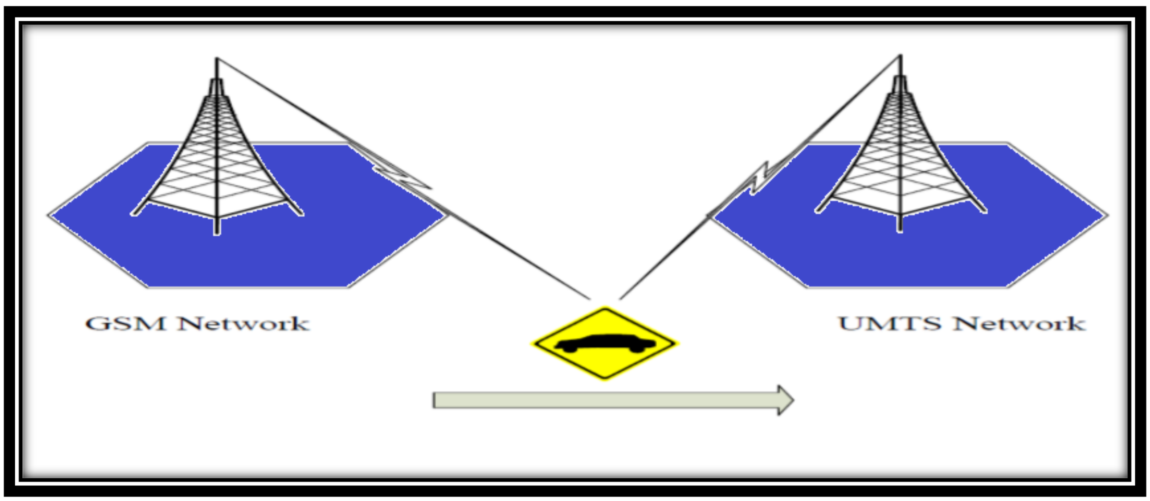

Figure 2.8 Vertical handover [2]

2.1.5 Handover Process

The handover process is divided into three phases: initiation phase, decision phase and Execution Phase as shown in Figure 2.4. Periodically the system monitors for a better network which the mobile terminal can be handed over. The handover considerations include several different criteria depending on the algorithms and the goals set for handover. [4]

2.1.5.1 Initiation Phase

In this phase, in order to start the handoff event, information to be collected about the network from different layers likes Link Layer, Application Layer and Transport Layer. These layers provide the information such as RSS, power, link speed, cost, bandwidth, jitter, user preferences and network subscription, throughput etc. Based on this information handoff will be initiated in an appropriate time. [12]

2.1.5.2 Decision Phase

In this step, mobile device decides whether the connection to be continued with current network or to be switched over to another one and the decision may depend on various parameters, which have been collected during handover initiation phase. [12]

2.1.5.3 Execution Phase

After the network selection procedure, the new link is established between the mobile node and target base station. The current network transfers the information regarding mobile node to the target network. After that the mobile node is disconnected from the previous network and connected to the new one. In this phase, new registration and care of address is provided to the mobile node [5].

2.1.6 Vertical Handover Criteria

There are some parameters used in the VHD algorithms as in Figure 2.9

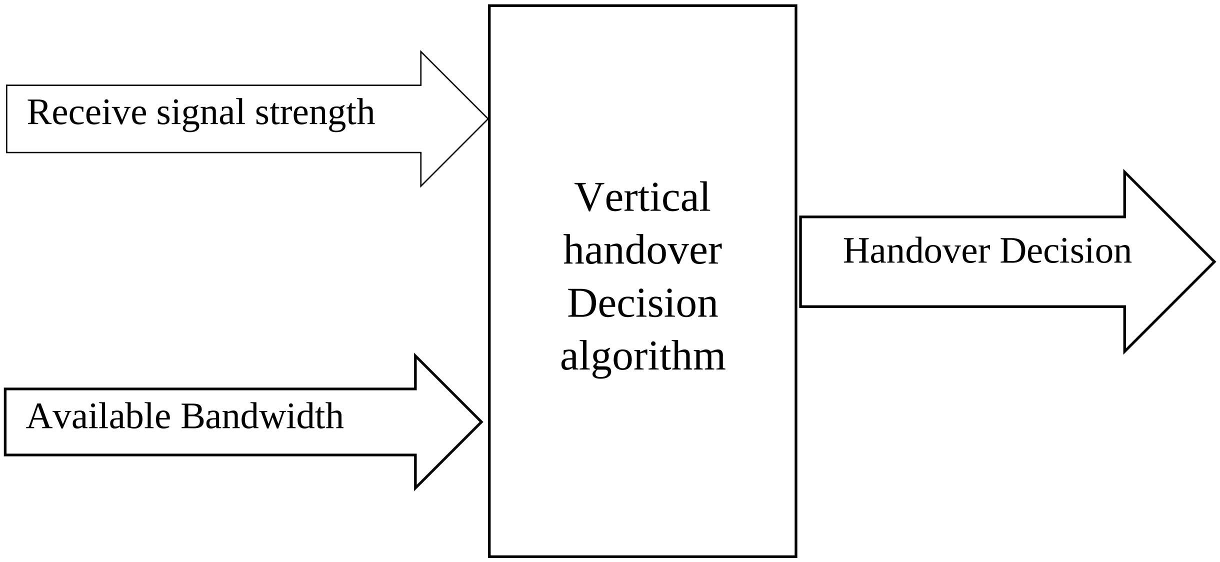

Figure 2.9 Parameters used for Making VHD Decisions [2]

- **Received Signal Strength (RSS)** is an important criterion for VHD algorithms. It also refers to a measurement of the power present in a received radio signal and is directly related to the service quality. in addition to that the RSS does NOT decrease linearly as the distance increases and it is affected by many factors such as (the antenna of the device that is transmitting, the antenna of the node itself, the number of walls and other obstructions in proximity of the nodes., The material of the objects inside the environment., the number of people.). The RSS values are measured in dBm and have typical negative values ranging between 0 dB-milliwatt (excellent signal) and -110 dB-milliwatt (extremely poor signal).Majority of existing horizontal handover algorithms use RSS as the main decision criterion.[9]
- **Available Bandwidth** is a good indicator of traffic conditions in the access network. Also it is a measure of available data communication resources expressed in bit/s in addition to that it is especially important for delay-sensitive applications. [3]

2.2 Related Works

The authors in [1] proposed three wireless technologies WLAN, WIMAX and UMTS are integrated for communication using OPNET Modeler. The performance of integrated network is evaluated using different applications such as FTP, VOICE and VIDEO with Various parameters delay, packet loss, jitter and latency and compared them. The simulation results show when applications are changed the parameters changes.

The authors [2] proposed the vertical handover techniques for mobile users in order to reduce the unnecessary handover and handover failure. By takes the receive signal strength (RSS), available bandwidth, Travelling time prediction and mobility as decision parameters. By using MATLAB-2013 simulation program to make handover decision. It is found that when the handover delay is (ti =1s) the probability of unnecessary handover is equal ZERO. And when the handover delay is (ti=455ms) the probability of unnecessary handover is equal 0.04. Therefore, the probability of handover failure when the handover delay is (ti=1s) it is reduced by 69.28% .And when the handover delay is (ti=455ms) the probability of handover failure is reduced by 85.71%.

The authors of [3] proposed to simulate the vertical handover decision making in heterogeneous wireless networks and evaluate the QoS for voice and data, using different basic bandwidth unit; this was done through a system-level MATLAB simulation. Different scenarios were considered. One of result the user moves away from the RAT, the RSS decreases then need handover to another network. also when providing a user with a high Qos, that is using a high value of Basic Bandwidth Unit, for a single call, the number of channels available is less than when using a low value of Basic Bandwidth Unit and providing the user with a low Qos for a single call.

The authors of [4] proposed the performance analysis of various types of wireless networks with many applications and two types of handoff using OPNET simulator. The simulation results show the successful implementation and simulation of the deployment of WLAN into WiMAX and UMTS network by using multiple network interfaces. It found that it is very difficult to successfully complete the vertical handoff between WLAN-

WiMAX and WLAN-UMTS without carefully and accurately engineering the WLAN network due to highlighting the fundamental different in HWNs.

The authors of [6] proposed the horizontal handover by focuses on the quality of service (Qos) of soft and hard handover in UMTS network, the performance analysis of UMTS network is done for voice conferencing with Different parameters using OPNET Modeller. The simulation results show that the uplink transmission power, traffic sent, throughput, received power and signal to noise ratio of network with hard handover are good as compared to the network with the soft handover. But the upload response time in soft handover is higher than the hard handover. The total transmit load, total received throughput, traffic received, delay and end to end delay are some of two types of handover in UMTS network.

The authors of [7] proposed the integrated WLAN and UMTS network the performance of these two networks has been evaluated for video conferencing and FTP applications on the basis of load, delay and throughput as quality of service (Qos) parameters using OPNET Modeller. The throughput of network with ftp application is good as compared to the network with video conferencing. But the delay in video network is higher than the ftp network.

CHAPTER THREE

SIMULATION MODEL AND STEPS DESIGN MODEL

SIMULATION MODEL

In this chapter the internetworking of the proposed model is introduced to enable the user to connect to better network with the best system depending on two parameters which are received signal strength and available Bandwidth. Also describes the simulation model and the simulation design using OPNET Modeler 14.5.

3.1 Vertical Handover Decision (VHD)

The proposed vertical handover decision for user connected with better network according to the RSS and available bandwidth parameters.

3.1.1 Vertical Handover Diagram for User Connected to WLAN

Figure 3.1 shows the flowchart of vertical handover execution of user connected to Wi-Fi network. Basically the user connected to the Wi-Fi network, unless there is a deterioration in this network the user vertically handover to alternative network such as UMTS. Number of system parameter should be checked to make this decision. Firstly, scans the existing network to determine RSS of Wi-Fi. Secondly, check the available bandwidth status of the user. Then if the Wi-Fi has strong RSS, it will stay in Wi-Fi and channel is assigned, otherwise; vertically handover to UMTS based on RSS and available bandwidth.

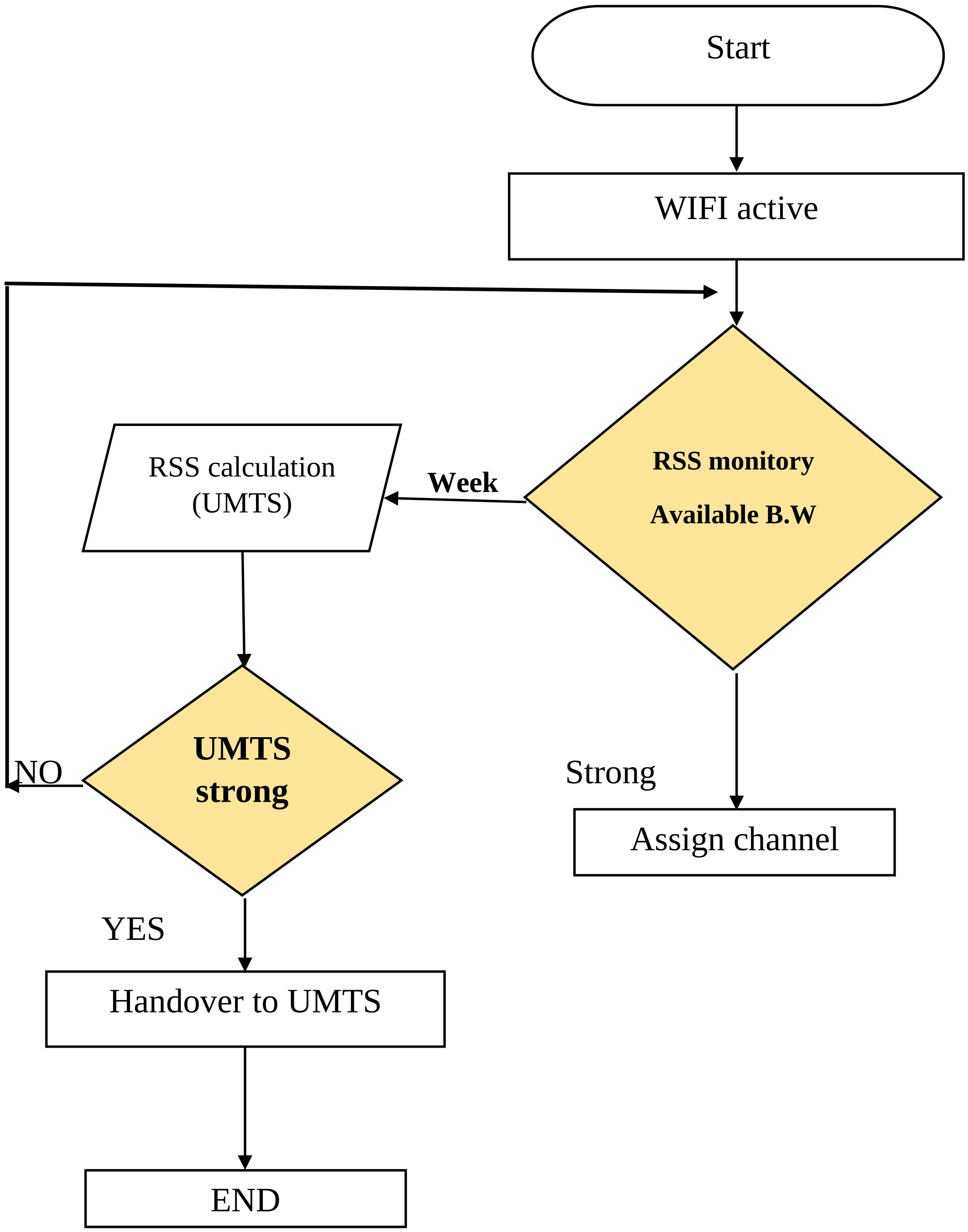

Figure: 3.1 vertical handover Flowchart from WLAN to UMTS

3.1.2 Vertical Handover Diagram for User Connected to UMTS

Figure 3.2 shows the flowchart of vertical handover execution, of user connected to UMTS network.

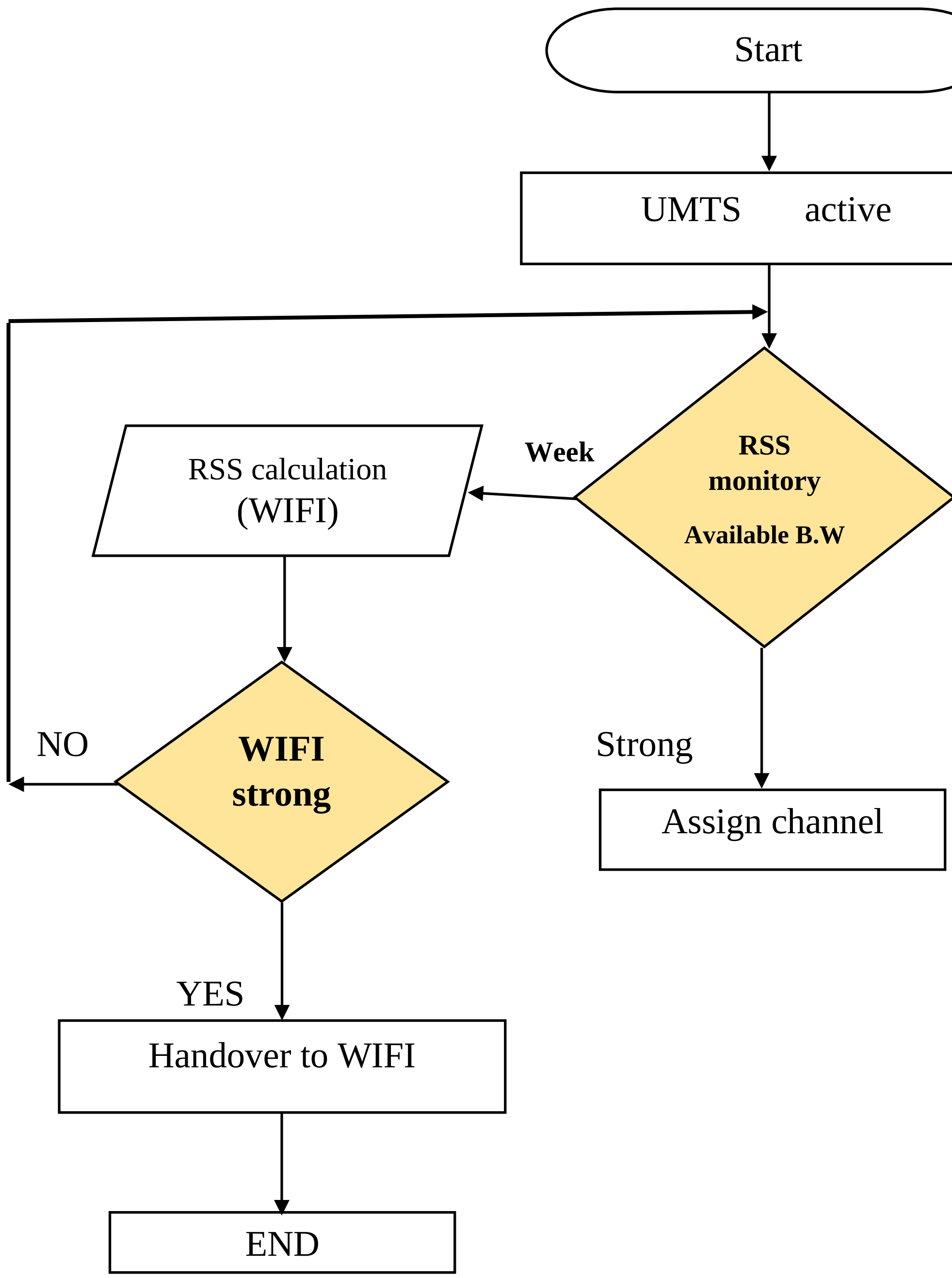

Figure: 3.2 vertical handover Flowchart from UMTS to WLAN

Again, the same process is done to UMTS. Basically the user connected to the UMTS network, unless there is a deterioration in this network the user vertically handover to alternative network such as Wi-Fi Number of system parameter should be checked to make this decision. Firstly, scan the exist network to determine RSS of Wi-Fi and UMTS. Soundly, check the available bandwidth of the user’s status. Then if the UMTS has strong RSS it will stay in UMTS and channel was assigned, otherwise; vertically handover to Wi-Fi based on RSS and available bandwidth.

3.2 Network Model

Depending on UMTS and Wi-Fi heterogeneous network as illustrated in Figure 3.3 the proposed topology of UMTS network consists of one Node_B, 9 UE, RNC, and SGSN/GGSN nodes. The coverage of cell in the area is approximately 5km. The proposed topology of Wi-Fi network model consists of one Wi-Fi Aps, 7 UE and router. Furthermore, there are 4 servers, ftp server, E-mail server, web server and voice server.

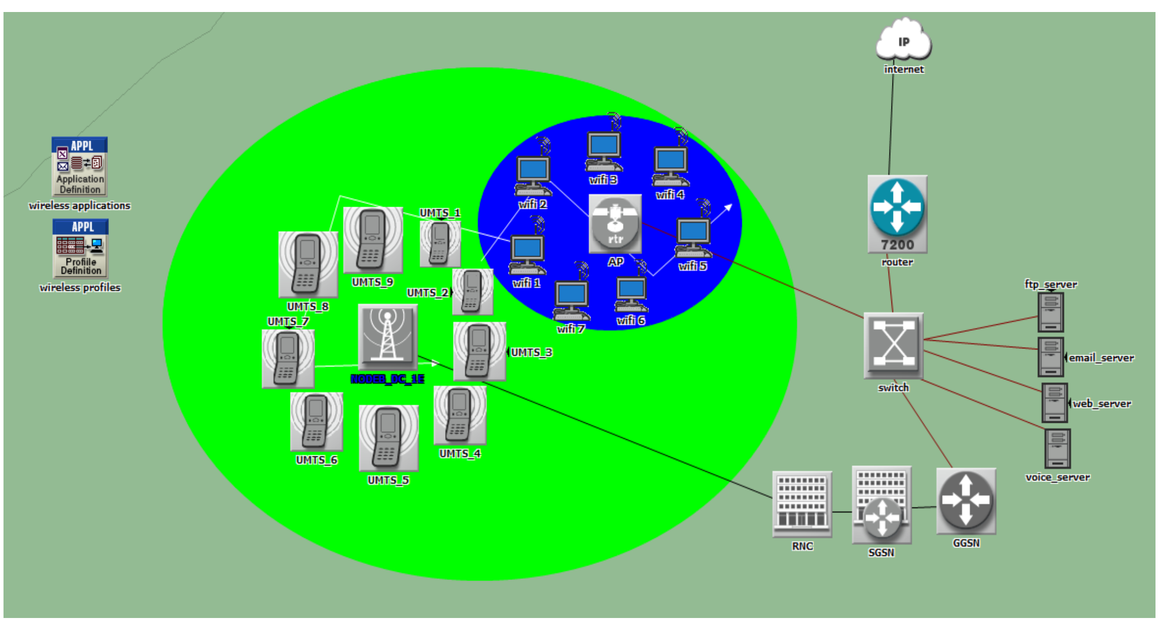

Figure 3.3 Heterogeneous Network System model using (OPNET)

3.3 Network Entities and Functions

Now I will explain the functionality and the configuration of each network node and interconnecting models and profiles.

3.3.1 Router

A router is hardware device designed to receive, analyze and move incoming packets to another network. It behaves such as an AP. also it has more capabilities than other network devices, such as a hub or a switch that are only able to perform basic network functions. For example, a hub is often used to transfer data between computers or network devices, but does not analyze the data it is transferring. By contrast, routers can analyze the data being sent over a network, change how it is packaged, and send it to another network or over a different network. [15]

3.3.2 FTP and VOICE Server

FTP and voice server is used to transmit and receive the data to and to from the user equipment. Application supported services parameters is set for various applications that is provided by the server. Voice server attributes are set for application supported services. The application supported services for voice server is voice application. Various voice application parameters are set on voice server. Voice server provides the voice specific services to check whether the packets are transmitted or received at user end. [10]

3.3.3 E-mail Server

A mail server usually consists of a storage area where e-mail is stored for local users, a set of user definable rules which determine how the mail server should react to the destination of a specific message, a database of user accounts that the mail server recognizes and will deal with locally, and communications modules which are the components that actually handle the transfer of messages to and from other mail servers and email clients.

3.3.4 Configuration Application

In OPNET modeler application configuration is a set of rules. Application configuration contains different types of OPNET libraries that are used to produce the traffic on the network according to the type of user requirement. As if user equipment contain voice data then for this user equipment voice traffic is set. To perform simulation for each new project in OPNET MODELER, It is required to configure the application configuration in the scenario. [10]

3.3.5 Configuration profile

Profile configuration is a profile of the nodes which they act according to the defined parameters in application configuration. It is essential to define profile configuration in the network, otherwise, there is no possibility to simulate the network. [11]

3.4 Performance Parameters

For performance evaluation of VHO heterogeneous network various metrics are considered. Different parameters are considered for the performance evaluation of the UMTS and Wi-Fi networks. Each network produce different impact on the overall performance of the proposed network model.

This thesis evaluates five parameters that are used to study the comparison of overall performance of the UMTS and Wi-Fi networks. The parameters are delay, throughput, Jitter, traffic send and traffic received for performance evaluation. These parameters are very significant in evaluation to calculate UMTS network performance under various weather and Qos in the proposed network model. [10]

3.4.1 End To End Delay

Packet end to end delay is defined as the time taken for producing a packet by the sender up to the receiving of a packet at destination. So packet end to end delay is the time taken by a packet to travel across the network. Time is defined in seconds. Entire delays like transmission time and buffering queues in the network are known as packet end to end delay. Sometimes this delay is known as latency. A multimedia application such as voice conferencing is a delay sensitive application so it is sensitive to packet delay. A low average delay is required for voice conferencing application in the network. FTP can tolerate a firm level of delay. Due to various types of activities, network delay is raised. Throughput is a measure of how sound congestion control protocols minimize the packet drops in the communication network. [10]

3.4.2 Throughput

Throughput can be classified as the ratio of the total amount of data sent by the sender with respect to the data received by the receiver. Throughput is also defined as time taken by the receiver to receive the last message. Throughput is measured as bytes per second (bytes/ second or bits/ second). Some factors like limited bandwidth, limited energy, unreliable communication between nodes and different topology changes in the network are the measurable reason that affects the throughput. If a network shows high throughput it means that it is the network with less number of dropouts and preference is given to this type of network. [10]

3.4.3 Jitter

Time variation between various packets arriving in the communication network is known as jitter. It means if multiple packets arrive at different delays such as one packet arrives after 2 m/s and other packets arrive after 3, 4, 5 m/s and so on this, it is known as jitter. In jitter packets arrive at receiver at different delay variations. Jitter occurred in the network by network congestion, route changes or timing drift. TCP/IP is accountable for dealing with the jitter impact on communication. [11]

3.5 Viewing Results (network and object)

After building the network with required node configuration in terms of parameters and network environment, we run the simulation model. Prior to running a simulation model in OPNET modeler 14.5, the output data options to be obtained need to be selected; these are referred to as the performance metrics. In OPNET two types of statistics are taken, object statistics and global statistics. Object statistics are described as the statistics that can be gathered from each and every node of the network and Global Statistics can be gathered from the whole network.

In This research gathered DES (global discrete event statistics) for every UMTS and Wi-Fi networks. Also gets various graphs from simulation like delay, throughput, Jitter, traffic send and traffic received.

Finally, results are available after the simulation is run. Each result can be viewed as the project or scenario is saved after running the simulation. Required results must have been chosen as part of the performance metrics earlier selected, likewise, to view results on the screen, one has to click the check box of the nodes or options whose results are needed. Results can be displayed in different views with the aid of the two presentation options available on the results window. This is done by making combination of the options that help to present the result in a better way. [10]

3.6 Simulation Steps

- **Step 1** To perform simulations, open OPNET modeler 14.5. Initially there is two mechanisms to perform simulations i.e. Project and Scenario.

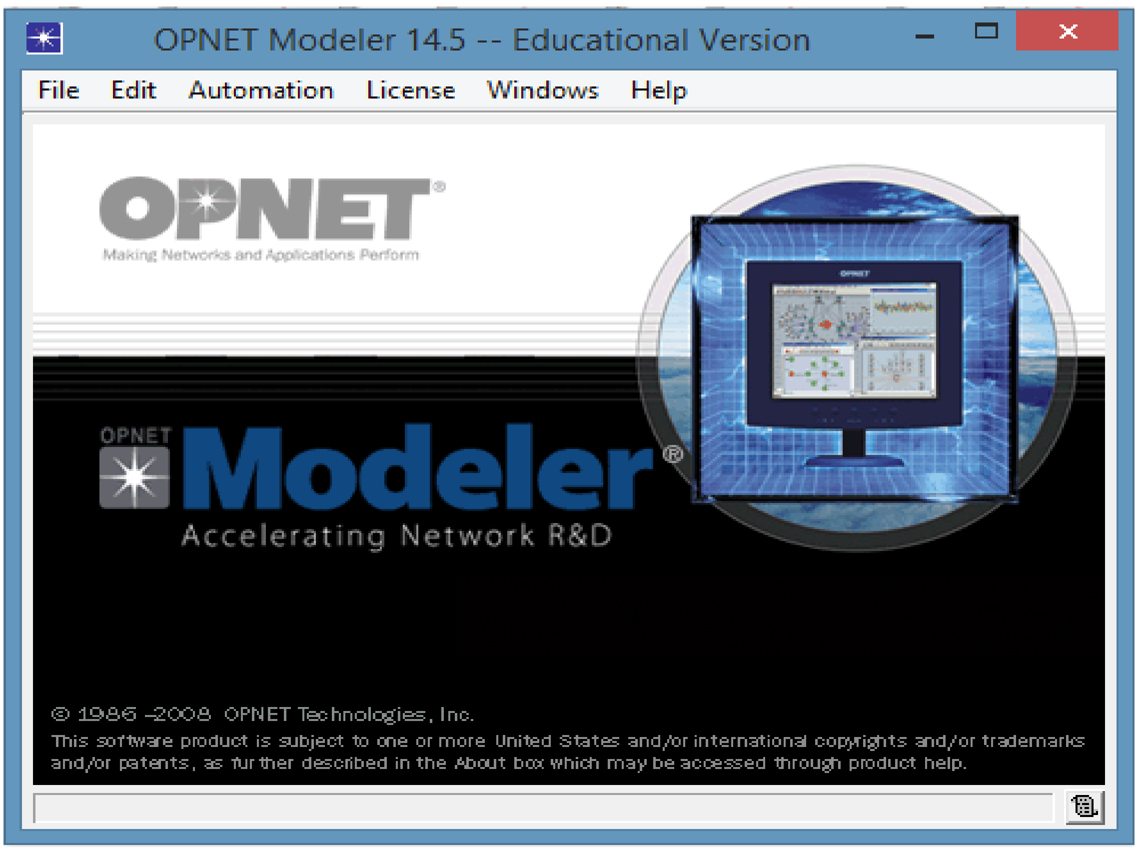

Figure 3.4 start page

- **Step 2** Click on the file, choose new, and then click OK to make a new project as in Figure 3.5. Each project has one or more scenario as per the requirement of network.

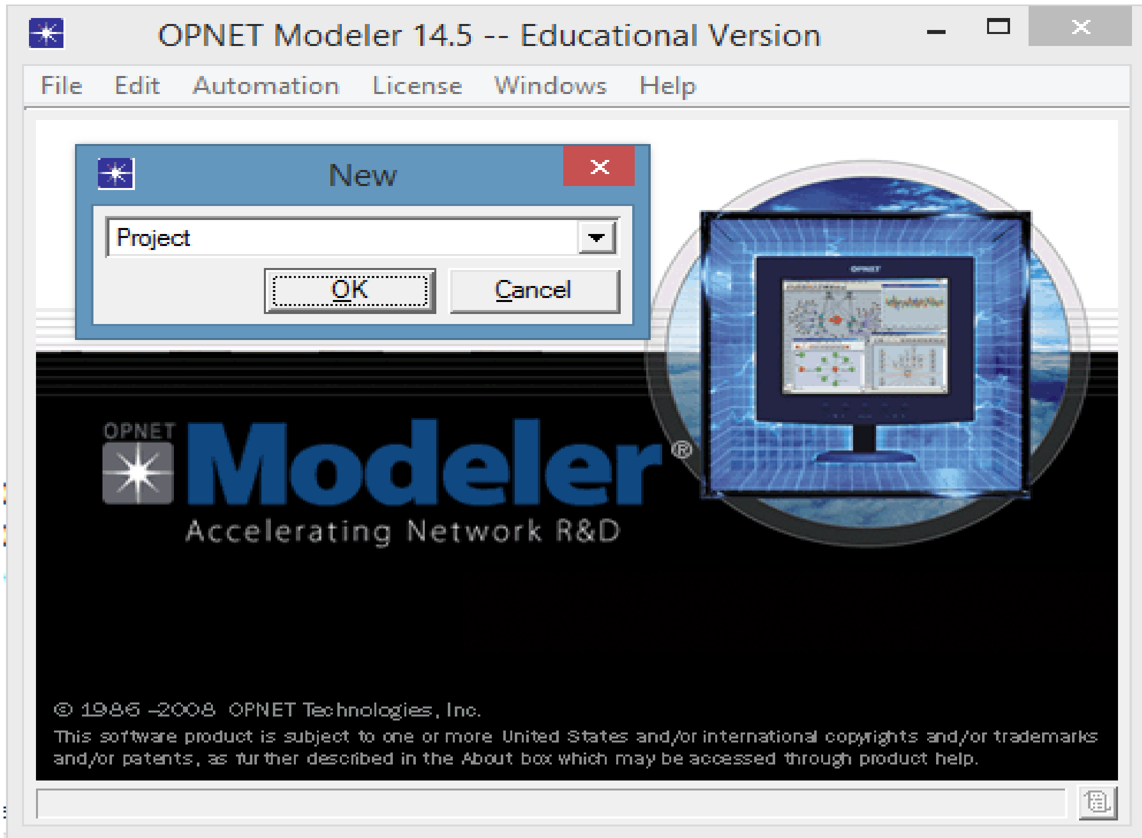

Figure 3.5 new project window

- **Step 3** Choose create empty scenario as in Figure 3.6 to build your network and press next. These scenarios show the network configuration that will be simulated by the modeler.

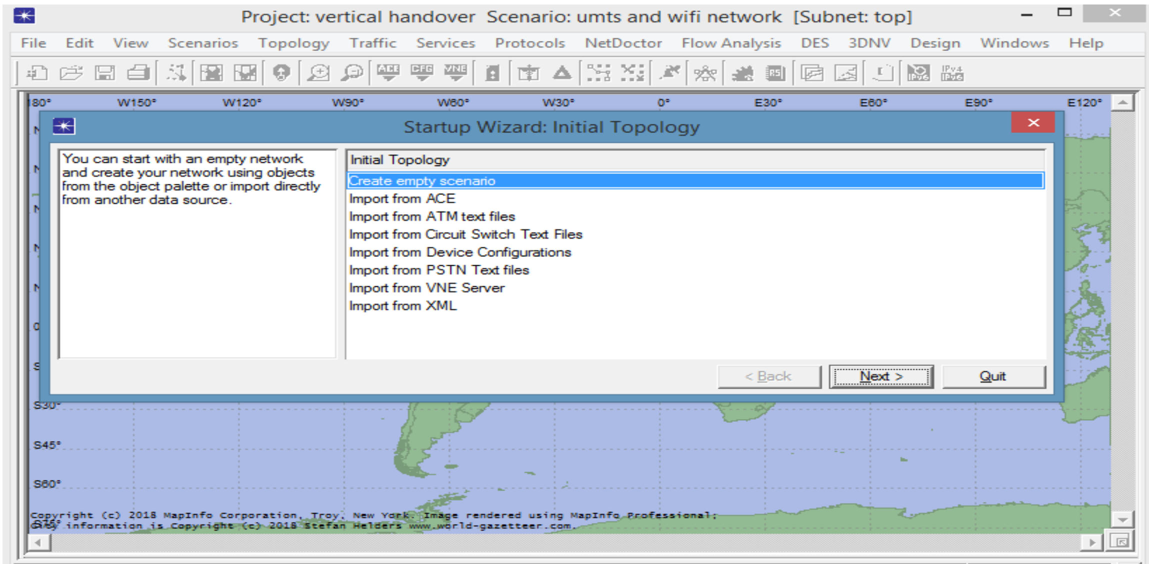

Figure 3.6 create scenario

- **Step 4** To define the network scale and its size network scale is used. Various network scale is shown in Figure 3.7 i.e. world, campus, office, logical and others. choose campus geographical area of network indicate the type of network you will be model and press next

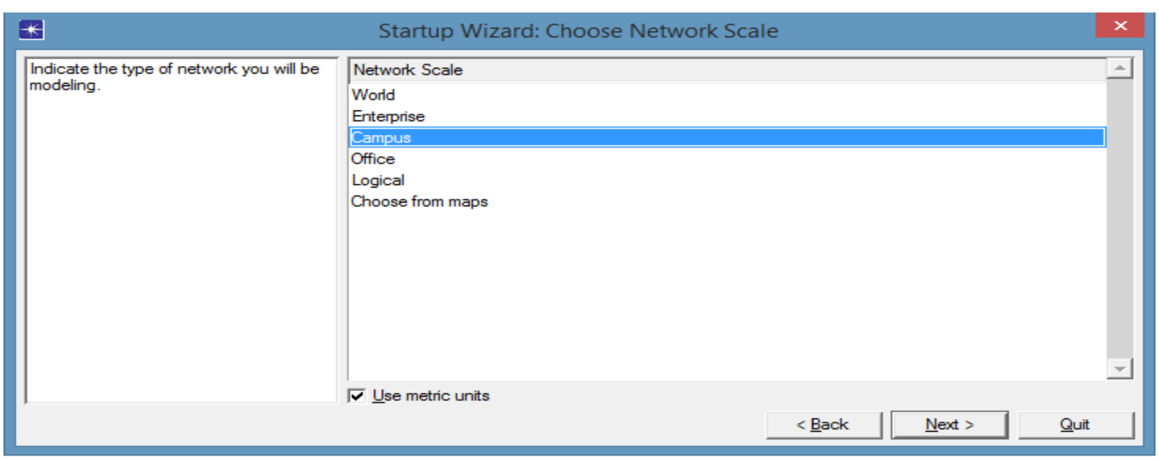

Figure 3.7 network scale

- **Step 5** select the suitable size you wish to use, to build your network as in Figure 3.8 and press next.

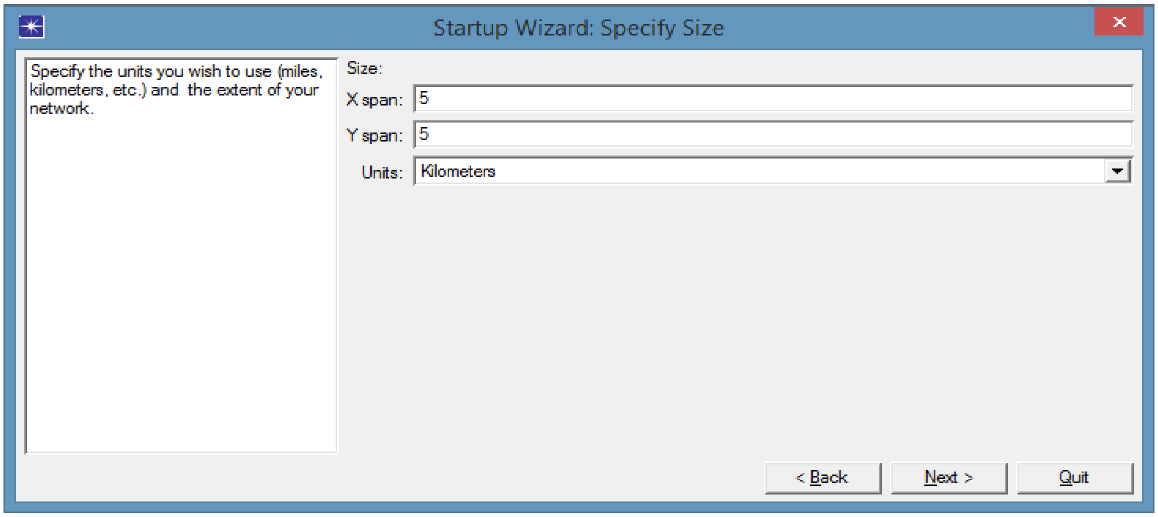

Figure 3.8 specify size

- **Step 6** from model family add UMTS and WLAN technologies by active them as Figure 3.9 and press next.

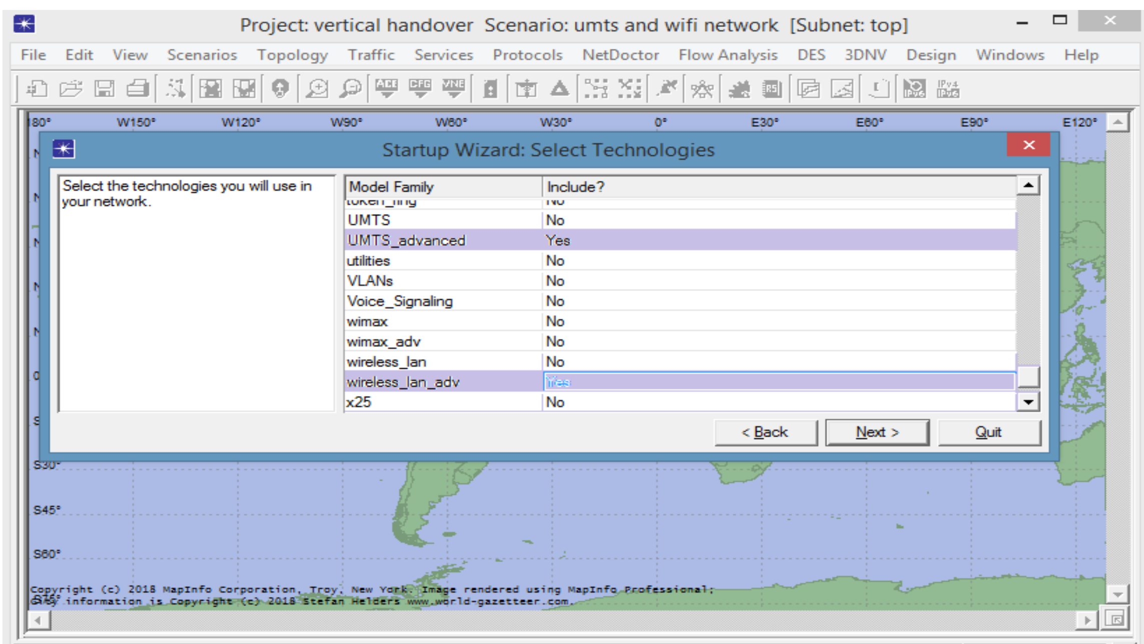

Figure 3.9 select technologies

- **Step 7** Choose Elements as in Figure 3.10. To make network architecture by drags and drops. Then select devices like (routers, user equipment's, application profile, application configuration, RNC, SGSN, GGSN, FTP server, voice server, web server and E-mail server) interconnecting models from object palette and selected (ATM link, fiber optics, both wired and wireless LAN and PPP links) this Link objects model physical layer effect between nodes, such as delays, noise then press close. When all of above steps are finished, the network simulation environment has been created and now it is ready to create network models and scenarios and perform simulation

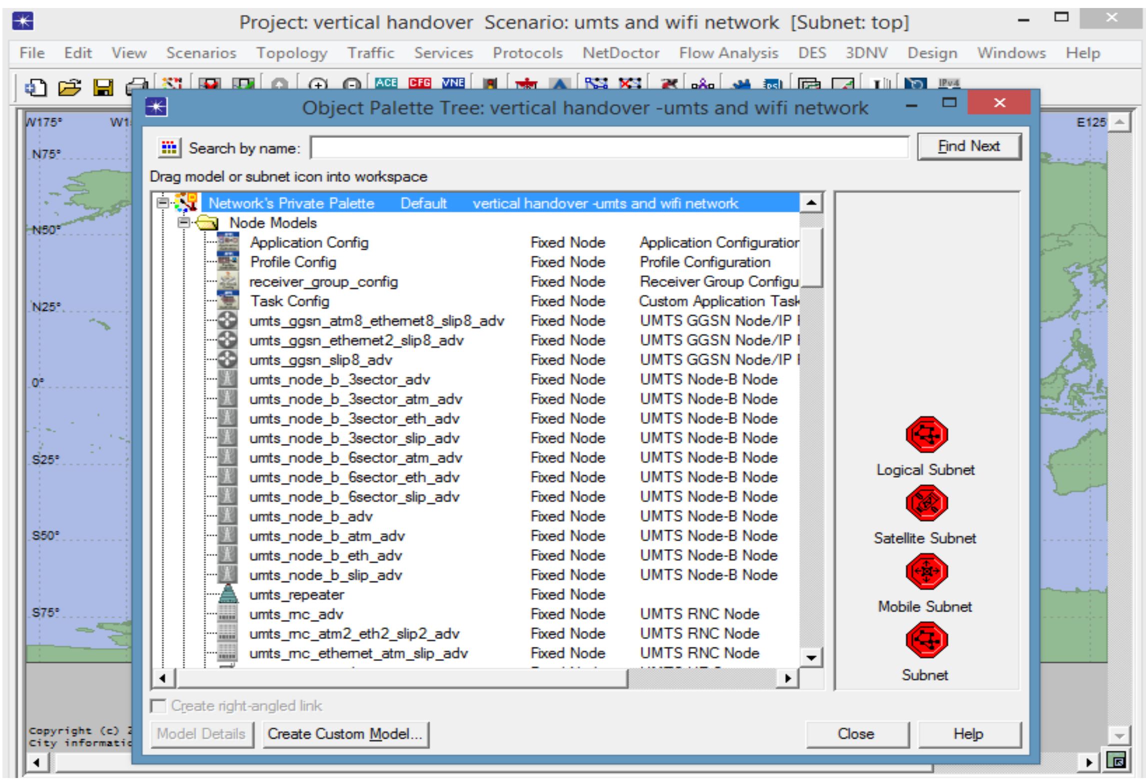

Figure 3.10 Network Elements

- **Step 8** Profile configuration setting. Right click on profile configuration and select edit attribute to set two profiles UMTS users and WLAN users as in Figure 3.11 Then press OK.

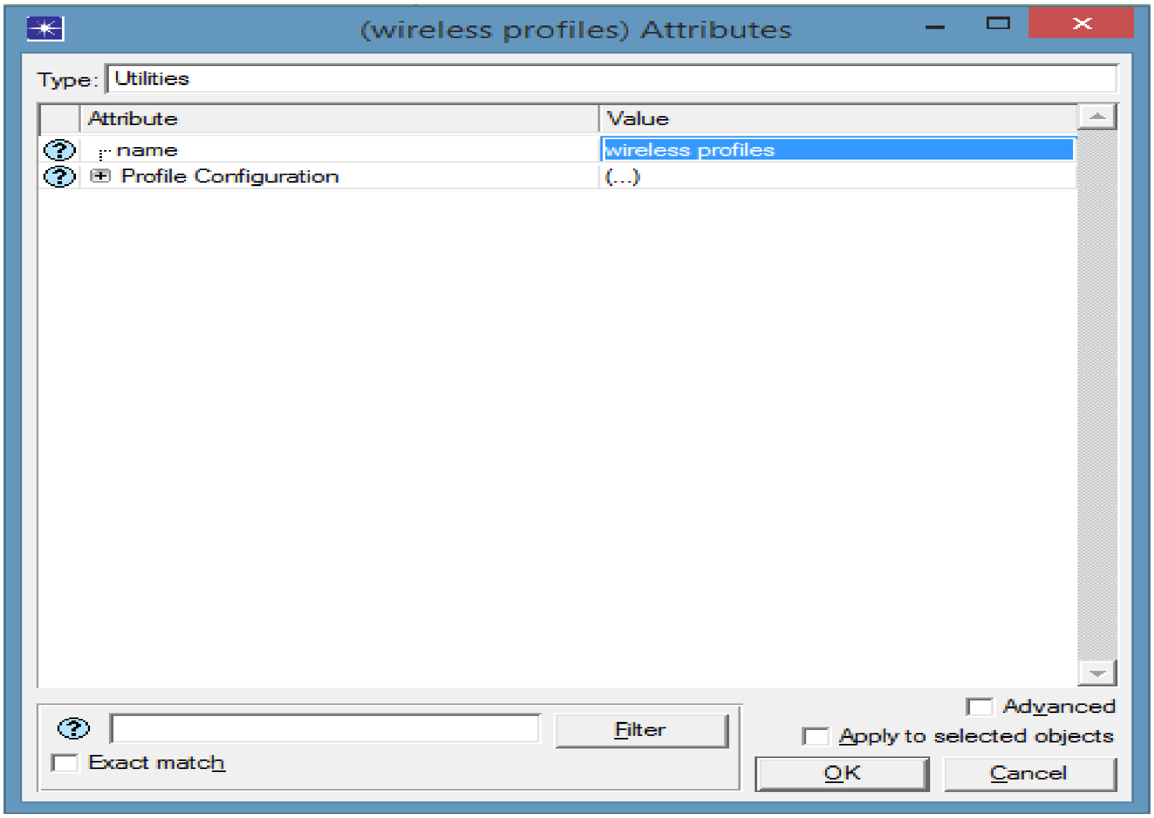

Figure 3.11 Network attributes

- **Step 9** In profile configuration window from applications column, determine all servers (voice, ftp, email and web) that have been used on UMTS and WLAN as in Figure 3.12 then press OK. Taking into account, the definition of any mobile node on his specify profile. By right click on mobile node, select “edit attribute”, “supported profile” and set profile name.

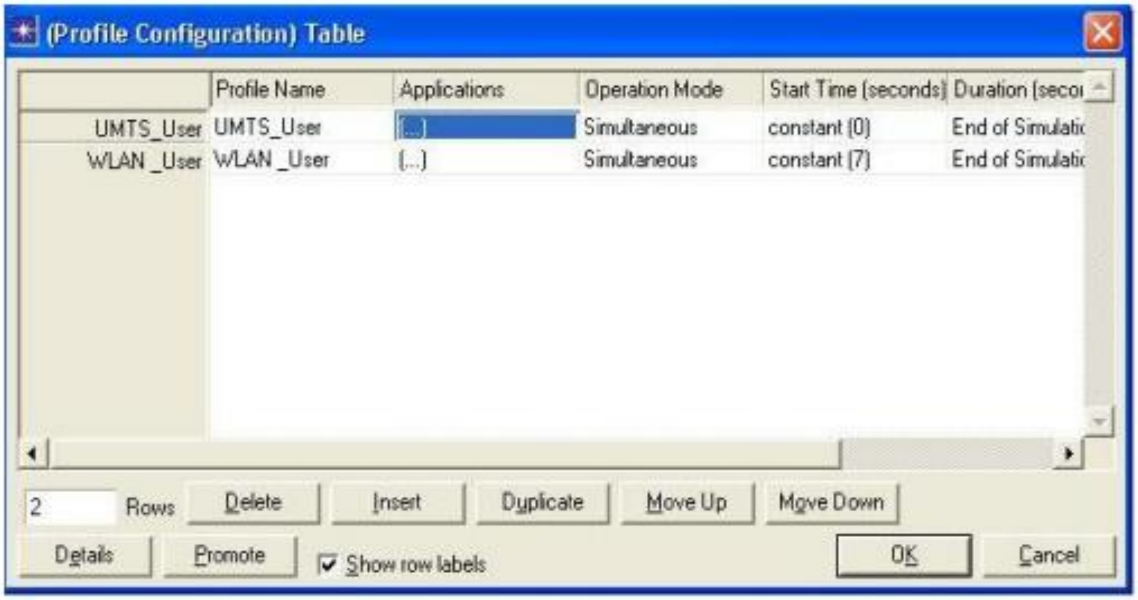

Figure 3.12 profile configuration table

- **Step 10** Application configuration setting as in Figure 3.13 Right click on application configuration node to change name and define all servers which has been configured.

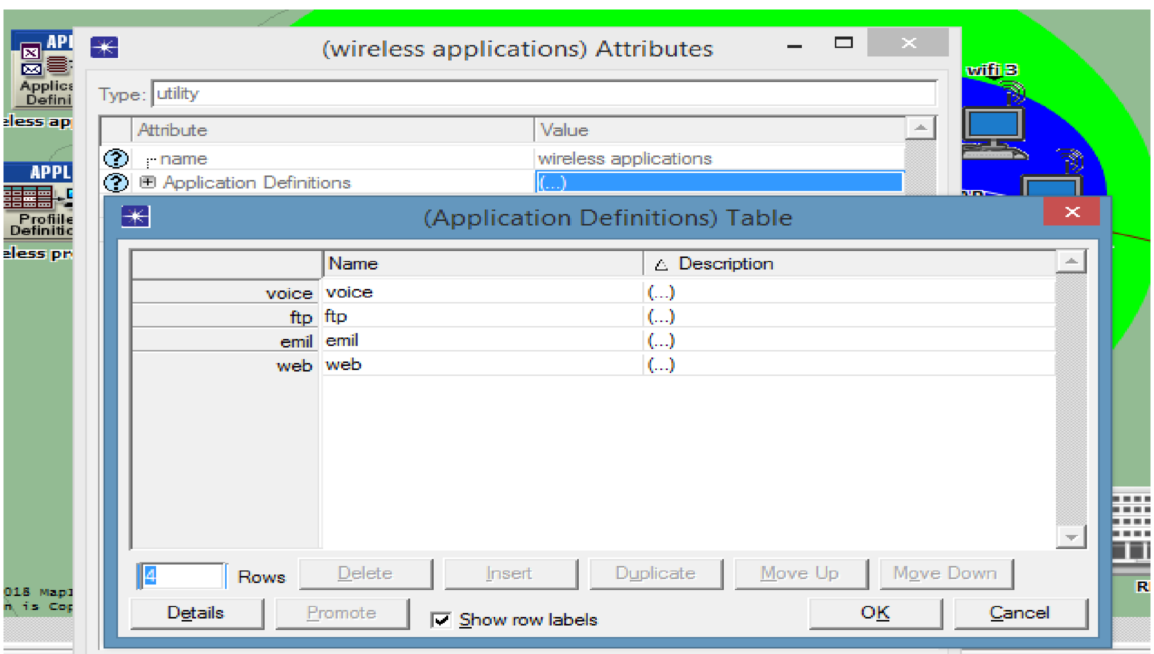

Figure 3.13 Application definition table

- **Step 11** Node attributes and supporting profiles setting for UMTS user as in Figure 3.14 Right-click on an object (UMTS_2) and select “Edit Attributes” to change Name, Network size, trajectory and application supported profile by defining all applications that used it such as VOICE, FTP, email and web.

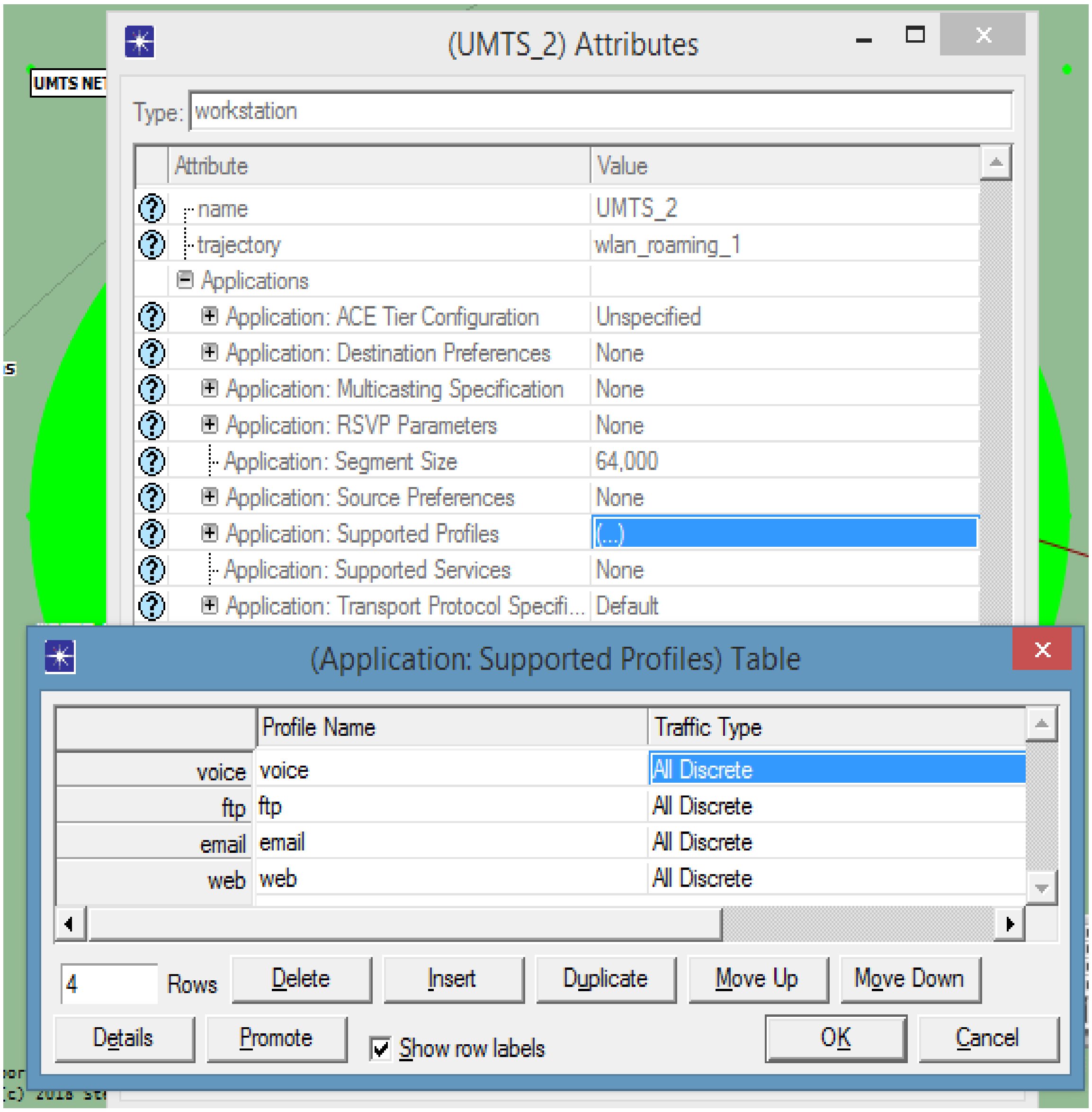

Figure 3.14 Node attributes for UMTS table

- **Step 12** Node attributes and supporting profiles setting for WLAN user as in Figure 3.15 Right-click on an object (UMTS_2) and select "Edit Attributes" to change Name, Network size, trajectory and application supported profile by define all applications were used it like VOICE, FTP, Email and WEB.

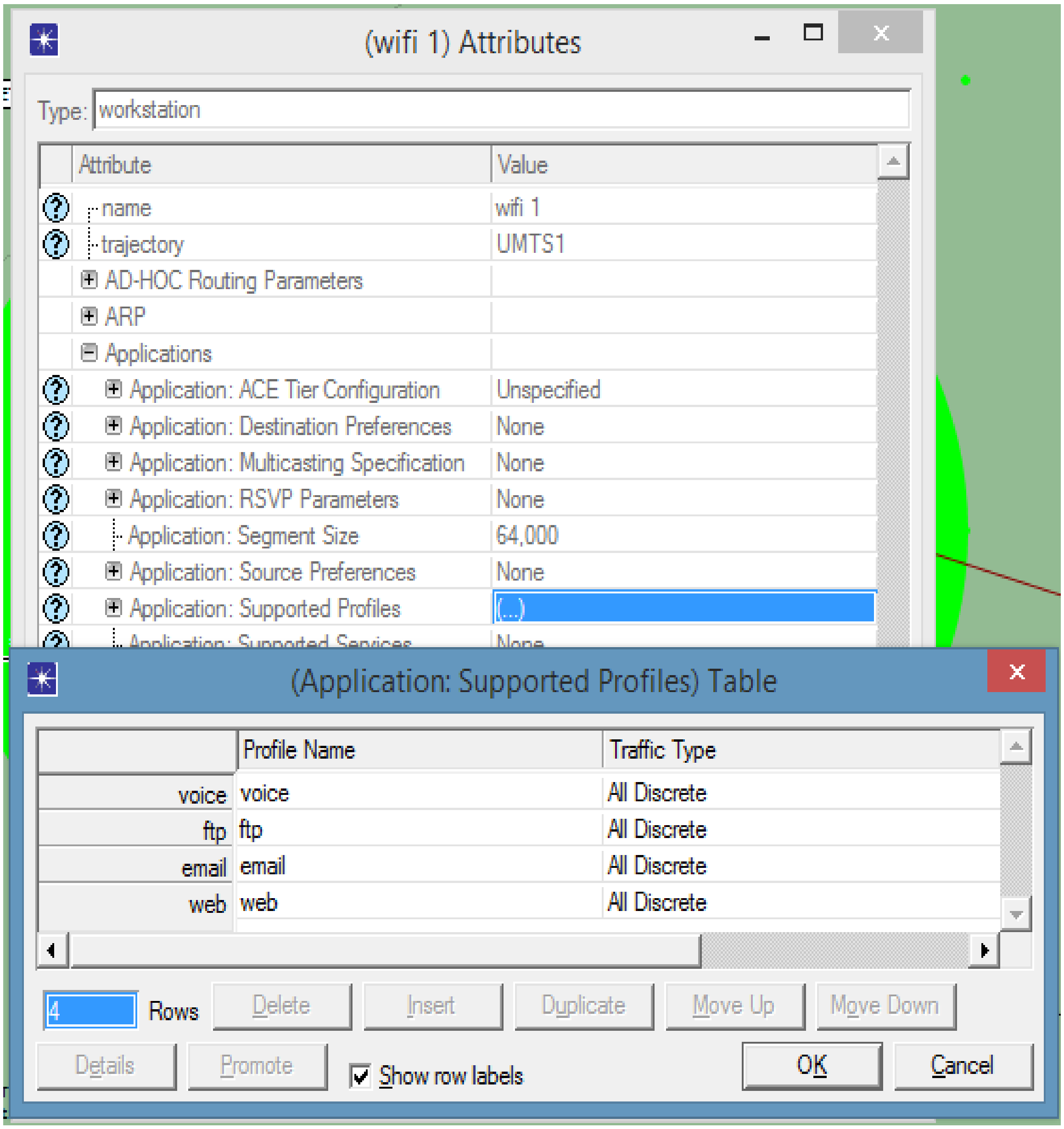

Figure 3.15 Node attributes for WLAN table

- **Step 13** WLAN parameters as in Figure 3.16 This step is part of the previous step, right click on mobile node to select "wireless LAN parameters" then choose edit BSS identifier and make it auto assigned this step as well in base station or AP by making BSS identifier auto assigned to facilitate the handover process.

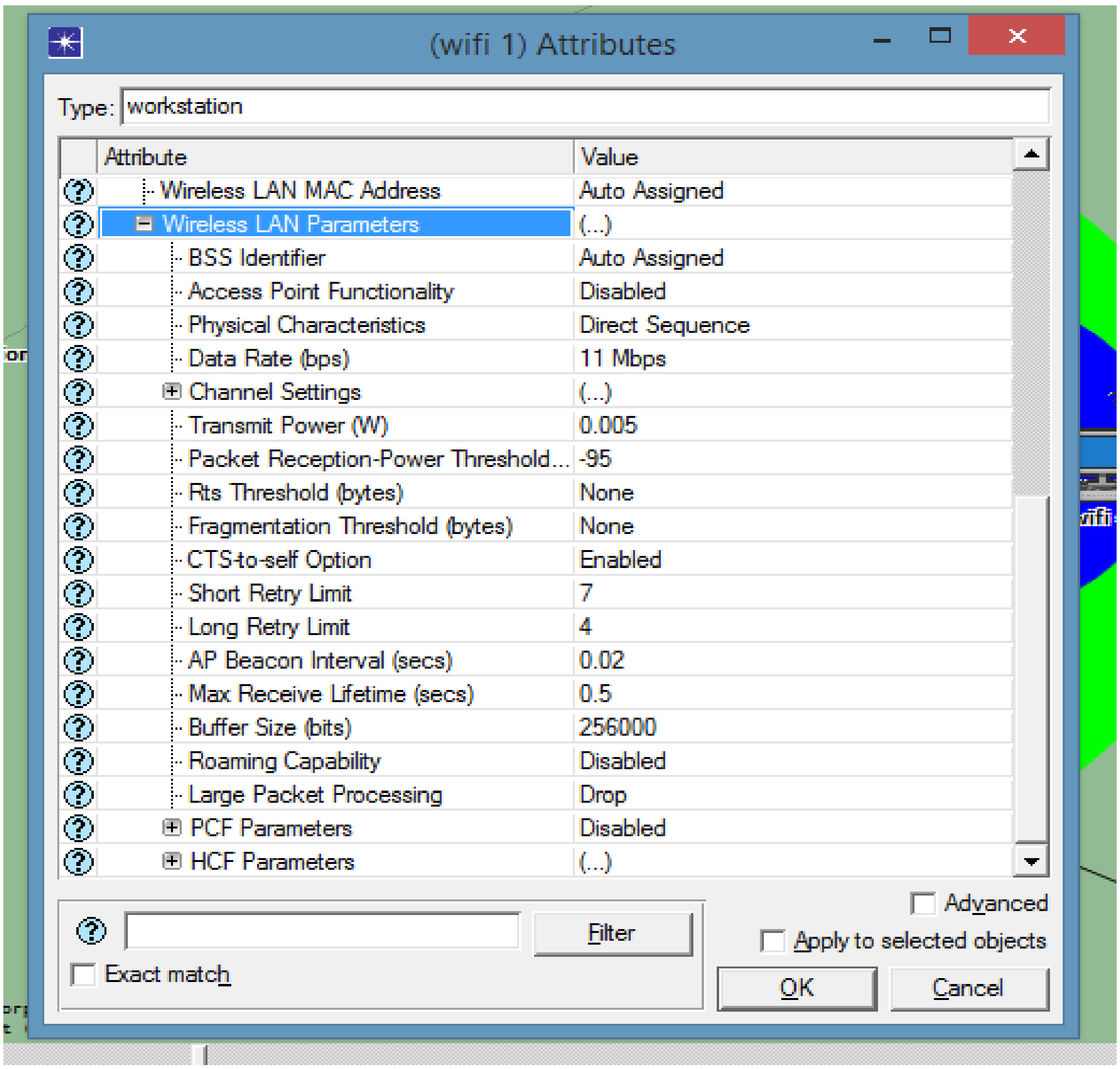

Figure 3.16 WLAN parameters

- **Step 14** Configuration and add supported services of FTP server as in Figure 3.17 Right click on the node after that the attributes window will show to edit name and supported services then press OK.

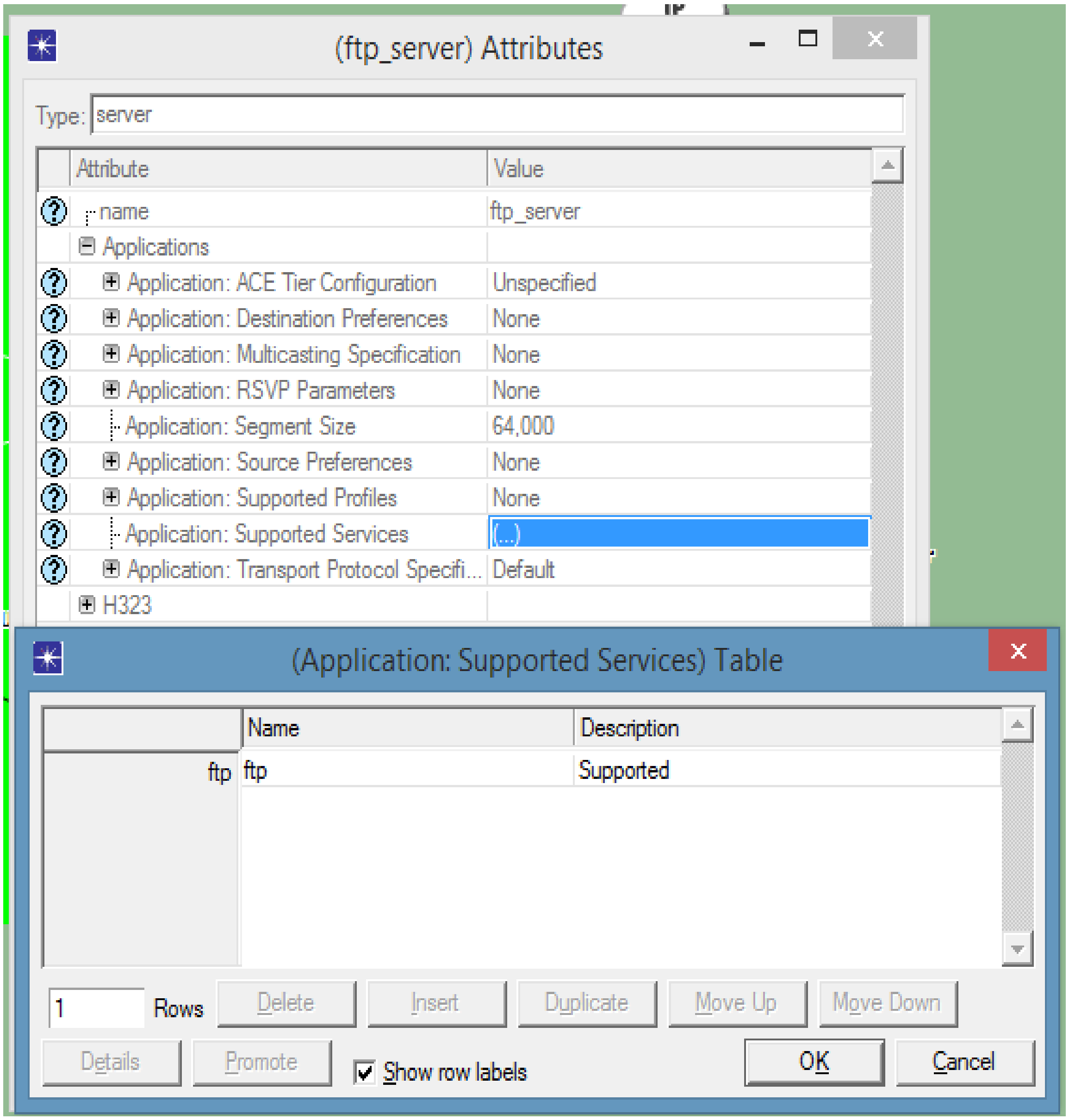

Figure 3.17 Configuration of FTP

- **Step 15** Configuration and add supported services of voice server as in Figure 3.18 Right click on the node after that the attributes window will show to edit name and supported services then press OK.

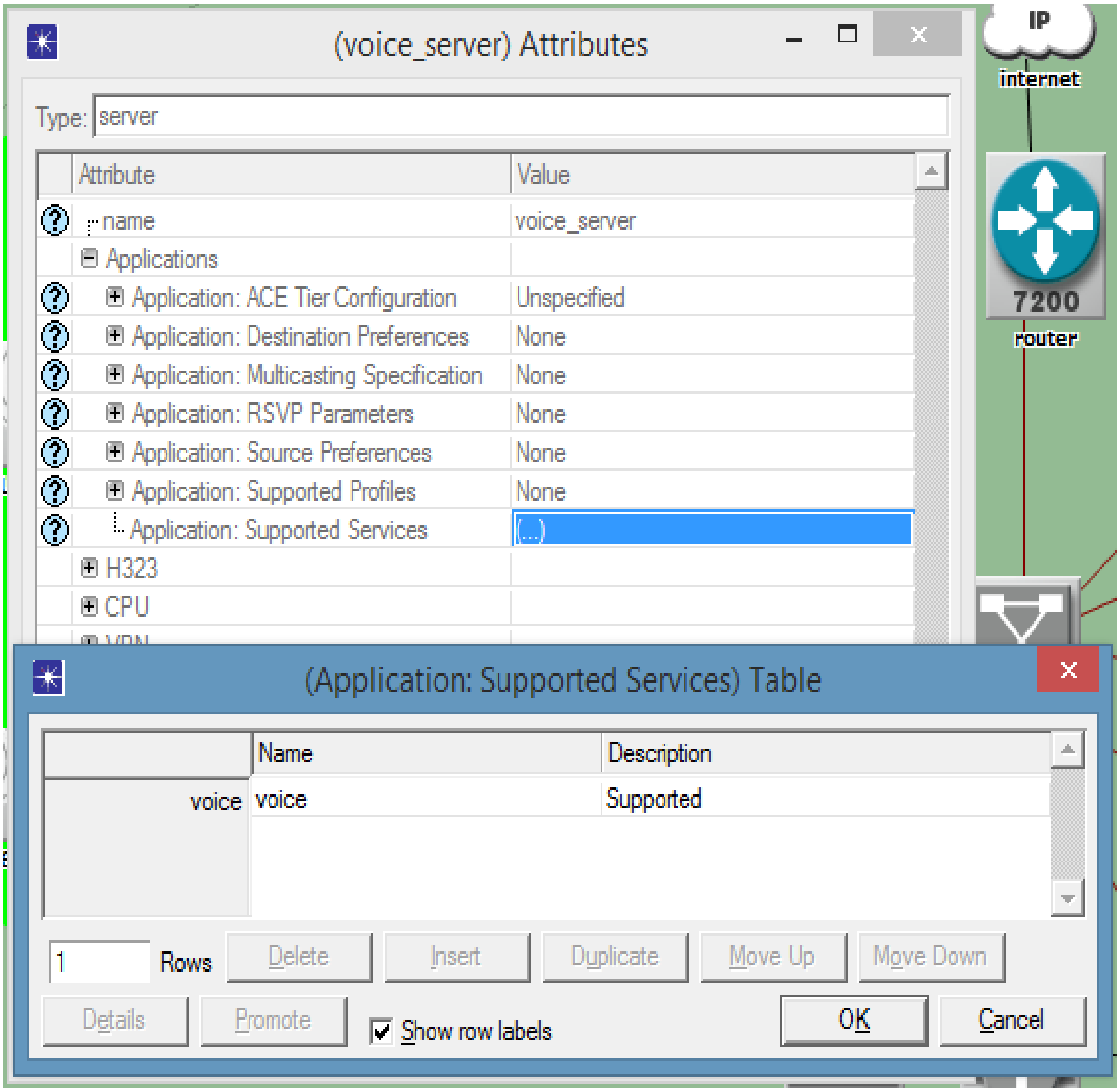

Figure 3.18 Configuration of VOICE

- **Step 16** Right Click on the work-space and select Choose Individual Statistics to select the statistics as in Figure 3.19.

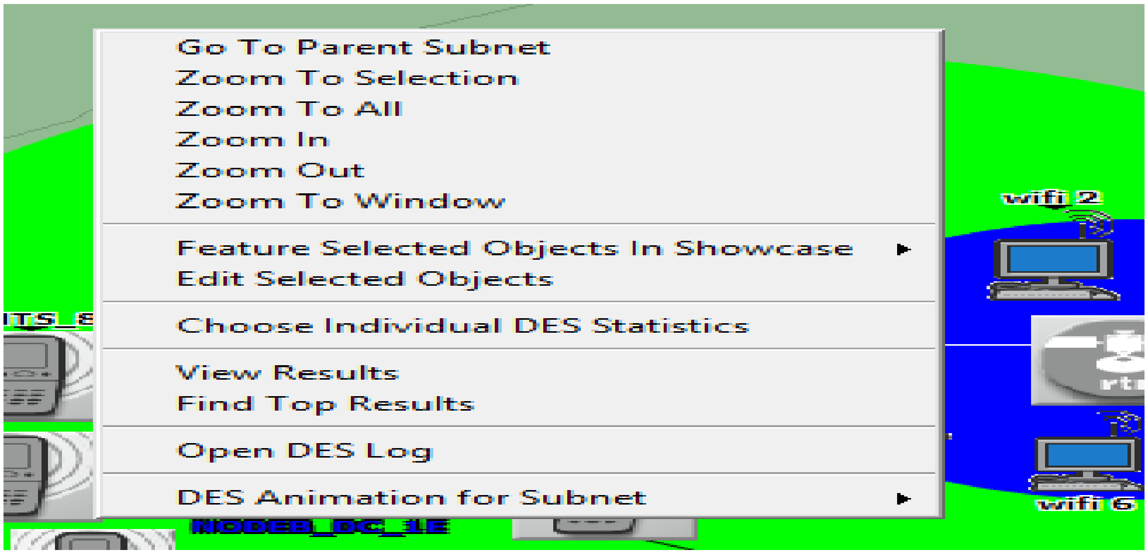

Figure 3.19 Individual Statistics

- **Step 17** According to select the statistics attributes (UMTS, WLAN, Node static, VOICE server, FTP server, email server and web server) it will be measured during simulation run as in Figure 3.20.

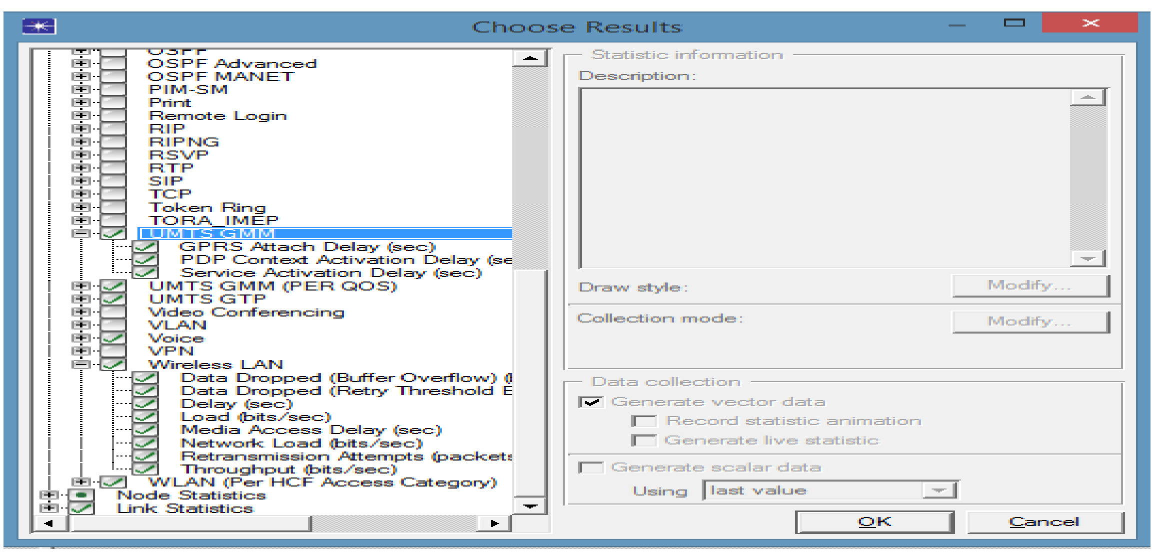

Figure 3.20 choose result

- **Step 18** before running a simulation, you must make sure that you have built the network correctly to get better results and identify simulation time on 20 min as in Figure 3.21 then press OK.

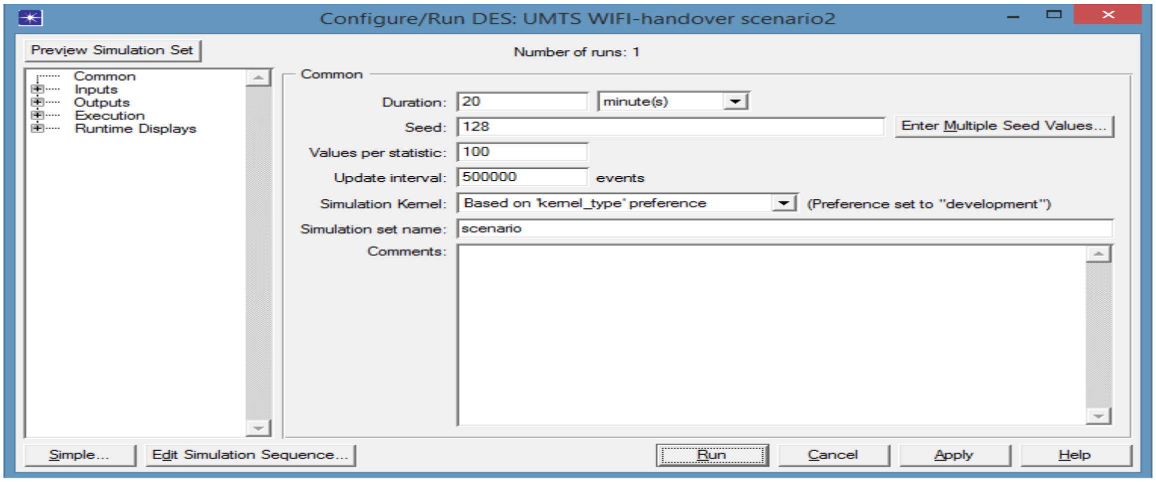

Figure 3.21 run a simulation

- **Step 19** Viewing Results after simulation run each result can be viewed as the project or scenario. They are three different ways to display the Results, Select the "View Results" button on the tool bar, Select View Results from the Results menu, or Right-click in the project workspace and select from the display menu. as in Figure 3.21

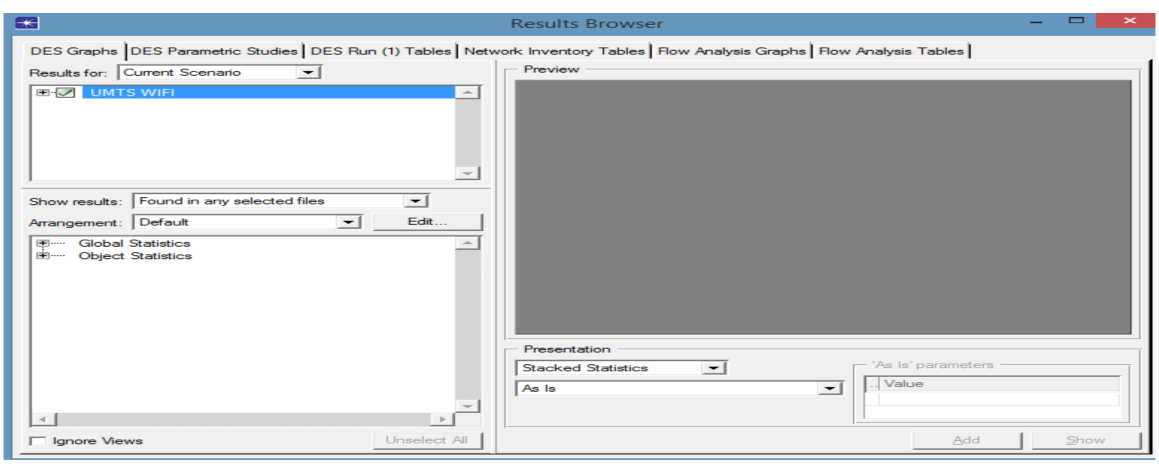

Figure 3.21 Results display

CHAPTER FOUR

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

In this chapter, networks was designed using OPNET MODELER This simulation evaluate the vertical handover between 3G and WIFI considering the performance parameters such as throughput, delay, traffic send traffic received and jitter.

4.1 Simulation Parameter

In Table 1 shown the simulation parameters that were used to obtain the results.

Table 4:1 Simulation Parameter

Network parameter	**WIFI(802.11n)**	**UMTS**
Simulation time	**40 Min**	**40 Min**
Data rate	**11Mbps**	**-**
Transmit power (w)	**0.005**	**-**
Propagation distance	**5 km**	**5 km**
Trajectory	**Wi-Fi**	**UMTS**

4.2 Simulation Results

In this section, there are two scenarios, with-handover and without-handover scenarios was simulated, based on various applications VOICE and HTTP by using OPNET modeler. As we have seen in chapter three. To choose the result, the process has two categories**:**

4.2.1 Global statistics: explain that the Statistics can be gathered from the whole network

4.2.1.1 HTTP Server

In Figure 4.1 X axis shows the time, Y axis shoes the MB/s and the distance from 0 second until the first second this time for simulation preparation the network. The HTTP traffic sent, according to the Static information concluded, the maximum value of with-handover scenario is 1.3Mb/s and without-handover scenario is 0.9 Mb/s in 3 min. In with-handover scenario the sending is higher by 27% because the sending well increase when the server attempt to identify BTS, and after identifying with the servers, sending become lower. Power as well has a big role in increasing the transmission.

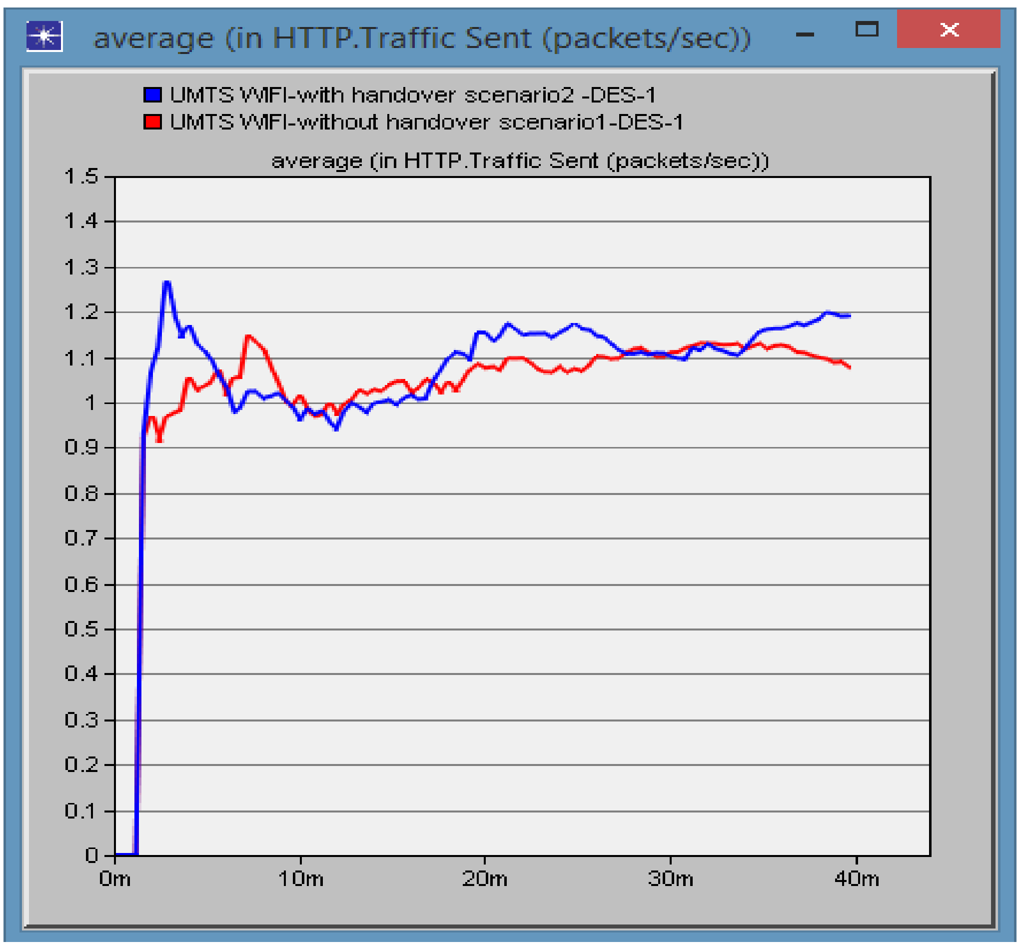

Figure 4.1 HTTP traffic sent between two scenarios

It is shown in Figure 4:2 that the HTTP traffic received in with-handover scenario and without-handover scenario, it can be observed that the maximum value is 1.2Mb/s in without-handover scenario at 4 min the received is higher by rate 22% than with-handover scenario because the scenario is not affected by the handover proses.

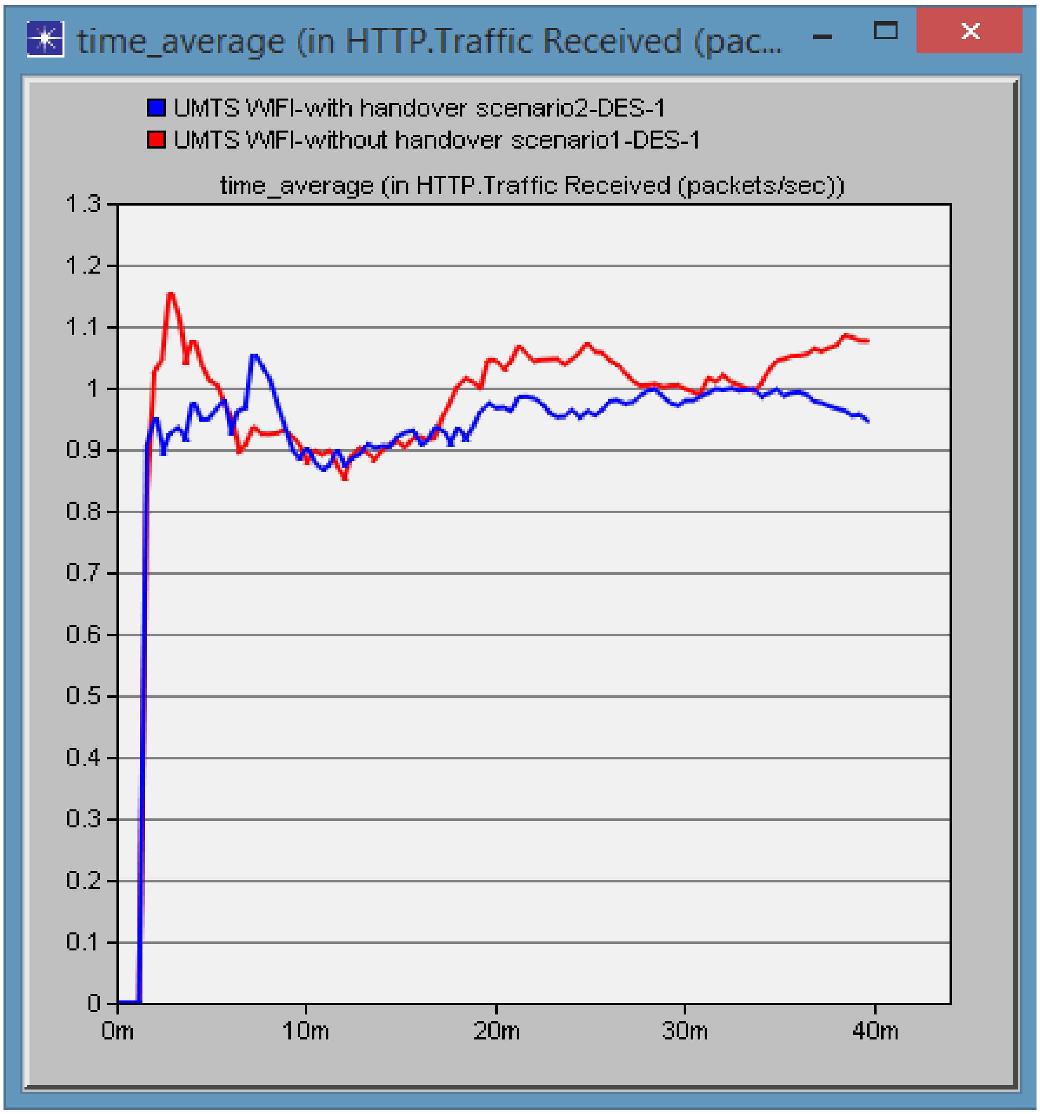

Figure 4.2 HTTP traffic received between two scenarios

4.2.1.2 Voice Server

Figure 4.3 represents the traffic sent of the voice applications over the integration between two scenarios during time, X axis shows the time, Y axis shoes the MB/s and the distance from 0 second until the first second this time for simulation preparation the network, each user sends a request to access the network to obtain service. So the result indicates that the network is effective.

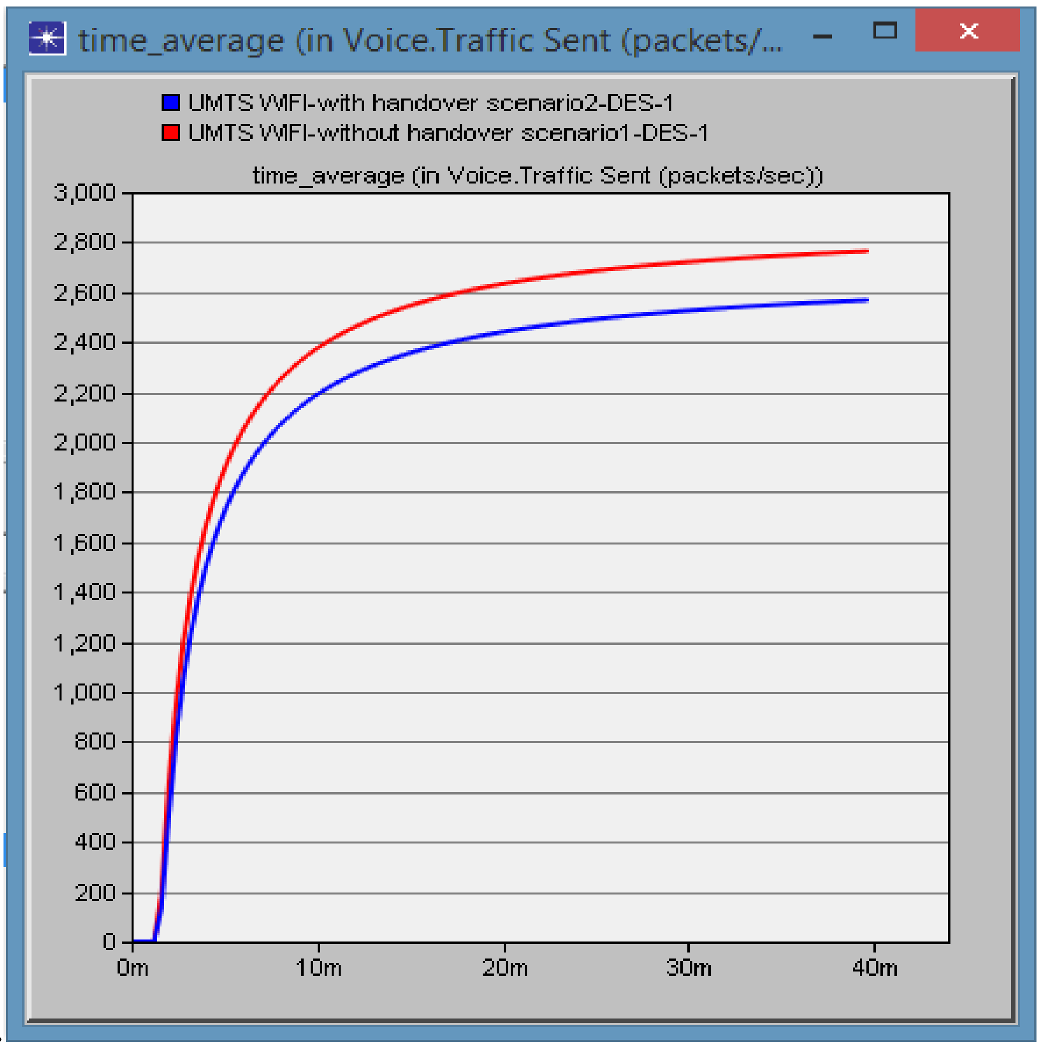

Figure 4.3 voice traffic sent between two scenarios

Figure 4.4 shows the traffic received in two scenarios during time, the traffic in without-handover is greater than the traffic in with-handover by rate 44% because traffic receive in without-handover scenario is not affected by the handover proses and the number of packets per second forwarded to the voice application by the transport layer in this node. It can be shown that the voice traffic send and received throughput is greater than the HTTP application due to servings.

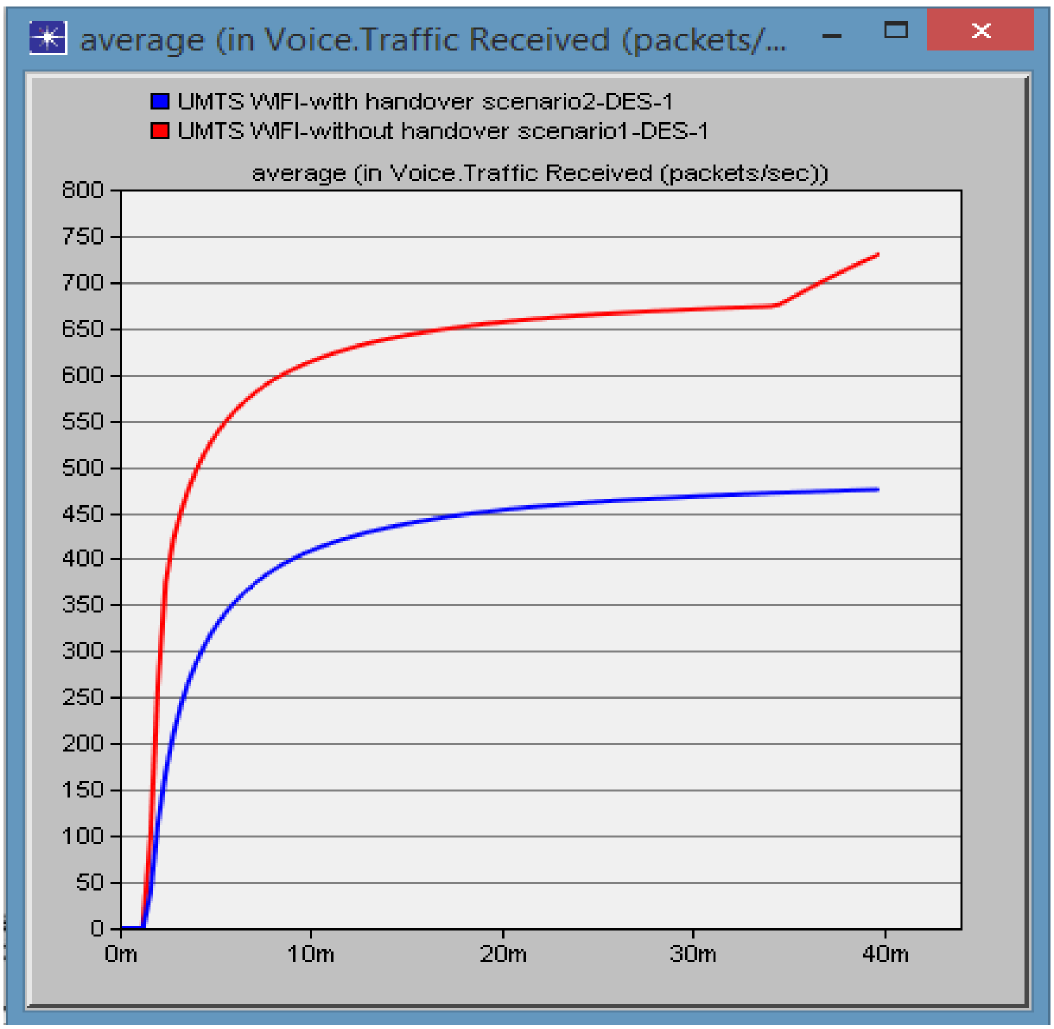

Figure 4.4 voice traffic received between two scenarios

In Figure 4.5 the Voice jitter indicates that the time difference between packets at the destination node was less than at the source node, it is noted that the maximum value of with-handover scenario is 0.0029 Mb/s and maximum value of without-handover scenario is 0.0037 Mb/s the jitter value is higher in without-handover scenario by the rate of 42%. The jitter in voice server is little compared to HTTP server due to voice use.

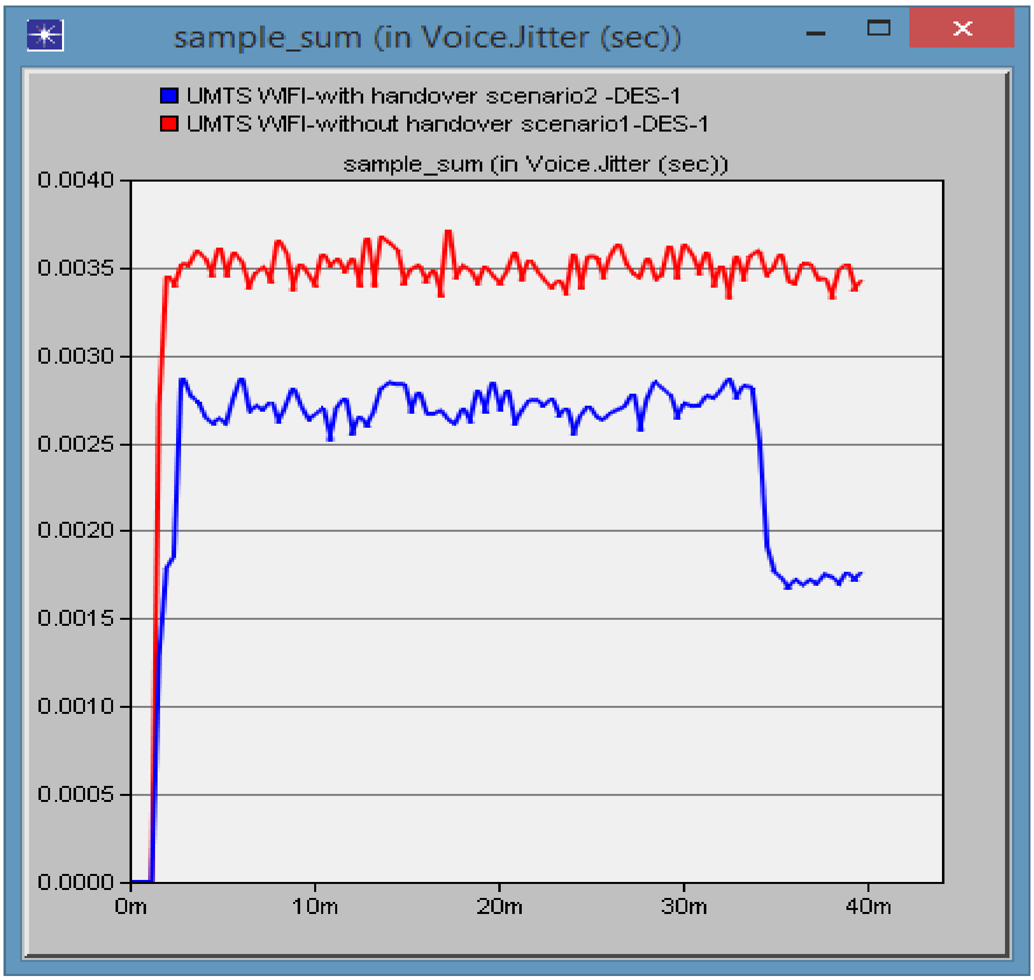

Figure 4.5 voice jitter between two scenarios

4.2.1.3 Wi-Fi in overall network

Figure 4.6 shows the throughput, Blue color graph shows throughput for with-handover scenario and Red color graph shows throughput for without-handover scenario, X axis shows the time, Y axis shoes the MB/s and the distance from 0 second until the first second this time for simulation preparation the network It was found that the throughput value in with-handover scenario is greater than without-handover scenario by the rate of 10% That means the total number of bits (in bits/sec) forwarded from wireless LAN layers to higher layers in all WLAN nodes of the network.

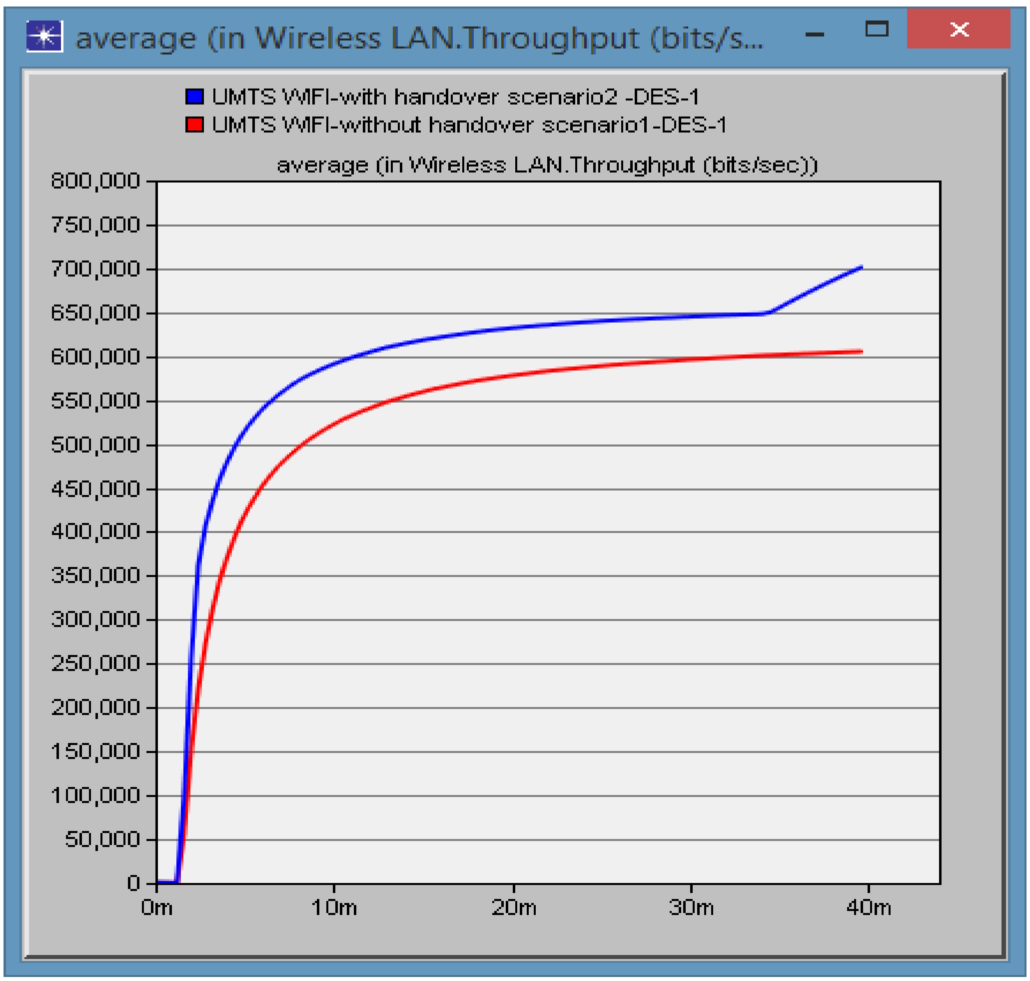

Figure 4.6 Wi-Fi throughput in overall network

It is shown in Figure 4.7 that the data which has been dropped in without-handover scenario is greater than with-handover scenario by the rate of 12%, because The total size of higher layer data packets (in bits/sec) dropped by all the WLAN MACs in the network due to full higher layer data buffering and the size of the higher layer packet, which is greater than the maximum allowed data size which is defined in the IEEE 802.11 standard.

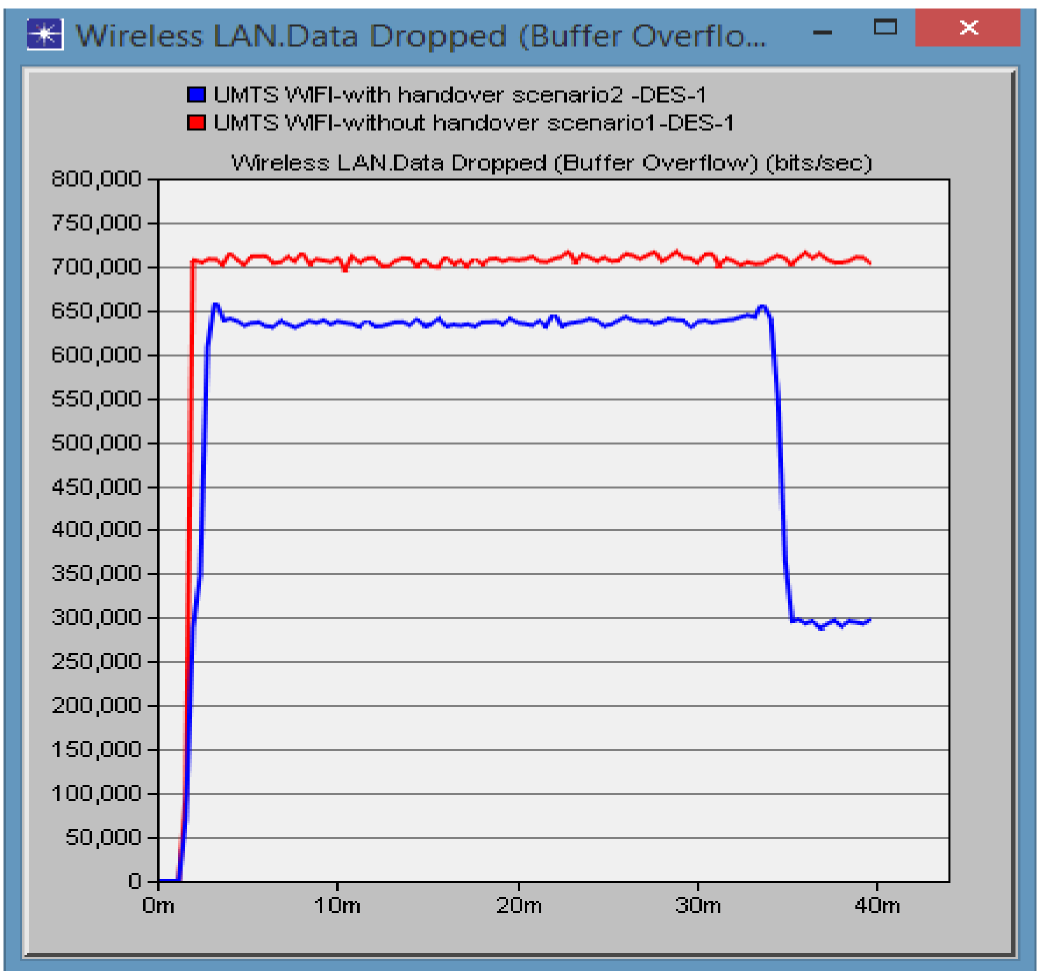

Figure 4.7 Wi-Fi data dropped in overall network

4.2.1.4 UMTS in overall network

Figure 4.8 shows that the delay for UMTS between two scenarios, the delay in with-handover scenario is less than with-handover scenario due to large coverage area of UMTS, also the delay between two Different scenarios is not large, and the decrease average between them is 18%.

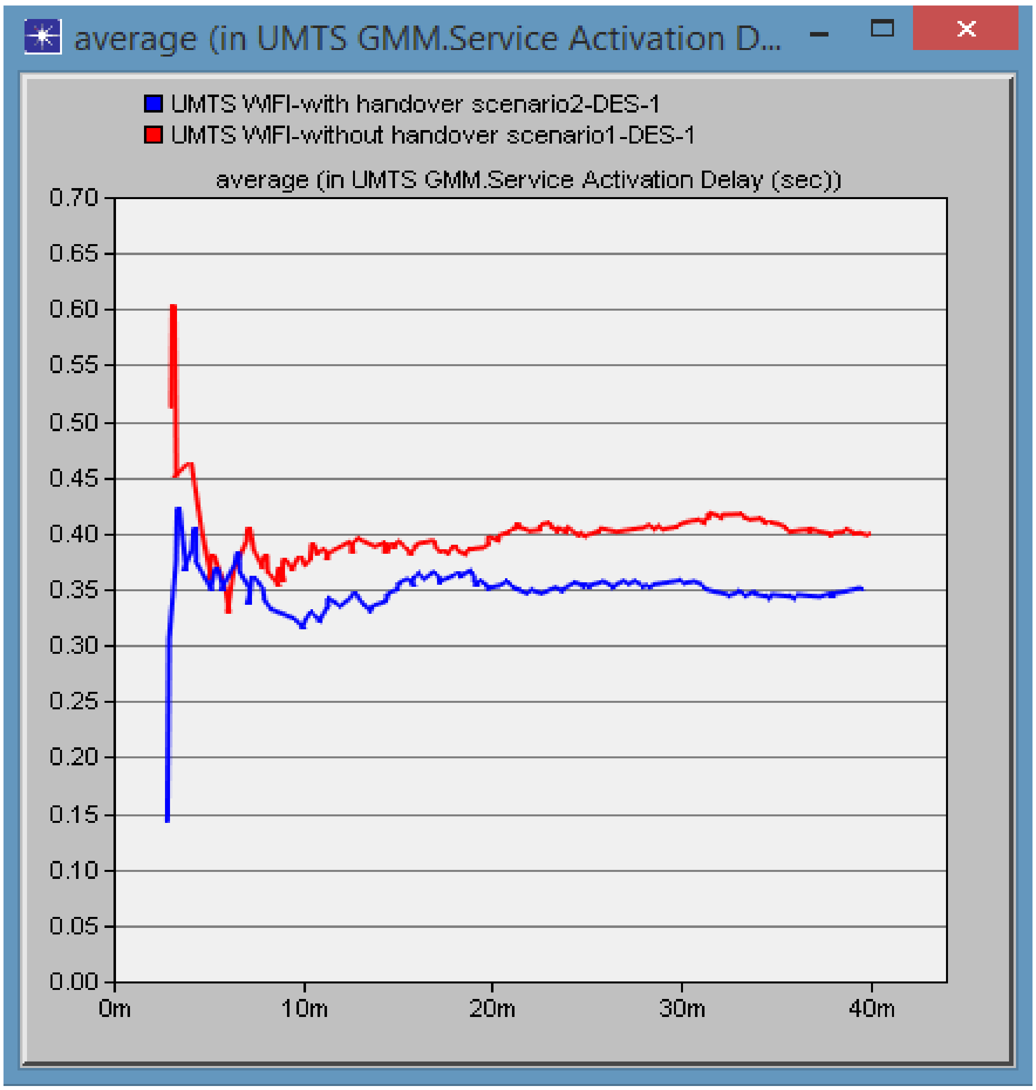

Figure 4.8 UMTS delay in overall network

4.2.2 Node statistics: explain that the statistics that can be gathered from the each and every node of the network.

4.2.2.1 WiFi user during two scenarios

Figure 4.9 X axis shows the time, Y axis shoes the MB/s and the distance from 0 second until the first second this time for simulation preparation the network, the End-to-End delay during mobility, with-handover scenario is less delay than without-handover scenario by the rate of -63%. Because, in without-handover scenario the user move away gradually from AP without handover that leads to signal deterioration, in with-handover scenario the handover makes place to the UMTS network in case the signal was decreased, that means user was maintaining Qos during connection.

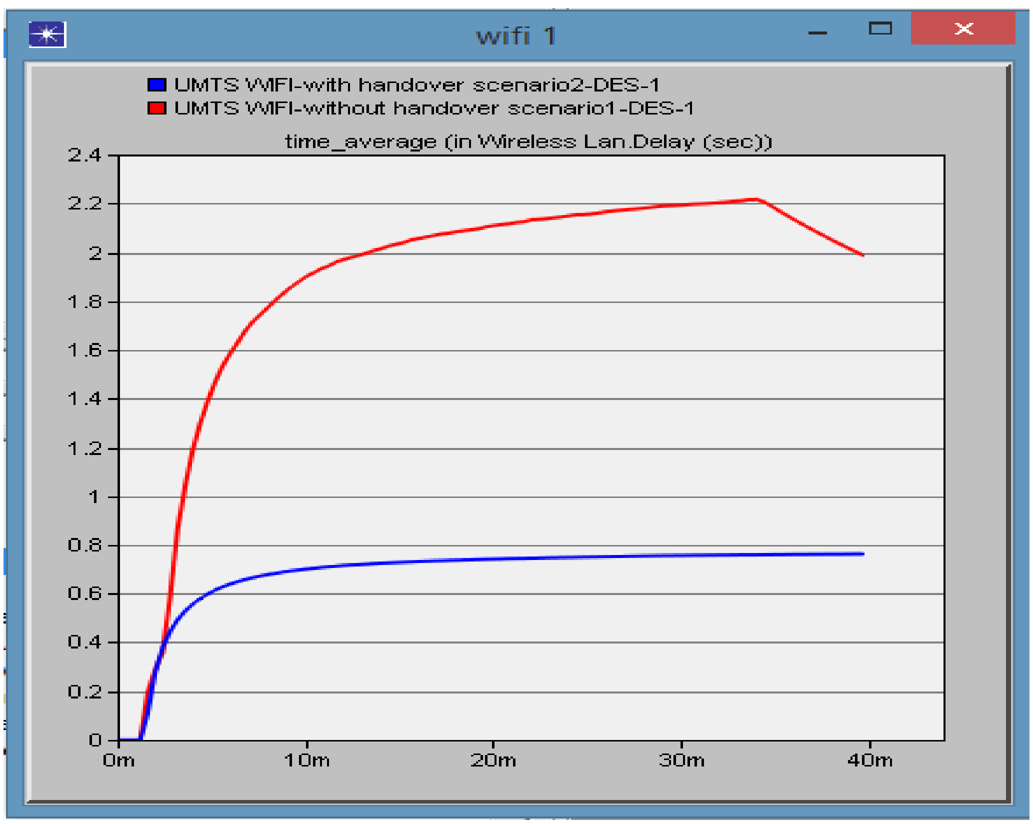

Figure 4.9 End-to-End delay between two scenarios for Wi-Fi user

Figure 4.11 shows throughput of user during mobility. The throughput in with-handover scenario is higher by the rate of 145% than without-handover scenario due to handover process. The handover probability occurs when distance criterion between user and AP is increasing. That is why the handover to the UMTS was improved the Qos for Wi-Fi user calls

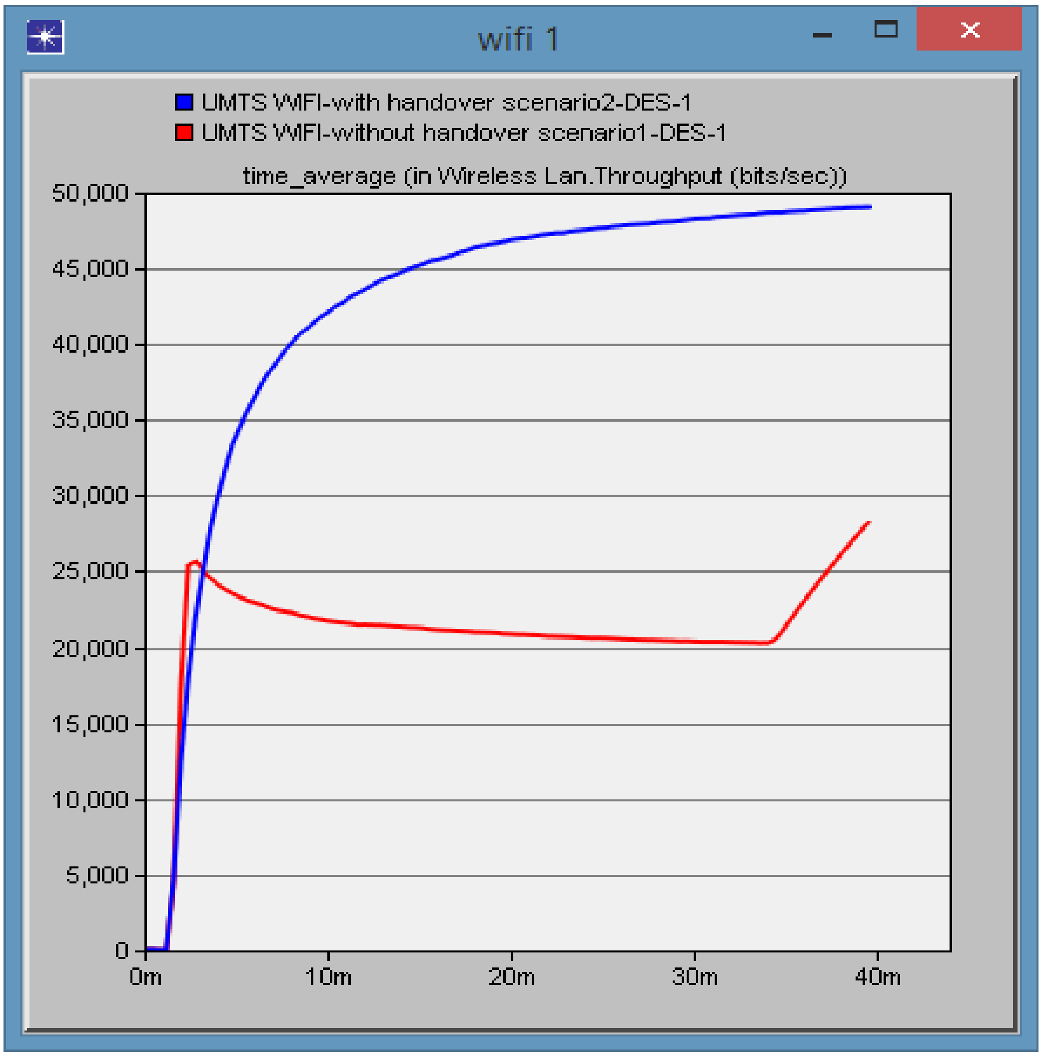

Figure 4.10 throughput between two scenarios for Wi-Fi user

Jitter (indicates that the time difference between the packets at the destination node was less than at the source node). In Figure 4.11 compares the jitter between two scenarios, we have seen that without-handover scenario is higher jitter than with-handover scenario, so the jitter value for Wi-Fi1 user in with-handover scenario has been decreasing gradually by the rate of -90% until it has reached 0 from 5 mints to 40 mints indicate the progress of calls and Qos as well.

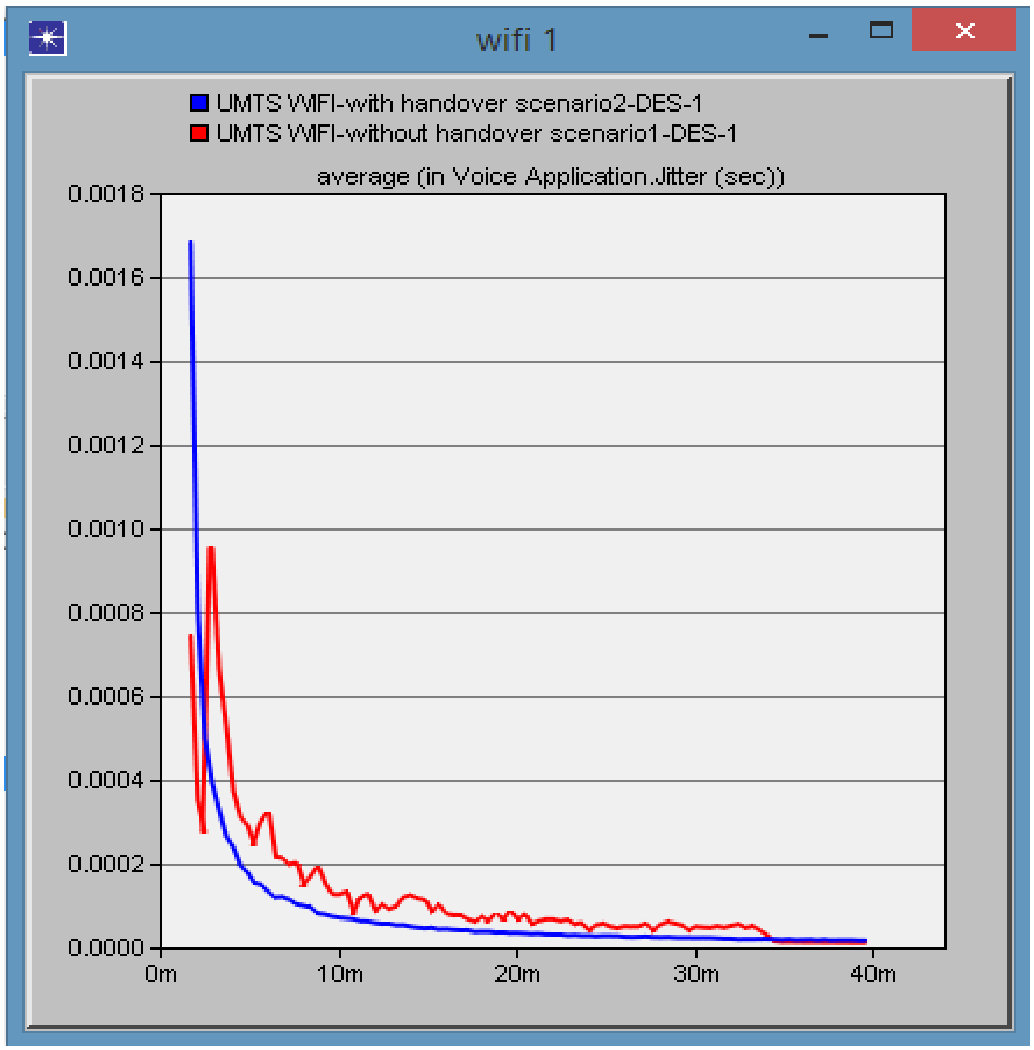

Figure 4.11 jitter between two scenarios for Wi-Fi user

4.2.2.2 UMTS user during two scenarios

Figure 4.12 represents delay value for UMTS users, X axis shows the time, Y axis shoes the MB/s and the distance from 0 second until the first second this time for simulation preparation the network, it can be note that the delay in with-handover scenario is decreased by rate of -55%, also the delay for user was stable all time which means the network was maintain Qos during connection.

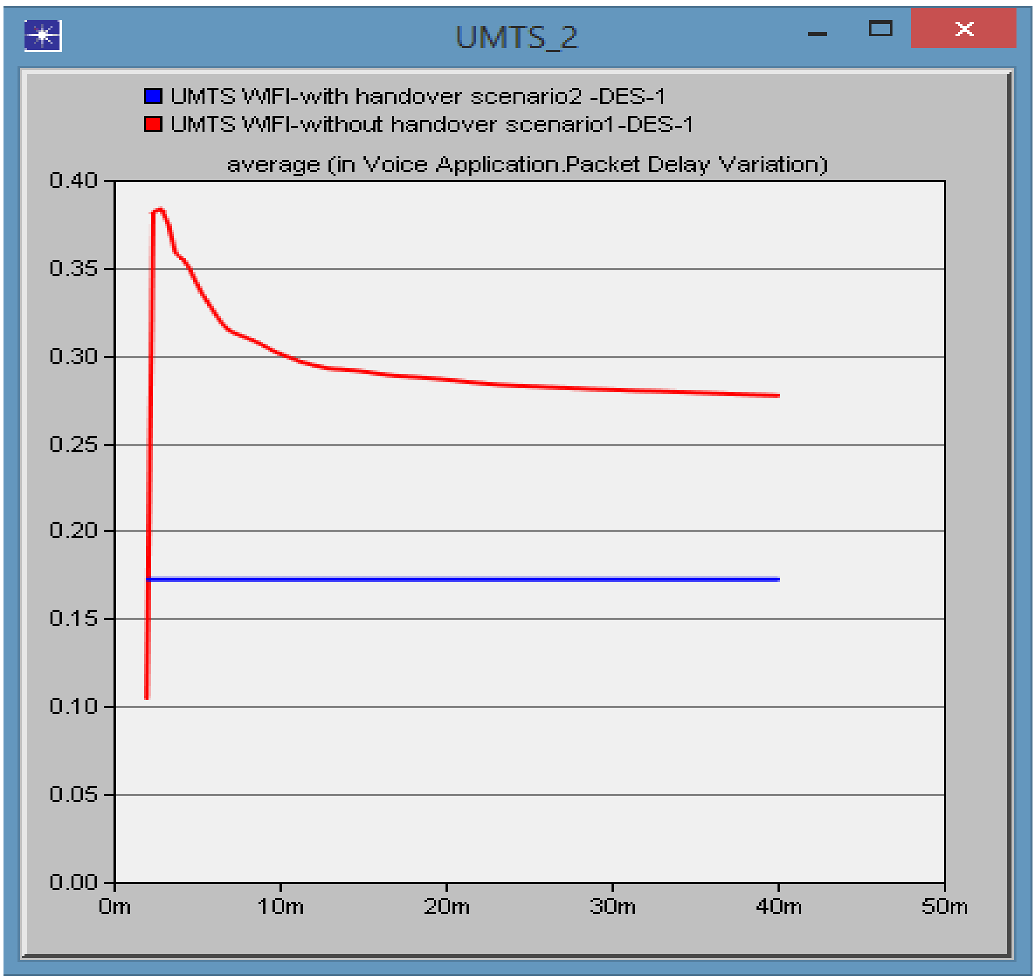

Figure 4.12 packet delay variation between two scenarios for UMTS user

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Recently users of mobile communication networks has increased rapidly, leads to users demand for high service availability to access information everywhere and every time with the best connectivity.

In this research, the proposed model is useful for supporting vertical handover between any heterogeneous wireless networks in general. The performance of WLAN into UMTS network with two scenarios with-handover scenario and without-handover scenario is based on the network parameters throughput, Delay and jitter is conducted by using OPNET modeler. The simulation results show the successful implementation and the deployment of WLAN into UMTS network, I have found that, in the Global statistics the delay for UMTS network is decrease by the rate of 18% and throughput value for Wi-Fi network is increase by the rate of 10% the with-handover scenario was improved significantly compare to without-handover scenario. In terms of Node statistics; the delay has decreased for user Wi-Fi by the rate of -63% and -55% for user UMTS that is why the user was connected to the better network and improved Qos when user moved between WIFI and UMTS.

5.2 Recommendations

This thesis discusses the Performance Evaluation of Handover in Heterogeneous Networks, It is recommended for future works to:

- Look for new method to improve Qos for calls and to develop an effective vertical handover policy by using other parameter.
- Use more than two technologies to test different types of vertical handover.
- Use other simulation programs to measure the vertical handover in heterogonous networks such as:
  - NS2, NS3 simulation
  - OMNET simulation

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