Optimized Algorithms of Vertical Handoff Management using Filtering Model in Heterogeneous Wireless Network

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CERTIFICATE

This is to certify that the dissertation titled "**Optimized Algorithms of Vertical Handoff Management using Filtering Model in Heterogeneous Wireless Network** " is a bonafide record of work done by **Ravindra Kumar Barkhiya, Roll No. 2K12/CSE/15** at **Delhi Technological University** for partial fulfilment of the requirements for the degree of Master of Technology in Computer Science & Engineering. This project was carried out under my supervision and has not been submitted elsewhere, either in part or full, for the award of any other degree or diploma to the best of my knowledge and belief.

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ABSTRACT

In wireless network based fourth generation communication system has played vital role for exchanging the information to the user on movement of mobile node.Wireless network may be broadly classified as homogeneous and heterogeneous. Wireless Homogeneous Network set consist of identical network containing same set of attributes , whereas, heterogeneous consist of dissimilar network containing different kinds of attributes. For examples new access technologies are such as IEEE 802.11(Wi-Fi Network), IEEE 802.16 (Wi-Max.), Bluetooth etc. Wireless LANs are changing the way of communication of public wireless access.They are having specific parameters viz. diverse variety of wireless access standards, network availability, coverage and Quality of Service (QoS) may rapidly change depending upon the device mobility and fading suffered by the signal.Initially mobile node is attached to specific cell but whenever mobile node wants to move in another cell while call is in progress. The transferring of mobile node from one specific cell to target cell is called handover problem while call should not be interrupted. The complexity of the challenge goes high with the consideration of random device mobility, resources availability, received signal strength, security and geographical topologies such as environments, buildings etc. One algorithms based model is proposed to minimize the number of handoffs across homogenous and heterogeneous wireless network ensuring the security features.

Also, the behavior of the algorithms is studied with change in number of member wireless nodes varying respective parameters viz. homogenous and heterogeneous, RSS, communication range, cost, velocity of mobile node, bandwidth in the system. It is also shown that this algorithm performs better minimizing the unnecessary handoffs with the proposed heterogeneous algorithm.

The proposed algorithm guarantees much more reliable handover in a multiple-operator environment. The thesis also focuses on the handover across heterogamous networks without a trust relation and focus the handover decision problem. The proposed scheme provides a secure and removes the noise like fading in RSS so unnecessary handoffs can be minimal.

Keywords : Vertical Handoff, Mobile Node, Wi-Fi, Wi-Max,Wireless Mess Network

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List of Abbreviations

WNs	Wireless Networks
BSs	Base Stations
APs	Access Points
RSS	Received Signal Strength
WLANs	Wireless Local Area Networks
3G	Third Generations
4G	Fourth Generations
VHO	Vertical Handoff
MCHO	Mobile Controlled Handoff
NCHO	Network Controlled Handoff
MAHO	Mobile Assisted Handoff
HWNs	Heterogeneous Wireless Networks
MNs	Mobile Nodes
UEs	User Elements
VIOP	Voice Over Internet Protocol
HDR	Hand Dropping Rate
NCBP	New Call Blocking Probability
DNCBP	Dynamic New Call Blocking Probability
VHDF	Vertical Handoff Decision Function
Wi-Fi	Wireless Fidelity
Wi-Max	Worldwide Interoperability for Microwave Access
MSC	Mobile switching Centre
NIC	Network Interface Card
UMTS	Universal Mobile Telecommunication System
GSM	Global System for Mobile Communication
WMN	Wireless Mesh Network
SOVHO	Secure and Optimized Vertical Handoff
HOs	Handoffs

CHAPTER 1

INTRODUCTION

There are two kinds of communication medium which are wired communication medium and second one is wireless communication medium. Wired based communication devices are fixed and connected to wire. But wireless based communication devices are not fixed at its location. They can move one place to other are called mobile devices. These mobile devices (mobile nodes) are attached to network called wireless network.

Wireless Networks based mobile nodes are composed of many limited battery powered nodes with rechargeable batteries. These nodes are set up randomly or with a static strategy or dynamic in the desired remote area to collectively fulfill the requirements for effective communication peer to peer. All the WNs form a network set amongst themselves using different optimal topologies (s) to establish a communication model which helps in transmission of the desired information like environmental and physical conditions like temperature, velocity of mobile node, bandwidth, sound, cost, noise, fading[9]etc. to a central authority efficiently.

The central authority is referred to as sink or base-station (BS) is fixed at its location and has ample power supply unlike constrained power of wireless nodes. This has increased use and applicability of WNs with unattended in vivid areas like vehicular movement, weather monitoring, security-surveillance, industry applications, health monitoring etc. There are several benefits to a WN as opposed to a physical infrastructure. There are additional features of wireless network viz. increased reliability, improved security[10], cost minimization, low battery power consumption, and increased coverage. Mainly reliability isa base factor which improves the QoS because when one MN keep talking to some other MN in its cell but after some time moves into a different cell, while a conversation is in progress, the MSC automatically transfers the call to a new channel belonging to the new base station without call terminating is referred to as handoff (HO)[3].

Basically there are certain challenges associated with the mobile nodes used in HWNs other than limited power battery are limited processing capability , low bandwidth for communication, load, RSS, user mobility, network load[2] and less memory space, communication cost. Mobile nodes communicate over short distances using radio frequency channel to transmit the sensed information using Wi-Fi technology. On second hand Wi Max can provide facility to communicate for long distant areas[3].

Now a days, the growing demand for high speed data access at anytime, roaming around anywhere and on any device leads to a new research field in the design of the Heterogeneous Wireless Networks. From a mobile user's viewpoint, some key features of the HWNs include high bandwidth, low latency, and wide coverage area, low power consumption etc. However, none of the current wireless technologies can simultaneously satisfy these needs at low cost, low power consumption, minimize no of handoffs, security removal of fading in RSS. Basically "high bandwidth", " secure communication, "Low batter power consumption" and "vivid coverage" needs of a mobile user are best satisfied if it can freely hand over to optimal target networks to maintain its services at all times without termination of call which is on conservation.

Seamless integrating heterogeneous wireless networks would enable a high speed effective network access infrastructure across its coverage area for mobile users so it can move free as It wants without call blocking and dropping [1].For example, a mobile user is connected to a Base Station (BS) via a radio link. If the mobile user moves to the coverage area of another BS, the radio link to the old BS would be eventually disconnected, and a radio link to a new BS should be established to continue the telephony conversation[3]. In wireless network infrastructure, a mobile user switches between heterogeneous wireless networks to obtain the best available connection to the network based on RSS threshold value [2]. A typical case of a Handoff for service continuity in heterogeneous wireless networks is the Handoff of a mobile user's radio link from a high speed data link e.g. IEEE 802.16(Wi-Max) to a low rate data link e.g. IEEE 802.11(Wi-Fi) when it moves out of a Wi-Fi hotspot[3].Apart from Handoff for service continuity, Handoff can be initiated for optimizing service quality. Unlike a mobile user of a GSM network who makes solely voice calls, a mobile user of Wi-Max or WLAN may have multiple data services such as voice, video, and messaging being carried on top of the Internet Protocol (IP) at the same time. In this case, different priorities are need to be set to get QoS so as to guarantee a certain level of performance to a specific data flow, especially when the network capacity and battery power are constrained .

When multiple wireless networks provide overlapped radio coverage to a mobile user, Handoff can be an effective method of optimizing service quality. Maintaining a mobile user's service continuity and service quality in a Handoff makes sure that the Handoff is performed seamlessly[4]. Seamless Handoff makes the transfer of a mobile user's network connections made transparent to MN. With seamless Handoff, a mobile user can obtain service portability and application persistence across heterogeneous wireless networks after minimizing the no of handoffs and properly transfers a call from current cell to target cell.

My thesis research is done to increase the network lifetime of the WNs which is achieved by making efficient use of energy of the nodes and by reducing the number of handoffs to mobile nodes while MN is roaming around. One effective and secure algorithms and protocol have been proposed to increase the QoS and decrease power cost based on the communication architecture between the nodes to transfer the connectivity of mobile node from one cell to another during conversation is in progress.

1.1 Wireless Mess Network Architecture

A WMN is dynamically self-organized and self-configured, probably based on battery power along with the mesh routers and mesh clients automatically establishing and maintaining mesh connectivity among themselves[10]. It eliminating wires dramatically so reduces the implementation costs, and substantially simplifies on-going operations. Without wires, the network becomes far more adaptable and flexible. Like the Internet, a wireless mesh network is also scalable, reliable and portable. The mesh can literally configure itself, allowing the installation to occur in hours instead of days or weeks. In a WMN, mesh routers form the wireless mesh backbone.

Mesh clients works as a host with required functions for mesh networking and also can work as routers forwarding packets on behalf of other nodes that may not be within direct wireless transmission range of their destinations. Such feature brings many advantages such as low up-front cost, easy network maintenance, robustness, portable device and reliable service coverage. WMNs are classified to three types in [20]: Infrastructure/Backbone, Client, and Hybrid WMNs. In figure 1.1, wireless mess network is shown. In Infrastructure/Backbone WMNs, mesh routers form a backbone network to clients. Mesh routers can use different radio technologies for back bone and user communication. The mesh backbone is meant to be self-configuring, self-healing and to offer gateway functionality for connections to wired networks such as the Internet. In Client WMNs, all the nodes are counted as mesh clients which can perform routing and configuration functionalities. In fact, a Client WMN is a traditional ad hoc network without infrastructure. Hybrid WMNs combine the above two WMNs.

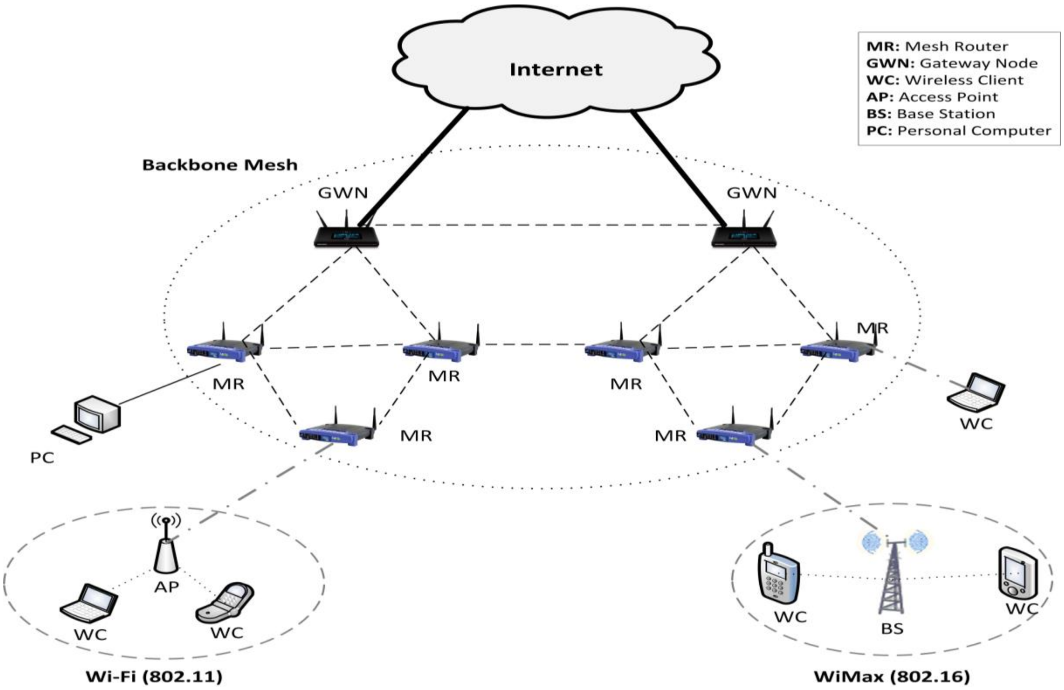


Figure 1.1: Wireless Mess Network

The mesh client can route the traffic for the other clients which cannot connect to the mesh backbone directly. This increases the coverage and connectivity of the networks. The wireless mesh backbone forming the core of a WMN provides a backhaul communication service to the Internet and multi-hop connectivity between a mobile client and a gateway. It is different from the conventional ad hoc networks due to node mobility. It covers a potentially much larger area than home, enterprise ,building, or community networks. Also, in a wireless mesh backbone, the mesh routers usually do not have strict constraints on power consumption. Therefore, the MAC or routing protocols optimized for mesh routers may not be suitable for mesh clients.

The small coverage range of existing WLANs limits the mobility of the MNs .Increasing the number of the hotspots will increase the deployment costs due to the wired connections between the hotspots and Internet. IEEE 802.16 can provide high speed Internet access in a wide area. The wireless mesh backbone based on the IEEE 802.16 standard can provide high speed network connections for WLAN hotspots.

1.2 Wireless Communication Characteristics

Wireless Network transmits signals using radio waves as the medium instead of wires using different technologies and routing protocols. They are flexible in nature means can be deployed and scattered randomly anywhere in reception area. They do not require much physical infrastructure that leads to low cost estimation. Now days we are using cordless keyboards and mice, PDAs, pagers and digital and cellular phones etc[8].

Some of the important characteristics of wireless communications systems which make it attractive for users, are given below:

- **Mobility:** A wireless communications devices allows users to exchange the information beyond their destination and provide the roaming facility from anywhere without having a wire connectivity.

- **Reachability**: Wireless communications systems enable mobile node to be better connected and reachable without any limitation of any location and physical infrastructure constraints.

- **Simplicity**: They provide ease of fast deployment in comparison of cabled network. Initial setup cost could be a bit high but other advantages overcome that high cost.

- **Maintainability :**Being a wireless system, you do no need to spend too much to maintain wireless network setup.

- **Self Configuration:** The topology of WNs is not static and is supposedly changed with no traceable patterns. So WNs have to be adaptable to such changes while keeping the power efficiency intact. Self configuration also has to handle the situations like node failures and node additions to the network or any other obstacles.

- **Efficient Energy Usage:** Power is very critical issue in increasing the performance of the network. So energy in a WN should be expended in optimal manner like nodes can switch off their sensors for a particular period of time and can switch on their transmitters only when any event occurs or after every frame time.

- **Single Hop Communication:** In this mode of communication all the WNs transmits all the information it has sensed to the BS directly without the involvement of others on its own. This mode of communication is very inefficient and power consuming with lots of redundant information to the BS. Thus modern protocols rely on the multi hop mode of communication for better efficiency.

- **Multi Hop Communication:** In case of larger networks where the distance of the BS from the node is greater than the transmission range of the sensor node. The single hop communication fails. Multi hop communication uses packet forwarding to increase the efficiency of the network. The nodes send the information to the target network with the help of other intermediate network which receives the information from the node and transfers the information to other node along the path of the BS or to BS itself. Multi hop communication saves transmission energy and is proved to be useful for energy efficiency and network lifetime.

- **Automatic Load Balancing[5]:**Nodes in the network must decide who will be the parent node to transmit the information based on the hop count to the respective node, signal strength, link quality and present load quantity of the parent node.

1.3 Research Motivation

The Handoff problem between different wireless access networks called as VHO has been a hot research and development topic in the past few years. Various types of algorithms and protocols are designed to overcome the problem in handoff management. The purpose of research work deals with distinct characteristics in terms of mobility management , security support, QoS, minimization of unnecessary of handoffs in heterogeneous wireless network. To achieve seamless mobility and end-to-end QoS guarantee for the users, these issues should be carefully dealt while developing secure and optimized handoffs schemes of WMNs in heterogeneous wireless networks. For example, the 802.11 access point (AP) functions and 802.16 base station (BS) functions can be taken into account for it.

When an MN exchange the network interface, only the link type is changed between the MN and mesh routers, and the MN still connects to the same mesh router. In this case, the traditional mobility management such as Mobile IP leads to a large handoff delay with too much signaling cost. Another factor is that how seamless vertical handoff can affect and when handoff decision should be made? What can be parameters to be worked on it? In traditional handoff, the received signal strength is the main handoff metric. However, in vertical handoff, only the received signal strength is not enough to make a handoff decision. The handoff metrics may be cost of service, available bandwidth, power requirements, QoS and user preferences, subscribers / non subscribers, security. Thus to achieve fast and seamless handoff, a new efficient handoff scheme should be come out.

It is a challenge to develop a vertical handoff decision algorithm for optimal radio resource utilization with various QoS support. The vertical handoff may not take place only at the cell edge. It can occur at any time (even when the MN does not move) depending on the network condition and user preference such as in a situation of network congestion. How to make a decision to trigger a vertical handoff according to the system performance and QoS parameters becomes the main part of this kind of vertical handoff. Therefore an effective and efficient vertical handoff decision algorithm in the interworking between 802.11 and 802.16 in WMN is needed to maximize the resource utilization.

In this thesis, we present an interworking architecture of wireless mesh backbone and propose an effective vertical handoff scheme between 802.11 and 802.16. The proposed vertical handoff scheme aims at reducing handoff signaling overhead on the wireless backbone and providing a low handoff delay to MNs.

Our proposed VHO decision algorithm combined considering relevant parameters can help in taking appropriate decision to switch new calls to differ network ensuring , reliability, QoS support to the existing traffic flows in WLAN.

1.4 Research Objectives

With the motivation explained in the previous section, the objective of our research work can be identified as:

- Development of a mechanism to let the mobile node communicate with someone without worrying about call termination while moving out of coverage area.
- To improve the signal quality of Receive Signal after removing fading from RSS that helps in correct approximation of handoff during HO decision.
- To apply the Savitzky - Golay Filter to remove the noise from signal and compute the standard deviation on them to analysis the variation on RSS .This will help in reduction of ping-pong effects means unnecessary of handoffs.
- To make the prior model secure providing authentication number to each network. It does not impose security checking to mobile node because it will consume more battery power.
- To give first priority to subscribers when both subscribers and non- subscribers are requesting to handoff that makes reliability to subscribers.
- To connect with nearest network first when more than one network are having same subscriber ids that makes handoff faster.

1.5 Thesis Organization

We start this dissertation with introduction in chapter 1 which includes WMN architectures, characteristics of WMNs, Research Motivation, and Research Objectives. A detailed description of background is presented in chapter 2 which includes applications, challenges, and generations. Chapter 3 describes the related work over handoff, types of handoff, and protocols in detail which are related to our research problem. Chapter 4 gives a brief about the network model we have used. Chapter 4 also explains in detail about our proposed model SOVHO and proposed and simulated using MATLAB. The description of the proposed work is explained in phases of causes of handoff, proposed model, handoff procedure, handoff decision function, flow chart in chapter 4. We evaluate the performance of the proposed model and technique with simulated in chapter 5. We conclude about the work done and observations in chapter 6.

CHAPTER 2

BACKGROUND

In 1895, Guglielmo Marconi firstly started the medium for modern wireless communications by transmitting the three-dot Morse code for the letter 'S' over a distance of three kilometers using electromagnetic waves[19]. From that point of time, era of wireless communications was come into account gradually. Wireless communications Firstly, relies on a scarce resource – namely, radio spectrum state. Second, use of spectrum for wireless communications required the development of key complementary technologies; especially those that allowed higher frequencies to be utilized more efficiently. Finally, because of its special nature, the efficient use of spectrum required the coordinated development of standards[18,19].The designing factor of cellular telephony was developed in AT&T's Bell labs in 1970s. The 1stcommercial mobile was developed in Scandinavian country in 1981 with the name of Nordic mobile telephone (NMT) networks [18]. The first mobile communication trial was placed in Chicago in 1978. After that, this launch occurred in Chicago in 1983 commercially. Meanwhile, other parts of the world were making progress in mobile communication. In 1979 the mobile phone system was introduced in Japan. The European countries were also very active in mobile communication; the first mobile system was launched in 1981 in Sweden, Norway, Denmark and Finland.

The growth in telecommunication industry is going exponentially very high during last little decades. The main contribution in this growth of industry is wireless mobile communication industry. The growth of this industry has experienced several generations. These generations are 1G, 2G, 3G, and 4G. Each generation have some standards, capacities, techniques and new features which differentiate it from previous generations. Due to these new features, the number of mobile phone subscribers is increasing day by day[18].Typical examples of this kind of wireless networks are classified it into three types according to the coverage area, wireless local area network can provide high-speed Internet access at limited places (i.e., Wi-Fi/ IEEE 802.11) whereas cellular networks can offer universal network access but with limited access rate, wireless metropolitan area networks (i.e., WiMAX/ IEEE 802.16), and wireless wide area network such as 3ed Generation[17,19]

2.1Generations of Wireless Communication

2.1.1 1G Mobile communication system

The 1G first generation mobile wireless communication system was analog system, which was based on a technology known as Advance Mobile Phone Service (AMPS). The AMPS system was frequency modulation radio system using frequency division multiple access (FDMA) with channel capacity of 30 KHz and frequency band was 824-894 MHz [18].

Generation	Starts from	Data capacity	Technology	Stander	Multiplexing	Switching	Service	Main network	Hand off	frequency
1G	1970-84	2kbps	Analog wireless	AMPS	FDMA	Circuit	Voice only	PSTN	Horizontal	800-900 MHz

Table 2.1 : 1st Generation Table

2.1.2 2G Mobile communication system

The 2G second generation mobile communication system offers digital communication[12]. This system was basically started in Finland in 1991. This generation is basically made for data and voice services. In this generation two digital modulation schemes are used; one is time division multiple access (TDMA) and the 2nd is code division multiple access (CDMA) [17, 18].

The family of this generation consists of 2G, 2.5G and 2.75G[19]. The specifications of this family are shown in the table below.

Generation	Starts from	Data capacity	Technology	Stander	Multiplexing	Switching	Service	Main network	Hand off	frequency
2G	1990	10kbps	Digital wireless	CDMA TDMA GSM	TDMA CDMA	Circuit packet	Voice data	PSTN	Horizontal	850-1900 MHz(GSM) 825-849MHz (CDMA)
2.5G	2000	200Kbps	GPRS	Supported TDMA/ GSM	TDMA CDMA	Packet switch	MMS internet	GSM TDMA		850-1900 MHz
2.75G	2003	473kbps	EDGE	GSM CDMA	TDMA CDMA	Packet switch		WCDMA		850-1900 MHz

Table 2.2: 2nd Generation Table

2.1.3 3G Mobile communication system

In search of high speed, fast data rate capacity and good QoS, the evolution of mobile generation reached to 3rd generation mobile communication system. GSM is modified to 3 G services to add more functionality.3G mobile system is equally available with all cellular standards like CDMA, GSM, and TDMA under one umbrella. The main features of 3G technology include wireless web base access, multimedia services, email, and video conferencing[18, 19].

Generation	Starts from	Data capacity	Technology	Stander	Multiplexing	Switching	Service	Main network	Hand off	frequency
3G	2001	384Kbps	Broad band /IP technology FDD TDD	CDMA/ WCDMA/ UMTS/ CDMA 2000	CDMA	Packet& circuit	High speed voice/data/video	Packet network	Horizontal	1.6-2.5GHz
3.5G	2003	2Mbps	GSM/ 3GPP	HSDPA /HSUPA	CDMA	Packet	High speed voice/data/video	GSM TDMA	Horizontal	1.6-2.5GHz
3.75G	2003	30Mbps		1xEVDO	CDMA	packet	High speed internet /multi media		Horizontal	1.6-2.5GHz

Table 2.3: 3rd Generation Table

2.1.4 4G Mobile communication system

The main aim of 4G technology is to provide high speed, high quality, high capacity and low cost services for example voice, multimedia and internet over IP[19]. 4G is totally IP based technology with the capability of 100Mbps and 1Gbps speed for both indoor and outdoor. A term MAGIC is used to explain the 4G technology.[18]

M= mobile multimedia
A= any time any where
G= global mobility support
I= integrated wireless solution
C= customized personal service

Generation	Starts from	Data capacity	Technology	Stander	Multiplexing	Switching	Main network	Hand off	frequency
4G	2010	200Mbps-to-1Gbps	LTE Wi MAX	IP-broadband LAN/WAN/PAN	MC-CDMA OFAM	Packet	Internet	Horizontal & Vertical	2-8GHz

Table 2.3: 4th Generation Table

4G wireless technology should put together different presently existing and prospect wireless network technologies (e.g. OFDM, MC-CDMA, LAS-CDMA and Network- LMDS) to make sure that free movement and faultless roaming from one technology to another is achieved [18]. The technologies under the 4G umbrella are; one is LTE (Long term evolution) and second is Wi-MAX (Worldwide Interoperability for Microwave Access)

2.2Next Generations of Wireless communication

These are upcoming generations which will increase the speed of internet and will provide the audio and video facility smoothly but it costs a lot.

2.2.1 5G Mobile communication system

The basic protocol for running on both 4G and 5G is IPv6. The 5G is complete wireless communication system having no limitation and is called as Real world wireless or WWWW worldwide wireless web. In 5G wireless network physical layer and data link layer defines the wireless technology[18].

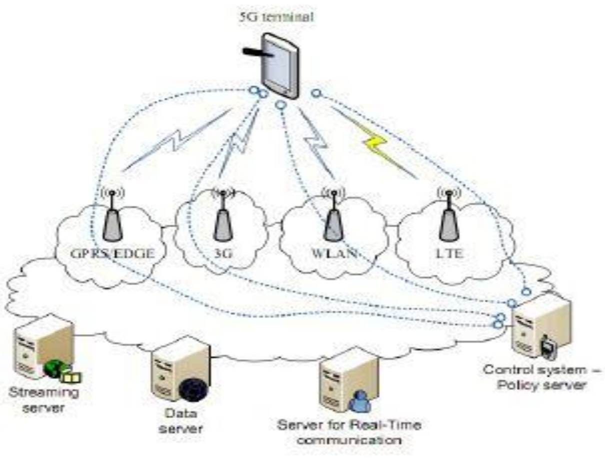


Figure 2.1 : 5th Generation

The two layers define that the 5G wireless technology is like open wireless architecture (OWA).The 5G technology mobile phone shall maintain virtual multi-wireless network. The important features of 5G technology includes bidirectional larger bandwidth, less traffic, equally availability of network across the world, 25Mbps connectivity speed, data bandwidth higher than 1GB and low-cost.

Generation	Starts from	Data capacity	Technology	Stander	Multiplexing	Switching	Service	Main network	Hand off	frequency
5G	2015	Higher then 1Gbps	IP v6	IP-broadband LAN/WAN/PAN &wwww	CDMA	All packet	Dynamic Information access, wearable devices with AI capabilities	Internet	Horizontal&vetrical	

Table 2.5: 5th Generation Table

2.2.2 6G Mobile communication system

The 6G mobile system for the global coverage will integrate 5G wireless mobile system and satellite network. These satellite networks consist of telecommunication satellite network, Earth imaging satellite network and navigation satellite network [18]. The telecommunication satellite is used for voice, data, internet, and video broadcasting; the earth imaging satellite networks is for weather and environmental information collection; and the navigational satellite network is for global positional system (GPS) [27].

In 6G handoff and roaming will be the big issue because these satellite systems are different networks and 6G has four different standards. So the handoff and roaming must take place between these 4 networks but how it will occur is still a question.

2.2.3 7G Mobile communication system

7G mobile network is like the 6G for global coverage but it will also define the satellite functions for mobile communication. In satellite system, the telecommunication satellite will be for voice and multimedia communication; navigational satellite will be for global positional system (GPS) and earth image satellite for some extra information like weather update [18]. The 6G mobile wireless network will support local voice coverage and other services.

2.3 Local Wireless Network (Wi-Fi)

Wireless Fidelity, they referred to as Wi-Fi is used to signify the line 802.11, 802.11a (with maximum bandwidth 54 Mb), 802.11b (with maximum bandwidth 11 Mb) and 802.11g (with maximum bandwidth 54 Mb) standards for these wireless communication equipment to produce the WMAN as we summarized it in Table 1. This term is by the WiFi alliance (an organization similar to WiMAX forum) they suggested that the organization is to allow the different companies to produce under the IEEE 802.11[11, 17] standard Wireless Local Area

Standard	802.11	802.11b	802.11a	802.11g	802.11n	
Years	1997	1999	1999	2003	2009	
Bandwidth (GHz)	2.4~2.4835	2.4~2.4835	5.15~5.35 5.725~5.825	2.4~2.4835	20	40
Channel Bandwidth	83.5 MHz	83.5MHz	300MHz	83.5MHz	40MHz	
Coverage	100m	100m	50M	100m	In 10m	Out 250m
Modulation	DBPSK,DQPSK	DBPSK,DQPSK	M-PSK,MQAM	M-PSK, M-QAM	OFDM	
Max.bitrate (bps)	1M / 2M	1M / 2M /5.5M / 11M	6M to 54M	6M to 54M	54M-60M	
PHY Mod.	FHSS, DSSS	DSSS, CCK, PBCC	OFDM	OFDM, CCK	OFDM	

Table 2.6: Wi-Fi Table

2.4 Wide Area Internet Access Infrastructure (WiMAX)

With the rapid development of wireless networks, people have become accustomed to anytime, anywhere access to information through a wireless network[11, 17], new applications constantly being developed, people use mobile devices for voice and video communication, while, can also send files and order such information. Therefore, the addition to be able to facilitate access in any location other than access the Internet, and mobile users for the bandwidth requirement of stability is gradually improving.

Standard	802.16	802.16a	802.16-2004	802.16e
	Last mile & Back haul			*Mobile Device*
Bandwidth (GHz)	10-66GHz	2~11GHz		2~6GHz
Max.bitrate (bps)	32~134Mbps	75Mbps		15Mbps
PHY Mod.	QPSK 16QAM 64QAM	QPSK, 16QAM, 64QAM (256 subcarrier OFDM)		QPSK, 16QAM, 64QAM (257 subcarrier OFDM)
Coverage	1~3 Mile	4~6 Mile (30Mile)		1~3Mile

Table 2.7: Wi-Max Table

2.5 APPLICATIONS OF WIRELESS MESH NETWORKS

Due to their wide applicability in wireless communication medium, WMNs can efficiently satisfy the needs of multiple applications. In this section, we will focus some of the most commonly applications of WMNs. WMNs offer considerable advantages as an Internet broadband access technology.

- **Hospitality & Entertainment** - With more and more people becoming accustomed to having network access constantly, businesses that fail to accommodate this need risk losing customers. The hospitality and entertainment industries has both public and private communication needs. Customers are served by public Internet access with Hotspots and Hot Zones throughout the facility. The internal or private needs of the facility itself can be served by either the same or a separate wireless mesh mezzanine network.

- **Warehousing and Manufacturing**– Providing full network coverage in large facilities, such as warehouses and factories, typically requires massive lengths of cabling that leads to a questionable return on investment. Using a wireless mesh as a backbone network simplifies installation and provides an affordable, unobtrusive and completely portable solution for both small- and large-scaled employments. In addition to being easy to install, mesh network nodes can be added virtually anywhere Ethernet is required, including time clocks, scales, surveillance cameras, and even on moving equipment, such as forklifts, cranes, and conveyor systems.

- **Transportation and Shipping** – Whether moving people or pallets, mobility is part and parcel to the transportation and shipping industries. The wireless mesh is a versatile way of serving these needs for anything from a seaport to a subway. The mesh can handle inventory tracking or logistics, security and surveillance, ship-to-shore communications—or some combination—all cost effectively.

- **Retail**– With the trend in retail to gigantic "super stores," many retail operations now share many of the same needs as large warehouses. So in addition to the obvious need for mobility in such a large facility, many retail establishments now offer Hotspots as a way of attracting more customers.

- **Public Internet Access Hot Zones**– Whether deployed by service providers or property managers, public Hotspots are becoming increasingly common. The wireless mesh network is ideal for the growing number of Wireless Internet Service Providers (WISPs) deploying and linking multiple Hotspots in widespread coverage areas, or so-called Hot

Zones. A variation on this theme is the public guest network, where the mezzanine created by a wireless mesh can give customers, consultants, business partners and other visitors access that is isolated from the rest of the private enterprise network.

- **Metropolitan and Community-Wide Networks** - Wireless is a natural for "open air" networks that span all or part of a metropolitan area. The wireless mesh allows separate mezzanine networks to be deployed to serve different needs. For example, cities are using wireless networks to deploy downtown hot zones to attract visitors and businesses, provide broadband services for underserved areas, and save money while improving government worker productivity.

- **Public Safety and First Responders**– Wireless mesh networks can enable police and fire departments and other first responders to better serve their community by providing connectivity to emergency vehicles anywhere in a city or town. This improves communications, provides instant access to local and national data base systems, and saves money. Other public safety applications that benefit from mesh include video surveillance, mobile and temporary networks for emergencies, and personnel and vehicle tracking.

- **Government/Military and Homeland Security**– Federal, state and local governments have both metropolitan- and building-based needs that can benefit from the reach, resiliency and security of wireless mesh networks. Some of these applications may fall under the category of Metropolitan and Community Networks, but others are likely to involve less "open" intra- or inter-agency applications and projects.

- **Educational Institutions**– A wireless mesh or multiple wireless meshes can be used to create extended Hot Zones connecting multiple buildings and facilities to unify an entire campus under a single network. In addition, different networking functions, such as video surveillance, Internet access, backup LAN services and Wi-Fi access, can all operate across the same mesh infrastructure, extending the physical reach of all these functions without additional wiring.

- **Health Care**– Although many hospitals have extensive network cabling in place, all can benefit from the portability and low cost of wireless networking. Indeed, with cost reduction a constant goal in the health care industry, newer and cheaper ways to improve information flow are attractive. One way to reduce costs is by moving the care to the patient rather than the other way around. For example, an Ethernet port on a wireless mesh node could be used to serve a parking area reserved for portable (and expensive) instruments, such as Positron Emission Tomography (P.E.T.) scanners.

2.6 Challenges in Wireless Communication

In this section we outline the major research issues related to WMNs. We follow a bottom-up layered approach and emphasize the less obvious issues at each layer.

2.6.1 Physical Layer

WMN technology is theoretically "radio agnostic" (i.e., independent of the physical layer); however, as for all networking technologies, the characteristics of the physical layer are reflected in the performance of the WMN. The challenges of the physical layer of WMNs are not fundamentally different from other wireless technologies[23].

As a minimum, the physical layer of a WMN should be reliable. The undesirable effects of fading and interference are well understood and several (typically spread spectrum) solutions (Frequency Hopping Spread Spectrum (FHSS), Code Division Multiple Access (CDMA), Orthogonal Frequency Division Multiplexing (OFDM) and Ultra-Wide Band (UWB)) are routinely employed to increase the reliability of the radio transmission. Since the MAC protocol of WMNs is commonly contention based, resistance to interference is more important than in the case of cellular systems and 802.16 that enjoy practically collision free MAC protocols.

2 .6.2 Data Link Layer

At the data link layer, the design of the MAC protocol is the most likely challenge in WMN. Despite the existence of a centralized entity (the gateway), it is unlikely that the gateway can efficiently coordinate the MAC layers of nodes several hops away[23].

There are a significant number of MAC protocols designed for MANETs. It is likely that many of those layers will work reasonably well in WMNs. In particular MACAW, (the RTS/CTS option standardized in IEEE 802.11 [24]) is particularly useful in preventing the effects of the hidden terminal problem.

2.6.3 Network Layer

The main function of the networking layer is to transfer the packets from the source to the destination over multiple hops. In this respect, WMNs are radically different from 3G systems, WLANs and WMANs. All these technologies use a single wireless link, and hence have no need for a network layer[23]. In contrast, for WMNs and MANETs the source and the destination can be several wireless hops away from each other, and hence the packets have to be routed and forwarded in the wireless network itself.

- **Routing:** The routing protocol is an important factor in any network, but in WMNs it can mean the difference between failure and success. Several of the advantages of WMNs over competing technologies are enabled by the routing protocol alone:

    - Scalability/Efficiency
    - Reliability
    - Mobile User Connectivity
    - Flexibility
    - QoS

2.6.4 Transport Layer

TCP is currently the most widely-used transport protocol on the Internet. Unfortunately, TCP was designed and fine-tuned for wired networks where most packet losses are due to buffer overflows in the routers[23]. This assumption is simply not true in WMNs where most losses are due to poor wireless links, medium access contention, and user mobility.

It is well known that even in single-hop wireless networks, TCP performs poorly (unnecessarily reducing its transmission rate in response to transmission errors and delays). In a multi hop environment such as a WMN, TCP will perform significantly worse as there are significantly more chances to lose a packet (several wireless transmissions for each packet, mobility of intermediate routers, etc.) than in the single-hop wireless networks. Furthermore, even for relatively simple scenarios, TCP is unfair favoring some links at the expense of others. The unfair behavior is, in some instances, inherited from the networking layer, while, in other cases, it is induced by TCP mechanisms [23].

2.6.5 Other Challenges

In this section we will describe several other challenges that are found in multiple layers of the OSI stack.

- **Provisioning:** Provisioning WLANs in multi access point deployments is far from trivial. In WMNs, the problem is considerably more difficult. Usually, the main provisioning problem is to determine how much bandwidth each subscriber can receive, given a WMN topology and the offered loads. Preliminary results with simplified network models and assumptions (e.g. single communication channel, Omni-directional antennas) have been recently published [25]. The problem with a more realistic model and for a more general physical and MAC layers is yet to be solved. The capacity of a WMN is decreasing with the number of clients connected to each gateway [26]. At some point, the ISP (operator) should upgrade the infrastructure by adding one or more gateways. In this case the problem is to determine the location of the additional gateways that maximizes the network capacity.

- **Security:** Unfortunately, security is sometimes an after-thought. For any commercial wireless product, however, security should be one of the first problems to be solved. For WMNs, there are at least several security issues to be considered:
  - ✓ **Authentication:** Before allowing a user to join the network, each client (stationary or mobile) should be authenticated[21, 23]. This can prevent access by unauthorized (sometimes malicious) users or those that simply are not willing to pay for the service.

  - ✓ **Privacy:** Especially in WMNs, where user data travels through multiple wireless hops, the clients will be concerned with the privacy of their information[23]. User data should be secured both from sniffing by occasional eavesdroppers while transmitted between WMN routers and from being read by other network users at intermediate hops. An end-to-end (at least client to gateway) encryption scheme is likely necessary.

- ✓ **Reliability:** In addition to user data it is imperative to protect the control data (routing, monitoring, etc.). If the control data is unprotected, it will be relatively easy for an attacker to disable a WMN (or alter its behavior at his or her will).

- **Transmission Power Level:** The choice of transmission power in MANETs is a prolific research area. Clearly the transmission power should be higher or equal to a lower bound that ensures network connectivity. The transmission power is also bounded from above by technology and regulatory limits. An algorithm that maximizes the network capacity by varying the transmission power between the two limits is needed. Many other parameters (error rates, delay, etc.) are influenced by the transmission power.

- **Quality of Service (QoS**): One of the primary concerns about wireless data delivery is that, like the Internet over wired services, QoS is inadequate. Lost packets, and atmospheric in are recurring problems wireless protocols[22].

- **Reachable Range:** Normally wireless network offers a range of about 100 meters or less. Range is a function of antenna design and power. Now a days the range of wireless is extended to tens of miles so this should not be an issue any more.

- **Call Admission Control (CAC):**The main objective of the CAC is to reduce the connection dropping probability for new and Handoff calls. The number of connection requests dropped by admission control to the overall connection requests in the network is the dropping probability. A call can be initiated in two scenarios, during Handoff and a new call. Depending upon the congestion in the network the call might be admitted or rejected or delayed. CAC in wireless communication is a process of administering the traffic volume. The decision of whether a new call has to be admitted, delayed, dropped or forwarded to a neighboring network is decided by CAC sub-system[22].

- **Resource Allocation:** Resource allocation is a mechanism where an admitted call is allocated with the required resources, such as bandwidth and buffer. Allocating the required resources depends upon the application (voice, data, or video). Incoming traffic, whether it is data, voice or multimedia, can be admitted only if there are sufficient resources in the network. This requires a smart resource allocation scheme.

- **Security and Fraud Management:** The open and distributed nature of the convergent NGWN architecture enables easy access to services, information and resources together with constant abuse by hackers, fraudsters and organized crime units (Bella, Olivier and Elo_, 2005).

  User identification based on the IP layer can be easily tampered with. The packets sent over the network can be easily marked with a "borrowed" IP address, enabling unauthorized users to impersonate legitimate ones. These intruders abuse services and beneficiate at the expense of the legitimate users, who are often unsuspecting until the bill arrives (Ericsson, 2004). The fraudsters can obtain a valid electronic serial number and mobile identification number during the registration process of the call. They can duplicate the same number on the other handset and utilize the services in the name of real user.

- **Location Registration:** In the current cellular network, the location update has to be maintained at two different locations namely Home Location Register (HLR) and Visiting Location Register (VLR). In (Lee, Lee and Cho, 2003) a mobile node uses both Mobile IP and Session Initiation Protocol (SIP) for providing mobility[22]. The redundancy of having a separate registration for Mobile IP and SIP is an overhead. Integrating mobility management in mobile IP and SIP is an acceptable solution authors proposed.

- **Access Technologies:** Heterogeneous wireless networks that employ a number of radio technologies may have overlapped radio coverage. A mobile user needs to switch between access networks to maintain service continuity and optimize service quality. How does a mobile user deal with heterogeneous access technologies?

- **Network Architectures:** Heterogeneous wireless networks rely on different network architectures and protocols for transport, routing, mobility management and so forth. How will they be interconnected in an integral manner to facilitate the cooperation between themselves?

- **Network Conditions:** Network conditions such as bandwidth, delay, jitter and so forth may vary across wireless networks, and result in different service quality to be provided. How does a mobile user deal with the variation in network conditions, and maintain service quality when crossing heterogeneous wireless networks?

- **Interoperability:** Services will be jointly provided by autonomous networks of multiple network operators. This is referred to as the *multiplicities* of network operators in this thesis. How will multiple network operators collaborate with each other in an effective manner to make best use of their network infrastructures?

- **Large Number Of Operators:** A large number of network operators are expected to co-exist and collaborate in the Next Generation Wireless Networks. In such circumstances, mobile users who are responsible for Handoff decision will require increased levels of control over how services can be secured in Handoff. This will be complicated by versatile trust relationships between network operators.

CHAPTER - 3

RELATED WORK

Handoff [9] is a process of transferring an active mobile user session from one Base Station (BS) or Access Point (AP) to another in order to keep the user's connection uninterrupted. In the traditional circuit-switched wireless networks such as GSM, Handoff is employed mainly for maintaining a mobile user's telephony voice. The Handoff in such a circumstance is motivated by the fact that the coverage area of a single BS transceiver can not cover the whole service area. The coverage area of one or more BS transceivers at a single physical site is referred to as a cell. In Frequency Division Multiple Access (FDMA) based systems, a cluster is a group of cells in which frequencies are not reused

3.1 System Model

Such a flat compound architecture can be supplemented by more intelligent radio resource management techniques such as the macro-cell /microcell overlay, which consists of large-size macro-cells and small-size microcells for balancing network capacity and network control load associated with Handoff.

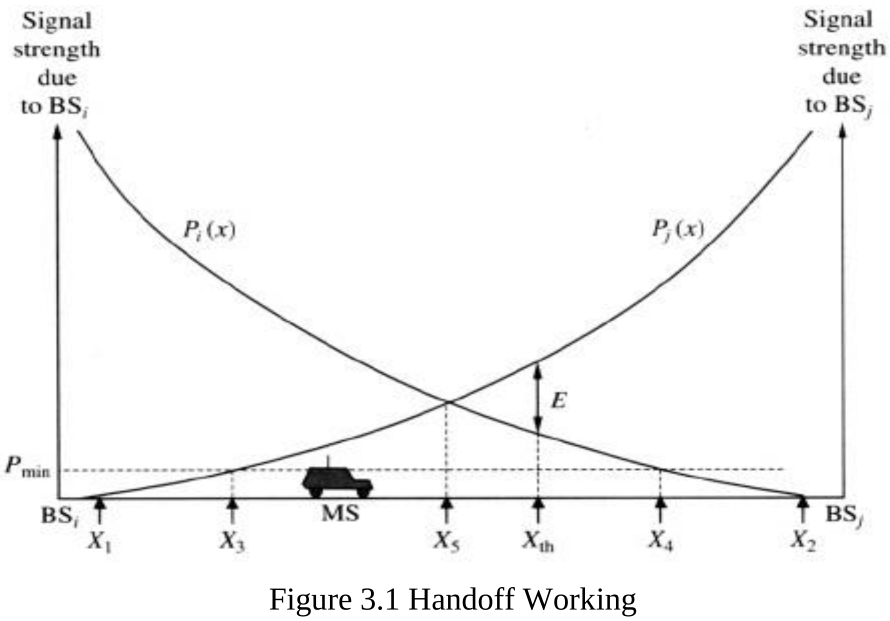


Figure 3.1 Handoff Working

When a mobile user connection to an AP or BS degrades below an acceptable threshold, it has to switch the session to a neighboring cell.

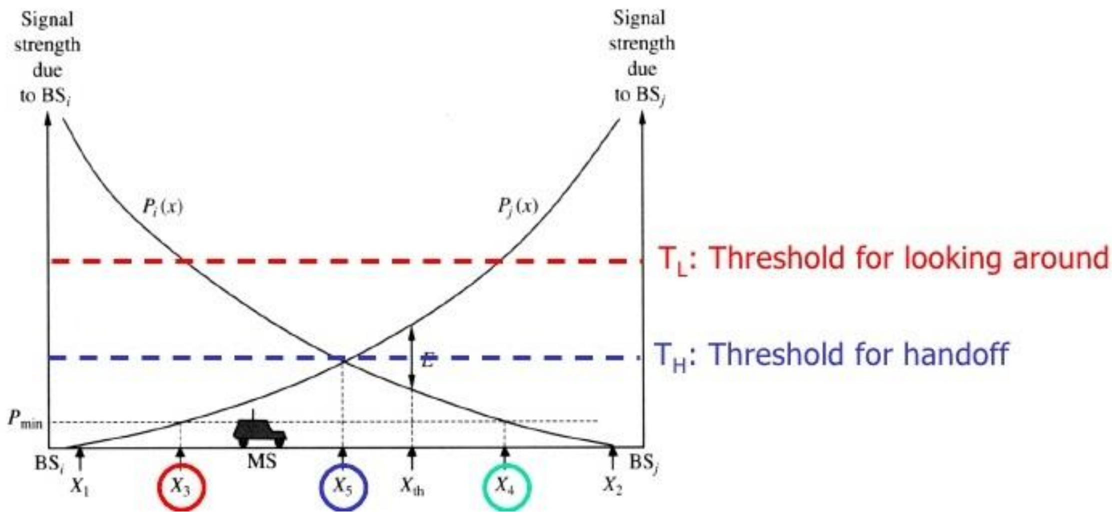


Figure 3.2 Handoff Due To RSS

Wireless technologies vary widely in terms of bandwidth, latency, network coverage, and mobility. Nowadays, no single wireless system provides an optimal combination with high bandwidth, low latency, wide area coverage, and strong mobility support. Given the current level of technology development, it is a great challenge to provide users with satisfactory mobile experience in existing wireless networks. The key to this challenge lies in a flexible utilization of the available networks achieved by switching between different wireless access technologies whenever necessary .

In the context of wireless mobility, the procedure of switching access networks is referred to as Handoff. By definition, Handoff is the process by which an active mobile host changes its point of attachment to the network, or when such a change is attempted. To enable host mobility in wireless networks with continuous connectivity, Handoff management is a fundamental issue that needs to be solved.

To discuss Handoff management we first introduce a mobile specific term, roaming, which is frequently used in current mobile systems. In the context of wireless mobility, roaming is a particular aspect of host mobility. It is an operator based term involving formal agreements between operators that allows a mobile node to get connectivity from a foreign network. Roaming includes the functionalities to help mobile hosts exchange their identities to the foreign access network so that inter-operator agreement can be activated to enable services in the visiting network .In wireless environment, Handoff management entails most of the functionalities that are necessary for seamless mobility across different networks while preserving the QoS and migration transparency. In general, the Handoff process includes a series of signalling and context transfer between mobile nodes and network side to exchange user credentials and network information. As an example, Figure 3.3demonstrates the signal flow of a simple Handoff between two access points in GSM.

Figure 3.3 Handoff Demonstration

In GSM system, MN is connected to base transceiver station (BTS), which functions as the access point to the network. Base station controller (BSC) manages the BTS and handles the Handoff management. When a MN moves into the coverage of anew BTS, it will receive wireless signal from this BTS. MN sends the measurement report to the old BTS, which forwards the report to BSC in charge. Based on the reported value, BSC will decide whether it is necessary to initiate Handoff. Once the decision is made, BSC will allocate resources for the new channel and send channel activation signal to the new BTS. The new BTS checks whether there are enough resources available, and if resources can be allocated, the new BTS will activate communication channel for the MN and send acknowledgement back to BSC. BSC then issues a Handoff command which is forwarded to MN via the old BTS. Upon receiving Handoff command, MN breaks its old link and starts access to the new BTS. The following step is to establish link between MN and new BTS. When the new link is up, Handoff complete signal will be sent from new BTS to BSC. To release the previously allocated resources, BSC sends clear command to the old BTS. Old BTS will send back a clear complete signal to BSC to indicate the end of a successful Handoff.

Given the current wireless environment, when mobile nodes move across different networks adopting the same or different access technologies, Handoff may arise if one of the following conditions is met:

- When a mobile node is moving out of the coverage of the serving domain and entering a new domain, while the signal strength of previous access point (or base station) falls below a certain threshold value;
- When a mobile node currently connected to one network chooses to switch to another one for its future service needs;
- When load balancing is needed to distribute the overall network load among different wireless systems .

In general, Handoff procedure can be classified to different types according to aspects such as control, scope, connectivity, and performance. For control aspect, Handoffs are considered to fall into one of the two classifications: host-initiated and network-initiated. Concerning the host-initiated Handoff, the mobile node is responsible to determine its new point of attachment and establish the link connection by following corresponding protocol required by the network side. Handoff in Mobile IP is a typical host-initiated process. On the other hand, network-initiated Handoff let the network side to carry out all necessary tasks such as network measurement and Handoff decision. Handoff adopted in the cellular system is regarded as network-initiated procedure.

In the hierarchy structure of wireless overlay network, lower levels consist of high bandwidth and low latency wireless systems that cover small area, while higher levels are comprised of lower bandwidth and high latency systems that provide wireless coverage over a larger geographic area. Vertical Handoff, in the overlay network architecture, is a Handoff between access points (or base stations) that are using different wireless technologies. On the other hand, horizontal Handoff refers to the switching process between access points (or base stations) that are using the same type of wireless technology. As an example, when a user switches the wireless access from campus area WiMAX to room area WiFi, it is regarded as a vertical Handoff. When a user moves from one room to another by switching between two Wi-Fi access points, this process is referred to as horizontal Handoff. Horizontal Handoff follows the traditional definition of Handoff in homogeneous cellular telecommunication systems.

3.2Handoff Classification

In order to improve the efficiency of the network, a proper Handoff scheme has to be used when a user moves between different cells of the same or a different network. There are basically four types of Handoff[11]depending on how the call is handed over from the current cell to a new cell of the same or a different network.

- **Hard Handoff :** This type of Handoff is also called a break before make connection. In this type of Handoff, the mobile terminal communicates with only one base station at a time. When a Handoff takes place the current connection is broken, and a new connection is made. When the current connection is broken the resources associated with the old base stations are released, and the mobile terminal is allocated new resources associated with the new base station. It is particularly suited for the delay-tolerant applications which are non-real time.

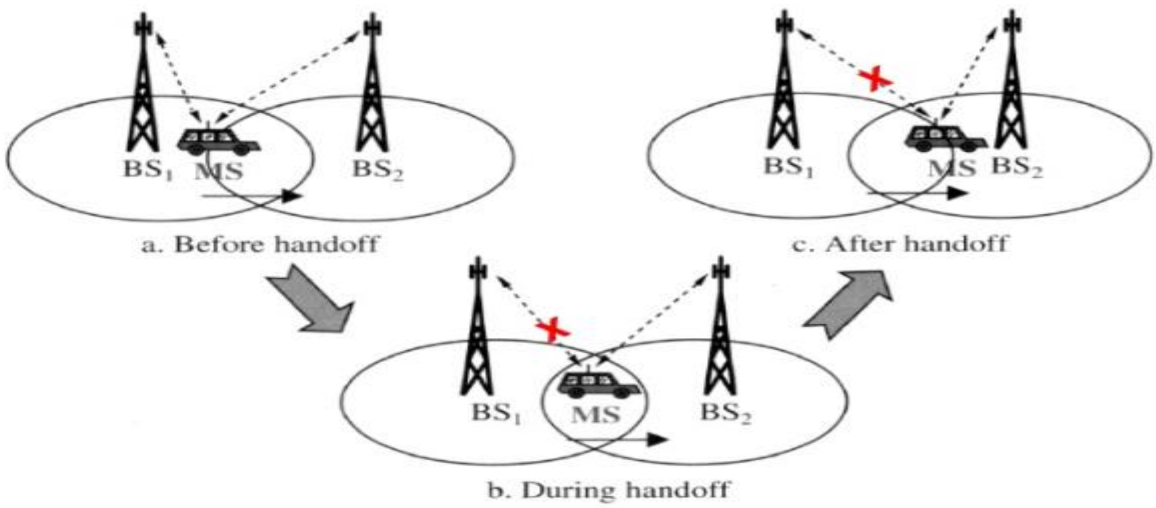


Figure 3.4 Hard Handoff

- **Soft Handoff :** This type of Handoff is also called a make-before-break connection. Soft Handoff is a process of making a new connection before breaking the previous one. Thus, a user has two connections with the two different base stations. The soft Handoff is used for time critical applications which are not delay-tolerant. The UMTS and WiMAX networks support soft Handoff.

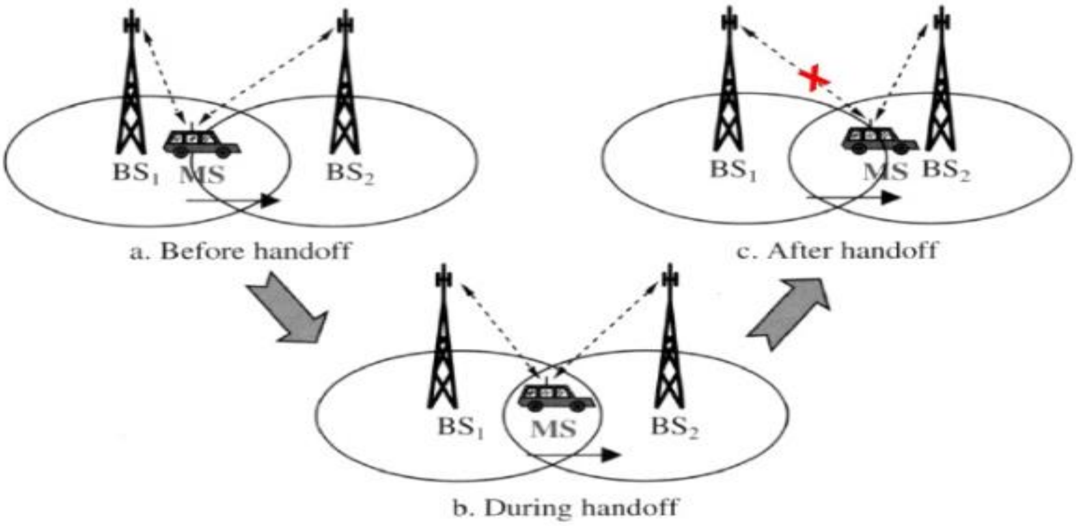


Figure 3.5 Soft Handoff

- **Horizontal Handoff :** When a connection is handed over to the base station within the same network, it is called horizontal Handoff or intra-system Handoff. Since both involved base station share the radio resources, network interface and QoS parameters, it is relatively easy to make a horizontal Handoff.

- **Vertical Handoff:** When the connection is handed over to the base station of a different network, it is called a vertical Handoff or inter-system Handoff. The connection is transferred to a different radio access network, e.g. Handoff between UMTS and WiMAX. During vertical Handoff the IP address of the connection is changed. It requires mapping of QoS parameter as both networks have a different QoS model.

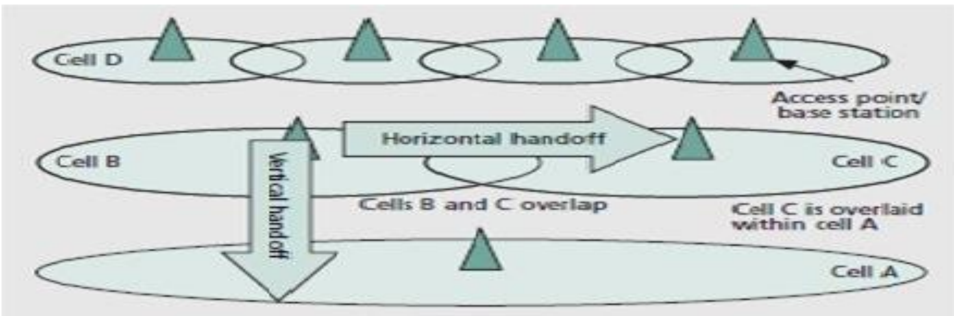


Figure 3.6: Horizontal Handoff and Vertical Handoff

3.3 TYPES OF PROTOCOLS:

VHO is having four basic kinds of handoff protocols which are stated: Mobile - Controlled Handoff (MCHO), Mobile- Assisted Handoff (MAHO), SHO (Soft Handoff) and Network-Controlled Handoff (NCHO). As far as the HO decision function making process is decentralized (i.e., moving from NCHO to MCHO), HO delay (i.e., the time taken to execute a handoff request) goes on decreasing level, but the measurement information available to make a handoff decision decreases as well.

In cellular wireless networks, it is very important to deal with Mobile station (MS) handoff between cells so that they can maintain a continuous and QoS-guaranteed service. There are four basic types of handoff protocols; network-controlled handoff (NCHO), mobile-assisted handoff (MAHO), soft handoff (SHO), and mobile-controlled handoff (MCHO). From NCHO to MCHO, the control protocols tend to decentralize the decision making process, which help shorten handoff delays; however, meanwhile, the decentralization makes the measurement information available to make a handoff decision also decreased. Next, we briefly introduce these four types of handoff mechanisms.

3.3.1 Network-Controlled Handoff

Network Controlled Handoff (CHO) is called as centralized handoff protocol because it is based on controlling in hand of network that makes handoff decision parameters based on measurements of the RSS’s quality of mobile station (MS) at a number of BSs. if the MS is evaluated to have a weaker RSS and other respective parameters in its connected cell, while a stronger signal in a neighbouring cell, then a handoff decision could be made by the network to switch BS from the currently cell to the new target cell. Such a type of handoff in general takes 100-200 ms and produces a noticeable "interruption" in the conversation.

Generally, HO process (including RSS receiving, data transmission, channel switching, and network switching) takes around 100–200 ms and creates a noticeable click in the conversation. But this click is difficult to perceive for user in a noisy voice channel environment. According to [29], the overall delay during this procedure can being range of 5–10 s. That’s why, this protocol is not relevant for a rapidly changing environment, real time device sand a high density of users because of associated delay. This protocol is used in first-generation which are based on analog systems such as AMPS, Total Access Communications System (TACS), and Nordic Mobile Telephone (NMT) [28].

3.3.2 Mobile-Assisted Handoff

A Mobile Assisted Handoff (MAHO) is such kind of protocol which handoff decision process is distributed. The Mobile Station makes measurements, and then Mobile station controller makes decisions on that. In GSM, the Base Station subsystem (BSS) is associated with a base transceiver station (BTS) and a base station controller (BSC). The BTS is associated with MSs through the radio link that includes receiver devices, radio transmission and signal processing. The BSC is linked with the network and controls the radio interface management, basically the allocation and de-allocation of radio channels and handoff management. One BSC offers the service to several BTSs, and many BSCs are associated with one MSC. Approximately Complete handoff procedure takes time of 1s in GSM. If the serving and target BTSs are having within the same BSS, then BSC for the BSS can do handoff without taking help of the MSC. That's why it is called as intra-BSS handoff.

While the MSC controls the handoff management which can be further categorized as inter-MSC (done between MSCs) or intra-MSC (done within the same MSC).. An Interim Standard 95 (IS-95)-based is a system that uses SHO (Soft Handoff) which is having conjunction with MAHO. SHO uses the policy of "make before break" connection in which the connection to the old Base Station is not broken until a connection to the new Base Station is made. SHO is having several variations.

A soft handoff is used when new and old Base Stations belong to two different cells. On the another hand softer handoff is used when the two signals correspond to the two different sectors of a sectorized cell. When simultaneously soft and softer handoffs occur, soft-softer handoff is basically term used. As working with MS, there is no much difference between SHO and softer handoff. For the network is concerned, soft handoff requires additional overhead. One BS-to-MSC trunk and one channel element hardware are required for each cell which is involved in SHO.

As compared to Network Controlled Handoff, this mechanism has more distributed control which helps to improve the overall handoff delay, typically comes in the range of 1 s.

3.3.3 Soft Handoff

Soft Handoff (SHO) is commonly used in conjunction with Mobile Assisted Handoff. In this connection between a MS and a BS is not immediately terminated until new connection establishes first between MS and new BS while maintaining the old connection between the MS and the old station. If new connection transmits data stably, then old connection is terminated. That’s why, SHO is called as "make before break" mechanism. This kind of handoff helps to ensure the service continuity, which is meant of cost of more capacity resource are consumed during the handoff (as per two connections are active simultaneously).

3.3.4 Mobile-Controlled Handoff

Mobile Controlled Handoff is such kind of handoff which is having short reaction time (order of 0.1 s) and is the most used in microcellular systems [29]. The MS is not able to get the information about the signal quality of other MNs, but HO must not lead to interference to other MNs. The Mobile Station measures the received signal strengths from neighboring BSs and interference levels on all available channels. A handoff can be triggered if the signal strength of the currently connected BS is lower than that of other BSs by a specified threshold value. The MS requests that target BS for a channel which is having lowest interference. MCHO offers highest degree of handoff decentralization. Few advantages of handoff decentralization are over handoff can take decision fast, and the MSC does not have to take handoff decisions for every mobile. It is not easy task for the MSC of high-capacity microcellular systems[31]. The MS and BS trace the current channel, and the BS reports measurements — Received Signal Strength and bit error rate (BER) — to the Mobile Station. There is a possibility of intra-cell and inter-cell handoffs. In this handoff time is taken approximately 100 ms.

As compare to NCHO, MS completely controls and takes HO decisions on handoff in the MCHO approach. We know that MS keeps on measuring RSS from all the nearest base station (BS)s. If the MS find that there is a new BS who has a stronger signal than that of an old BS and specified threshold value, it can consider to handoff from the old BS to the new target BS given a certain signal threshold is reached. It makes fast handoff having range in 0.1 s.

CHAPTER – 4

PROPOSED VERTICAL HANDOFF ALGORITHM

One of the main objectives of Handoffs in a cellular network is to provide uninterrupted connectivity between users and the radio access network While they move across cell boundaries Within the network. Efficient Handoff algorithms should be designed to preserve capacity and enhance Quality of Service (QoS) of communication devices in a cost effective manner. There is a number of research works in developing efficient Handoff algorithms.

4.1 Causes of Handoff

The occurrence of a Handoff can be attributed to a number of factors, which could be related to radio link quality, network management and/or service options [4] [6]. While radio link quality related HOs may occur frequently which may be difficult to handle, network management and service options related HOs usually may occur infrequently and are easy to handle. These causes of Handoff are discussed in the following sections.

4.1.1 Radio Link

Capacity of wireless communication channel is highly related to the quality of radio link on which the wireless communication takes place. The higher the quality of radio link the higher the capacity of Wireless communication can be achieved, and thus better quality of service can be offered. As each user in a cellular network is served on a radio link, it is imperative that the quality of the radio link is maintained to ensure requested Quality of Service to the user. As a user moves away from a Base Station (BS), the radio link quality between the user and the BS becomes weaker. This can be detected by measuring the Received Signal Strength (RSS) at the receiver e.g. base station in uplink communication and/or the Signal to Noise Ratio (SNR) of the received signal. Given that a user is connecting to a BS which is surrounded by a number of BSs, when the RSS of the user goes below a threshold that a reliable wireless connection can be guaranteed or there are other BSs in the vicinity with better RSS available, a Handoff occurs to pass the user connection from the BS with the

Weak RSS to the BS with the best RSS, without the service interruption. This type of Handoff is known as radio link quality related Handoff.

4.1.2 Network Management

As the number of users in a particular cell increases, resource consumption also increases, resulting in congestion within the cell. When congestion in a cell goes above a threshold and the neighboring cells are operating below threshold congestion, user may be handed over to neighboring cells that have lower congestion. This type of Handoff is known as network management related Handoff. Apart from this reason, network management related Handoff can also occur because of malfunctioning path between BS and a core network through which the user is served. For example, a network may detect some problem in communicating with one BS then it may trigger Handoff of user in that cell to the nearby cell. Other than this capacity related Handoff, Handoff may also occur to increase efficiency. For example, if the network detects a shorter path than the current path through which the user is served, then a Handoff could be triggered.

4.1.3 Service Options

In some cases, a network is designed in such a Way that certain services are available only through a particular BS. For example, in the combined network of 2G and 3G, a user can access some data services only when the user is in the coverage of 3G cells. If a user is currently on a 2G network and requests for a data service which is available only via a 3G cell, then the network will Handoff the user to the nearby 3G cell. Such a Handoff is called service option related Handoff.

4.2 Desirable Features of Handoff

Figure 3.2 summarizes the desirable features that an efficient Handoff is expected to achieve for improving user experience and service quality.

- Reliability Communication Quality should be maximum.
- Cell Coverage , Traffic Balancing should be maintained.
- Interference , Number of Handoffs should be minimum

To maintain a seamless service for a user, Handoffs should be made in very shortest time and fast enough so that the user does not feel any disturbance in connecting call or interruption to the service. The quality of communication link may be degraded due to reducing RSS below an acceptable level or increasing Co-Channel Interference (CCI). For example, a mobile user may move in to a location that the line of sight between the user and the connecting base station (BS1) is blocked. Thus the RSS from BS1 may suddenly decrease . In this case handing the connection to the another base station that can provide the higher the RSS value would maintain link quality. Radio communication link can be maintained by fast Handoff mechanisms. One of the most important requirements in cellular networks is that any Handoff that have been triggered by the networks should be successful. A Handoff is said to be successful when the call is not dropped while the MS is handed over to the target cell. This can be maximized using efficient channel allocation algorithms and traffic balancing techniques. The impact of Handoff on the QoS should be kept at minimum. The Handoff margin level. lf the Handoff margin is kept high then MS will stay connected with current BS even when signal quality is very low which will decrease QoS. Congestion within a cell and interference between cells should be minimized, which can be achieved when the Handoff maintains a planned coverage area of cells. Planning the increasing its power to serve a faraway MS and consequently increasing the interference level in the cell owing to high power. There should be a check on the total number of Handoffs. An excessive number of Handoff increases processing load and signalling which results in the waste of radio resources. Handoff in a cellular network is carried out so that users can be served efficiently. However, carrying a Handoff also require signalling in the network. If there are more number of Handoffs in the network then it can reduce efficiency of the network by more signalling in the network. The selection of a target cell should be efficient. Good selection of a target cell leads to decreased number of Handoffs and increase in communication quality. If a target cell is selected with poor quality, then it is likely that user is far from that BS and there are more chances that user Will leave the cell soon. This will in turn increase number of Handoffs Another factor that should be minimized is the signalling involved during Handoff. This will lead to low Handoff latency. The signalling in a network takes time, which increases latency. Increase in latency can lead to increase number of call dropping. As discussed above, Handoff causes signalling in the network which reduces efficiency. Therefore reducing signaling in Handoff will allow network to serve more traffic. Handoff should do minimum effects on call blocking. For this some of channels can be reserved specially for Handoff. However, this channel reservation in the cell should be selected carefully as higher number of channel reservation can lead to waste of network capacity and lower number of channel reservation can cause more call dropping in the network. For example, if a network has total N channels. If there are H channels reserved for Handoff then network can use N-H channels to serve other traffic. If in order to accommodate Handoff calls efficiently, M channels are required and H > M, then H-M channels are wasted. If H < M then this will cause more call dropping.

4.3Proposed Methodology

VHO is said to be as when handoff occurs between two different base stations (BSs) with different wireless network technologies. Handoff is also called as Handover somewhere. Basically, vertical handover process is divided into no of the three phases. First phase is termed as network system discovery in which a mobile node must search and know which wireless systems are reachable to me. The second step is used for handoff decision. In this step basically the mobile node receives and evaluates vertical handoff parameters associated with a new and remaining wireless networks to make handoff decision. If the mobile node decides to handoff to other network, the last step will proceed. The last and third step is made for handoff execution. In this case, after selection the most optimum target network then mobile node finally decides to perform vertical handoff procedure and executes the vertical handoff procedure to be connected with a new wireless system.

It is to be noted that a handoff execution goes a successful handoff to the other target network. We basically focus on the second step in this research work. These are having three protocols used for detecting the necessity for mobile node for handoff: mobile-assisted handoff (MAHO), mobile-controlled handoff (MCHO), and network-controlled handoff (NCHO). MCHO is basically used in IEEE 802.11 WLAN networks and where a mobile node keeps monitoring the signal of an access point (AP) and triggers the handoff procedure when all conditions for handoff on the basis of received parameters from different networks are satisfied. Because of no of limited resources of mobile nodes, low power consumption and minimization of unnecessary handoffs are a primary motive for vertical handoff decision in wireless communications.

4.3.1 Traditional Vertical Handoff Algorithm

This is the traditional algorithm which is discussed in [32,33]. As a mobile node goes out across different networks, the vertical handoff decision function (VHDF) evaluates all the received parameters for all accessible networks. The any reachable network which is having the highest calculated value for Vertical handoff decision function is the most desirable for the mobile node based on specified conditions. The network quality Q_i which gives a measurement of the appropriateness of a certain network n_i , is measured via the function

$$Q_i = f\left(\frac{1}{C_i}, S_i, \frac{1}{P_i}, D_i, F_i\right) \tag{1}$$

Where these are parameters like F,P, C, D, S are the network performance, network conditions, cost of service, power consumption, security, respectively. This algorithm can be expressed as follows. The user which is keeping mobile node's preference is to get the highest possible QoS by receiving the maximum amount of bandwidth apart from other factors such as usage cost, network condition, security, and power consumption.

$$Q_i = f\left(\left(0 \times \frac{1}{C_i}\right), (0 \times S_i), \left(0 \times \frac{1}{P_i}\right), (1 \times D_i), (0 \times F_i)\right) \tag{2}$$

The basically this approach is also expressed as given.

$$Q_i = b_i \tag{3}$$

A mobile node evaluates the current available bandwidth which is being received from its current connected network and for the newly detected networks. The network with the highest available bandwidth is considered as to be connected a preferred network. If newly detected network is having a higher available bandwidth, vertical handoff's execution takes place. Otherwise at point of time, mobile node remains connected to the current network.

4.3.2Extended Vertical Handoff Algorithm

We introduce the given proposed handoff algorithm[1] in this model, which include network model,dynamic new call blocking probability and new call blocking probability.Without loss of generality, wireless networks under consideration are denoted as n_i , i = 1, 2, . . . , N. For example, there are three available networks, Wi-Fi, ,Wi-Max and satellite. Another example is having two available networks, Wi-Fi andWWAN. Where B_i and b_i represents respectively the total bandwidth and current available bandwidth of network n_i. And maximum number of considered networks are N.

○ New Call Blocking Probability

For the measuring the network traffic characteristics, we have considered that the bandwidth changing process of network $n_i$is taken as an M/M/Bi /Biprocess. And no. of that requests arrives for the given channels follows a Poisson distribution with mean λi (i.e.; themean number of request arrivals per unit time by network n_i is λ_i), wherei = 1, 2, . . . , N.

The call holding time (CHT) is taken to consider an exponential distribution with mean value $1/\mu_i$(means that mean number of calls serviced per unit time by network n_i is μ_i). It is considered thata network does not keep holding queue, the capacity is equal to the total number of channels [32-35]).

In the parameters which decide the network condition and performance such as $\lambda_i$and $\mu_i$real world scenariocan be properly estimated using some techniques (e.g., exponential averaging computation). Assume thatPi denotes the new call blocking probability (i.e., represents grade of service being offered) of network n_i. On the behalf on Erlang-B model, the following givenequation holds:

$$P_i = \frac{\left(\frac{\lambda_i}{\mu_i}\right)^{B_i}}{B_i!}\left(\sum_{n=0}^{B_i}\frac{\left(\frac{\lambda_i}{\mu_i}\right)^{n}}{n!}\right)^{-1} \qquad (4)$$

○ Dynamic New Call Blocking Probability

For getting Dynamic New Call Blocking Probability (DNCBP) of network ni, we introduced*bi* to replace the*Bi* in above given Eq. (4). Thus, to set thepriority to handoff calls which is calculated in a more dynamic nature. It is denote asHiof DNCBP of network n_i.

This equation which is continued on next pages which describes performance of system dynamically for each network.

$$H_i = \frac{\left(\frac{\lambda_i}{\mu_i}\right)^{b_i}}{b_i!} \left(\sum_{n=0}^{b_i} \frac{\left(\frac{\lambda_i}{\mu_i}\right)^{n}}{n!} \right)^{-1} \quad (5)$$

4.3.3 Proposed Vertical Handoff Algorithm

VHO procedure is made by resource-limited mobile devices when there is signal loss during conversation is in progress. But there is problem in achieving optimal target network [7]choice and low-power consumption for vertical handoff decision and these problems must be avoidedwhich is the prime motive in this thesis. That can be done by keeping vertical handoff decision simple and fasters, which led to results in that the selected network might not be optimal. But the optimal which is selected target network [7]choice could be achieved by doing the handoff decision function complex. But it will create the problem of an inordinate waste of power.

Thus, we can say thatin each handoff decision making process, these questions can be arised : How does vertical handoff decision process works on resource-poor mobile nodes and resource-rich mobile nodes respectively? How can this process be secured andfaster? For developing a simple, optimized, secure handoff decision, a two-step vertical handoff decision algorithm is first presented. The first step states the quick evaluationmethod which is considered as pre-handoff decision. The second step describes the handoff decision function for handoff execution kin WNs. First step is considered as best for resource-poor mobile devices. But first and second steps both are executed for resource-rich mobile nodes to be handoff. Obviously, this approach will reduce energy consumption on mobile nodes, especially on low energy mobile nodes.

In the following sectionsof the proposed VHO decision algorithm, we assume a picture that where a MN only detects more than one available networks along with respective parameters and finally decides which available network is best suited to be handed off for data transfer. Here we considerthatthe number of availableheterogeneous wireless networksare N .

4.3.3.1 Handoff Parameters

In this section, different parameters involved in making a Handoff decision are described. The conditions of a network can be understood by studying the different network and user parameters

- **Received Signal Strength**

RSS is an important and useful parameter that is widely used in Handoff decision making. A close relationship exists between RSS and the distance between BS and MS. RSS is affected by topological features such as buildings and environment factors. The coverage area would become smaller than the planned one because of the topological obstacles. Using only the RSS value as a Handoff, criterion can lead to excessive number of Handoffs because it can trigger ping pong effect [1].

- **Fading**

In wireless communications, fading is defined as deviation of the attenuation affecting a signal over certain propagation media. The fading may vary with time, geographical position or radio frequency, and is often modeled as a random process.

  - Slow Fading

Slow fading can be caused by events such as shadowing, where a large obstruction such as a hill or large building obscures the main signal path between the transmitter and the receiver. The received power change caused by shadowing is often modeled using a log-normal distribution with a standard deviation according to the log-distance path loss model.

  - Fast Fading

The channel impulse response varies rapidly within the transmitted baseband signal causing frequency dispersion due to Doppler spreading. In this regime, the amplitude and phase change imposed by the channel varies considerably over the period of use.

- **Transmission Power**

In uplink communications where MS transmits signal to the BS, the transmit power of MS needs to be considered carefully as it is directly related to MS battery life.Wireless devices run on battery, so they have limited power consumption. If the battery level decreases, switching for a network to another network with low power consumption can provide a longer usage time. For example, if a device with the battery almost exhausted, switching from a WLAN to a WWAN network would be a smart decision. The Power Requirements becomes a critical issue especially if the hand held battery is low. In such situations, it is preferably transferred to an attachment point, and this will extend battery life [1].

- ## Bandwidth

In wireless communication bandwidth is defined as a measurement of bit-rate of available or consumed data communication resources expressed in bits per second or multiples of it (bit/s, kbit/s, Mbit/s, Gbit/s, etc.).Thebandwidth is used to refer to analogsignal andmeasured in hertz. The connection to the computing term is that, according to Hartley's law, the digital data rate limit (or channel capacity) of a physical communication link is proportional to its bandwidth in hertz.

- ## Network Condition

During a handoff procedure, the metrics, which upper-layer applications are really interested in, are network conditions (available bandwidth and delay, user preference, etc.), rather than the physical layer parameters such as signal-to-interference ratio. available bandwidth is used toindicate network conditions and is a major factor especially for voice and video traffic.

- ## Subscriber / Non- subscriber

During handoff, first priority should be given to subscribers when both non- subscribers and subscribers are requesting to target network selection[7]. This process is done on the basis of subscribers id is given to each network and mobile itself. When they are matched considered as subscribers otherwise non-subscribers.

- ## Power Dissipation

Power is defined as the rate of energy transfer so power dissipation is a measurement of the rate at which energy is lost, from electrical devices. When an electric current runs on a conductor, then internal energy of that conductor goes high that leads to rise temperature above the surrounding temperature. This process causes energy to dissipate away from the conductor into the surrounding, due to process of heat transfer. The rate of this heat transfer(measured in joules per second) is called power dissipation. Its unit is watts.

- ### Distance Matrix

It is a very important decision criteria for making handoff faster. When mobile node moves around its cell boundary, then it starts searching the nearest network to be hand off. So nearest node will be handoff first when more than one network are having same subscriber's id and same RSS value. For getting nearest location of network, we have to use coordinate value of given parameters:

- Mobile Node Coordinates
- Base Station Coordinates

Based on these parameters, location of nearest network can be found in order to make handoff faster and searching as wellso delay in Handoff can be reduced.

- ### Security Cost

Risks are inherent in any wireless technology. Some of these risks are similar to those of wired networks, some are exacerbated by wireless connectivity, and some are new. Perhaps the most significant source of risks in wire-less networks is that the technology underlying communications environment. For some applications, confidentiality or integrity of data transmission may be critical. That's why a network with a high security level may be preferred over another network with a lower security level. Therefore, security has been chosen as one of the main factors in decision-making vertical handoff.

- ### Network Load Balancing

Network load is to be considered during effective handoff. It is important to balance the network load to avoid overloading of the network.

4.3.3.2 Handoff Procedure

In this section we have proposed a secure and efficient vertical handoff algorithm that covers the previous research shortcoming like security feature, priority based on subscribers and non-subscribers, nearest network should be on first priority to reduce connection establishment delay to avoid call termination and removing the fading in receive signal strength. Here are the steps are given below;

- Handoff Information Gathering: This phase is used to collect all information necessary to identify the need for handoff and which is the moment when they should be initiated;

- Handoff Decision: This phase is used to determine when and where to make the handoff process by selecting the appropriate access network;
- Handoff execution: This phase is used to change channels according to the details required during the decision phase; [18]

Subscriber List (SL): Each WirelessNetwork contains subscribers list of mobile mode that can be used to hand off subscriber's mobile node first when multiple non-subscribers are sending the request to handoff on it. When non-subscribers and subscribers are requesting to target network based on different parameters so subscriber mobile node should be Handoff first after matching subscriber id from subscribers list.

Network Authentication Table (NAT): Before forming network set unique authentic number is stored in NAT for each network. This table is stored in each network. When MN gets the request from network along with the associated authenticate number. This number is compared with authentic number is stored with NAT in currently connected network. If number is matched so considered as trustee network and performed handoff activity. Otherwise this network is considered as malicious network and no handoff would be taken place with this network.

Savitzky- Golay Filter : This filter is used for smoothening the received signal that applies the basically a polynomial regression of a certain degree to a time series of a RSS. It also preserves the certain features of time series like local minima and maxima[9]. It computes a local polynomial regression on the input data by solving equation[9] :

$$\boldsymbol{Y} = a_0 z + a_1 z^1 + a_2 z^2 + \ \dots . . + a_k z^k$$

Above smoothening process is equivalent to discrete convolution with a fixed impulse response. It filters and smoothens the noise from data preserving the shape and height of the waveform or signal, electrocardiograms and processing the images from ultrasound and synthetic aperture radar. MATLAB Signal Processing Toolbox has a function **sgolayfilter(x, k, f)** where x is the signal, k is the degree of polynomial used for least square approximation and f is the no. of points average taken.

4.3.3.3 Handoff Decision Algorithm

This algorithm makes the decision after analysing the various parameters like RSS, cost, bandwidth etc. This algorithm is given below:

1) Scan the required inputs like RSS, Bandwidth etc.
2) Find out slow fading and fast fading from given RSS.

Slow fading = Pk + shadow fading

$$P_k = 32.44 + 20log_{10}R_{km} + 20log_{10}f_{MHz} + L_{gas} + L_{rain} + L_{pol} + L_{imp} + L_{coup} - G_{TdB} - G_{RdB} \tag{6}$$

where Pk is the propagation loss suffered by the signal, R is the distance of the MN in Km and f is the frequency of the network and Lgas, Lrain, Lpol, Limp, Lcoup, GTdB, GRdB are the losses due to the environment variables such as polarization, coupling, antenna losses of transmitter and receiver, noise levels etc.

Here shadow fading is assumed to be zero.

The fast fading calculation can be obtained from Jakes' model.Jakes popularized a model for Rayleigh fading based on summing sinusoids. Let the scatterers be uniformly distributed around a circle at angles αn with k rays emerging from each scattered. The Doppler shift on ray n is

$F_n = f_d \cos\alpha n$ (7)

Where fd is the Doppler shift, which is calculated as follow

$$f_d = \frac{(velocity\ of\ MN * frequency\ of\ the\ network)}{velocity\ of\ light} \tag{8}$$

and with *M* such scatterers, the Rayleigh fading of the *kth* waveform over time *t* can be modelled

$$R(t,k) = \sqrt{\frac{2}{M}} \left[\sum_{n=1}^{M} A_k(n)(\cos\beta_n + j \sin\beta_n) \cos(2\pi f_n t + \theta_{n,k}) \right] \tag{9}$$

Ak(n) is the kth weighting function and □n is the phase shift suffered by the signal. The fast fading value is calculated using the equation:

$$Fast\ fading = 10log_{10}(E|R(t,k)|^2) \tag{10}$$

3) Calculate optimum RSS value after removing the fading from received signal.

4) Calculate M_i for each network.

5) If M_i equals to 1 and Authentication number matches with NAT ,

Then add to the network.

6) Else no handoff is possible with this network.

7) Apply Savitzky- Golay Filter on series of RSS for each network for given TS

8) Calculate standard deviation of filtered data.

9) If standard deviation is greater than pre-defined value for each network

Then ignore the these networks. // To remove ping-pong effect

10) else select these network in S.

11) If Network set S is empty

Then stay connected to that current network.

11) Else if sizeof S is 1

12) If only network is current network in S

Then stay connected to the current network.

13) Else Connect to the sole network in S

14) Else

If mobile is resource poor , Connect to any network in S.

Else Calculate EQ_jvalue of each network in S.

$$EQ_j = \frac{\omega_C\,(1/C_j)}{\max((1/C_1),\ldots,(1/C_m))} + \frac{\omega_S S_j}{\max(S_1,\ldots,S_m)} + \frac{\omega_P P_j}{\max(P_1,\ldots,P_m)} + \frac{\omega_D D_j}{\max(D_1,\ldots,D_m)} + \frac{\omega_F F_j}{\max(F_1,\ldots,F_m)} \tag{11}$$

If only single network with Max(EQ_j) , then Connect to that network.

15) Elseif two or more network with same Subscriber_Id

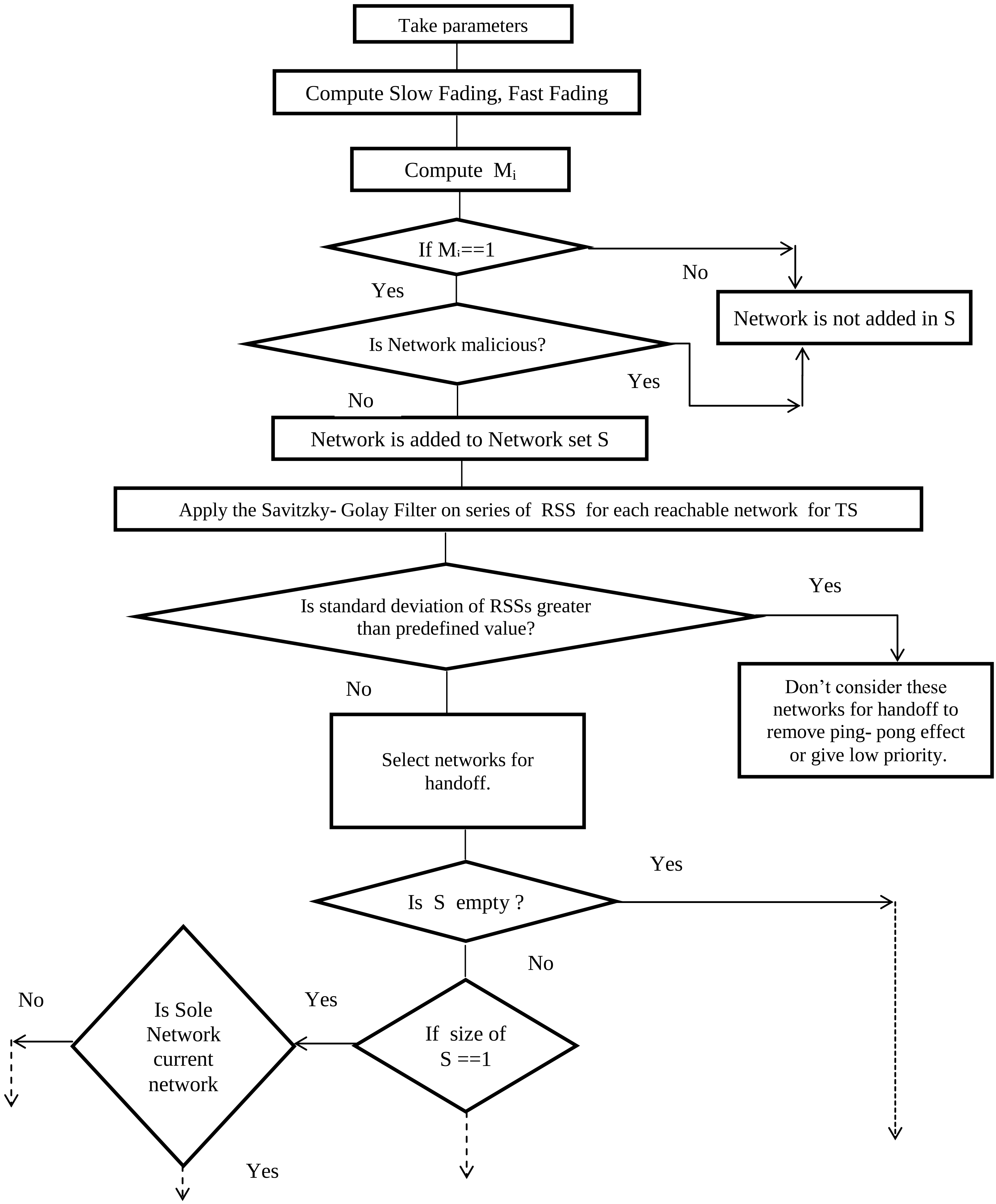
Then connect to any network having Max(EQ_j)

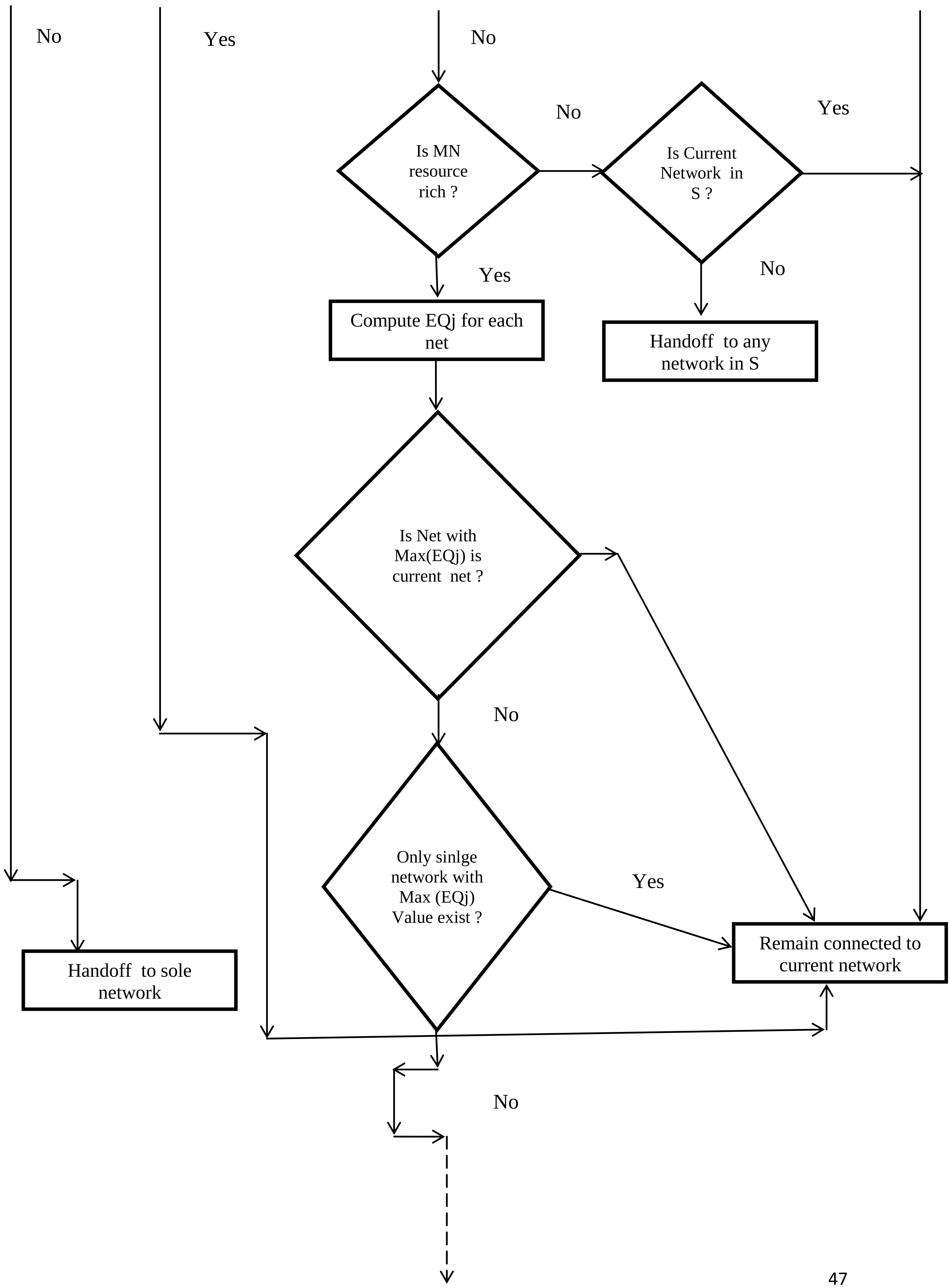
16) Elseif one network with same Subscriber_Id, then Connect to that network.

17) Calculate distance of MN with each network having same Subscriber_Id

Then connect to the network having smallest distance,

4.3.3.4 Flow Chart of Proposed Model




No
Yes
No
No
Is MN resource rich ?
Is Current Network in S ?
Yes
Yes
No
Compute EQj for each net
Handoff to any network in S
Is Net with Max(EQj) is current net ?
No
Only sinlge network with Max (EQj) Value exist ?
Yes
Remain connected to current network
Handoff to sole network
No

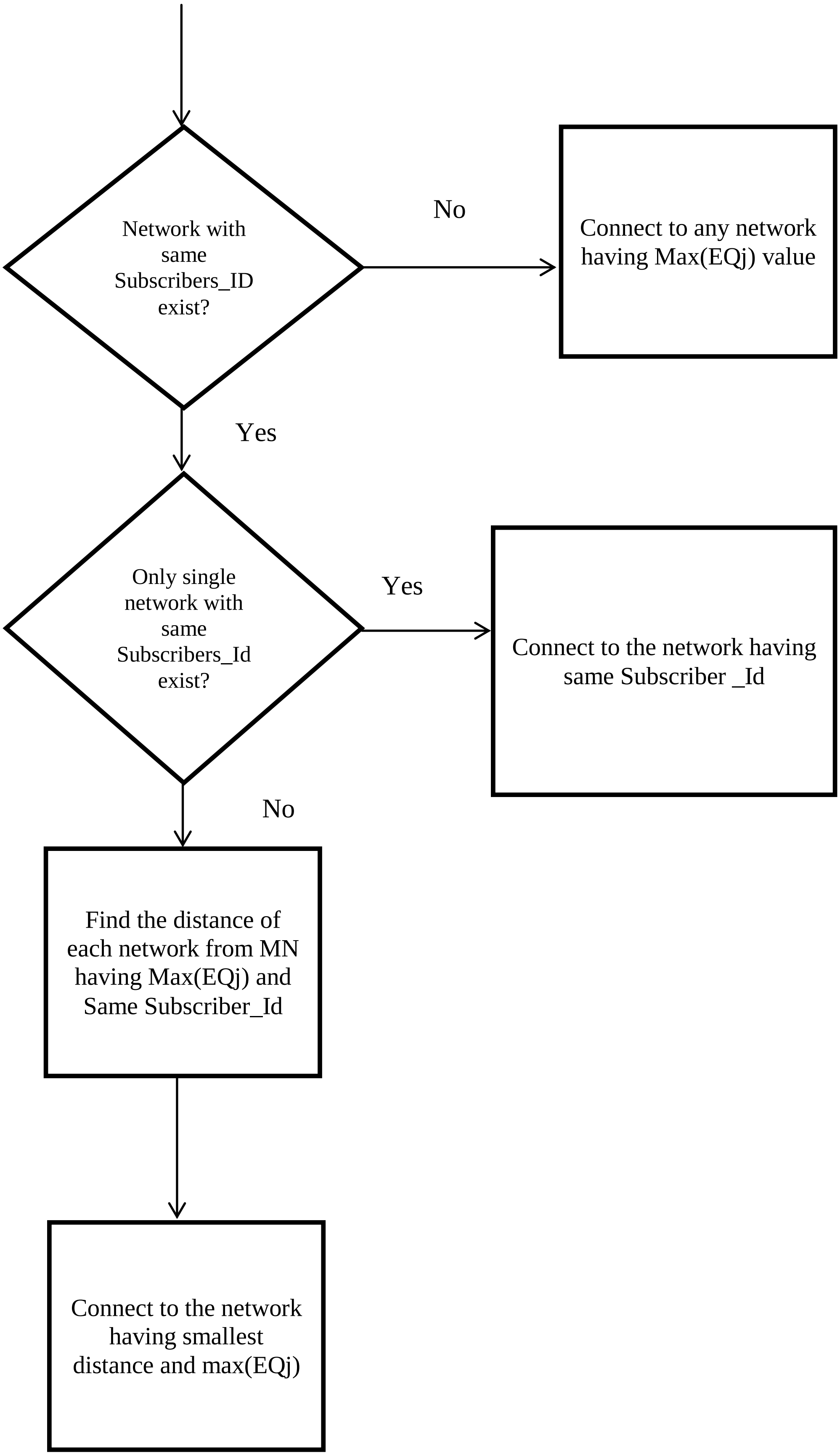


Figure 4.1 Flow Chart Of Proposed Model

CHAPTER – 5

SIMULATION AND RESULT

The simulation study has been conducted using MATLAB (R2013b) and no additional packages were used. In this study all results have been obtained independent of the network. That is, it is assumed that no communication delays, protocol delays, synchronization delays, no packet losses and interference due to communication signal occur. It is also assumed that no processing delays take place.

Simulation is considered as efficient and flexible tool to evaluate the performance of the protocol working under vivid environmental conditions. In this chapter, Optimized Algorithm of VHO technique proposed in chapter 5 are evaluated on a simulation platform. The performance of this algorithm compared with other conventional algorithm in terms of security, priority base decision and throughput.

The proposed technique is implemented on MATLAB Set up and our proposed algorithm protocol and comparison is made on the performance of traditional algorithm with and without the proposed technique in terms of network reliability of user, security and throughput.

The MATLAB Signal Processing Toolbox consists of a function called **sgolayfilt (x, k, f)** where x is the signal , k is the degree of polynomial used for least square approximation and f is the no. of the points average taken(considered as span length). These are some constraints in use of polynomial fitting as given:

- The Span f should be odd.
- The polynomial degree k should be less than the span.
- The data points are not required to have uniform spacing.

For vectors , in MATLAB, y = std(x) returns the standard deviation. For matrices, y is a row vector containing the standard deviation of each column. For N-D arrays, STD operates along the first non-singleton dimension of x. This function will help for elimination of heavy loaded network , low coverage network and low bandwidth which may not give the proper connectivity to mobile node. Very soon they may direct the mobile for handoff because they are offering proper data transmission. This may increase the ping - pong effect in wireless network and performance will go down and battery power consumption will go high. So which network is having high standard deviation will be eliminated form network set to be handed off.

5.1 Performance Evaluation Parameters

In this research work performance of VHO is evaluated considering two factors which are given below :

- No of Network
- Received Signal Strength
- Bandwidth
- Network Load
- Network Condition.
- Power Consumption
- Power Dissipation

But we have proposed a model that offers the additional features in this previous model which are given below:

- No of Network
- Received Signal Strength
- Slow Fading
- Fast Fading
- Bandwidth
- Network Load
- Network Condition.
- Power Consumption
- Power Dissipation
- Subscriber List
- Distance Matrix
- NAT

5.2 Performance Metrics

5.2.1 Subscriber List (SL): Each Wireless Network contains subscribers list of mobile mode that can be used to hand off subscriber's mobile node first when multiple non-subscribers are sending the request to handoff on it. When non-subscribers and subscribers are requesting to target network based on different parameters so subscriber mobile node should be Handoff first after matching subscriber id from subscribers list.

5.2.2 Network Authentication Table (NAT): Before forming network set unique authentic number is stored in NAT for each network. This table is stored in each network. When MN gets the request from network along with the associated authenticate number. This number is compared with authentic number is stored with NAT in currently connected network. If number is matched so considered as trustee network and performed handoff activity. Otherwise this network is considered as malicious network and no handoff would be taken place with this network.

5.2.3 Distance Matrix

It is a very important decision criteria for making handoff faster. When mobile node moves around its cell boundary, then it starts searching the nearest network to be hand off. So nearest node will be handoff first when more than one network are having same subscriber's id and same RSS value. For getting nearest location of network, we have to use coordinate value of given parameters:

- Mobile Node Coordinates
- Base Station Coordinates

Based on these parameters, location of nearest network can be found in order to make handoff faster and searching as well so delay in Handoff can be reduced.

5.3 Result Analysis

In this section we have shown the simulation result after analyzing the relevant parameters that helps in taking the exact decision in vertical handoff decision making in heterogeneous wireless network. These value are taken as randomly because it does not cover the specific wireless network. This is only logical model that will help in decision of handoff in various technology based wireless network environment.

5.3.1 When No. of Networks are 81 , Resources Rich Mobile Node, then NO HANDOFF

In this section no of heterogeneous are taken 81 randomly, mobile node is considered as resources rich. So in this simulation , handoff is not taken place because all parameter values of all remaining network are not greater than threshold and from currently connected network that have been taken as randomly. So currently network is best network and handoff is not done.

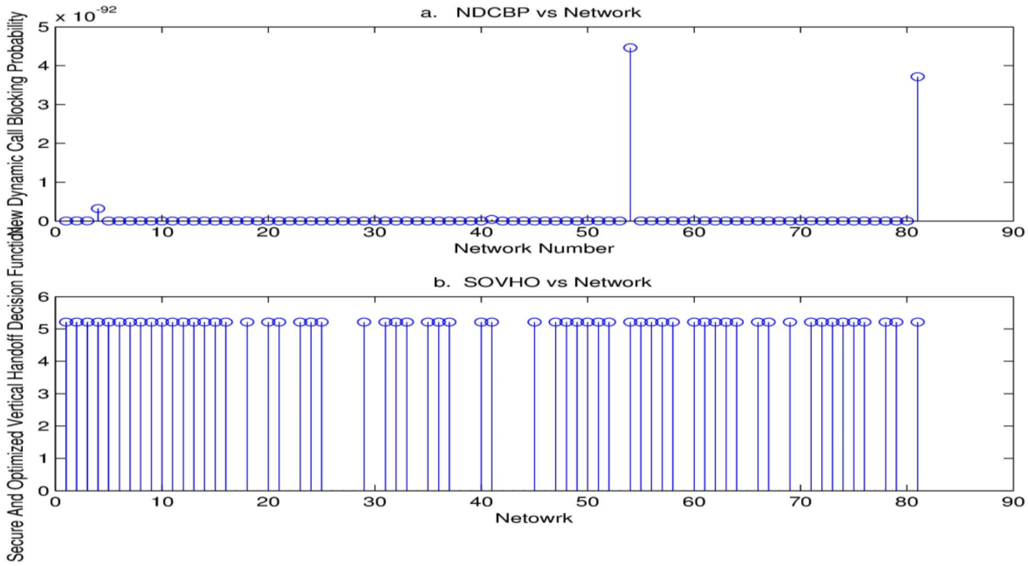


Figure 5.1: Model withN=81, Resources Rich Mobile Node

5.3.2When No. of Networks are 54 , Resources Poor Mobile Node, then NO HANDOFF

No. of heterogeneous are taken 54 randomly, mobile node is considered as resources rich. So in this simulation , handoff is not taken place because all parameter values of all remaining networks are not greater than threshold and from currently connected network that have been taken as randomly. So handoff is not done.

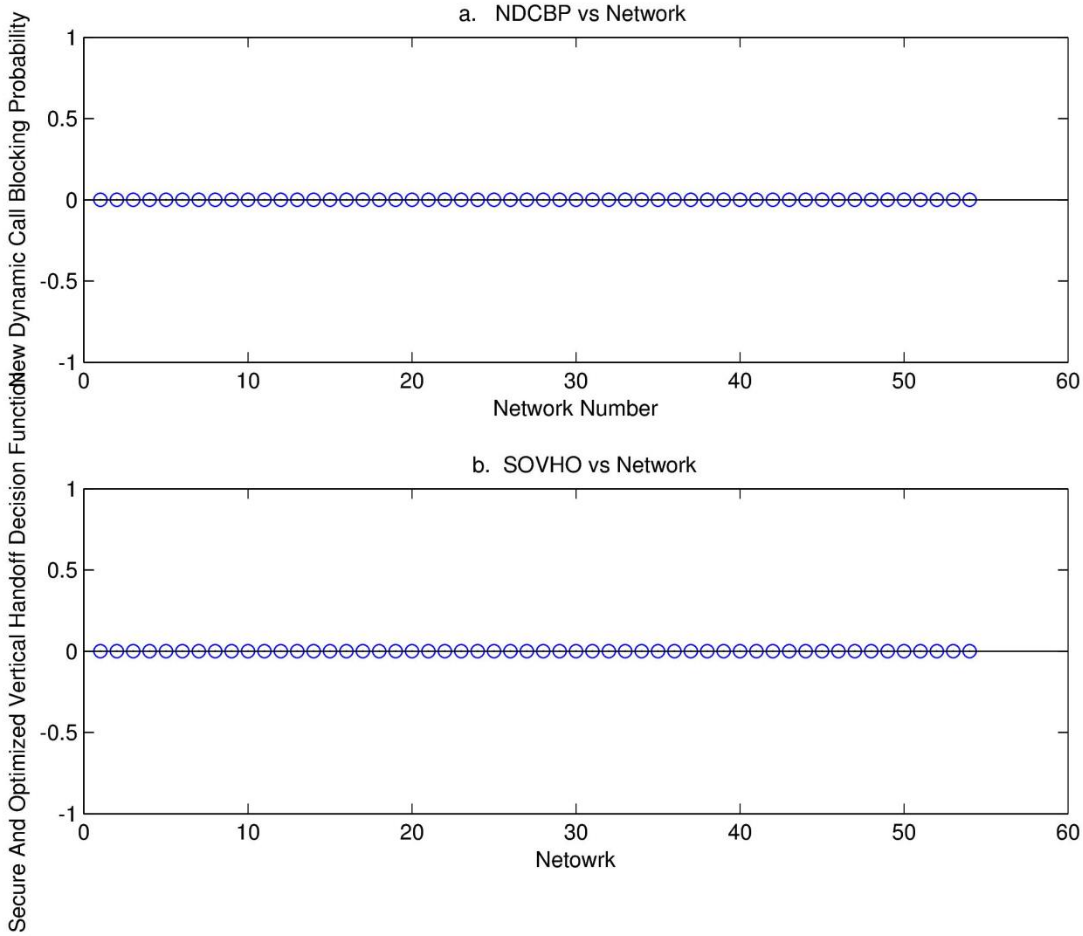


Figure 5.2: Model withN=54, Resources Poor Mobile Node

5.3.3 When No. of Networks are 78 , Resources Rich Mobile Node, then HANDOFF to 2nd Network

No. of heterogeneous are taken 78 randomly, mobile node is considered as resources rich. So in this simulation, Vertical handoff is taken place to 2nd Networkbecause allparameters value of 2ndnetwork is greater than threshold from remaining networks and currently connected network that have been taken as randomly. 2nd network is best network for mobile node to be connected for roaming and handoff is done.

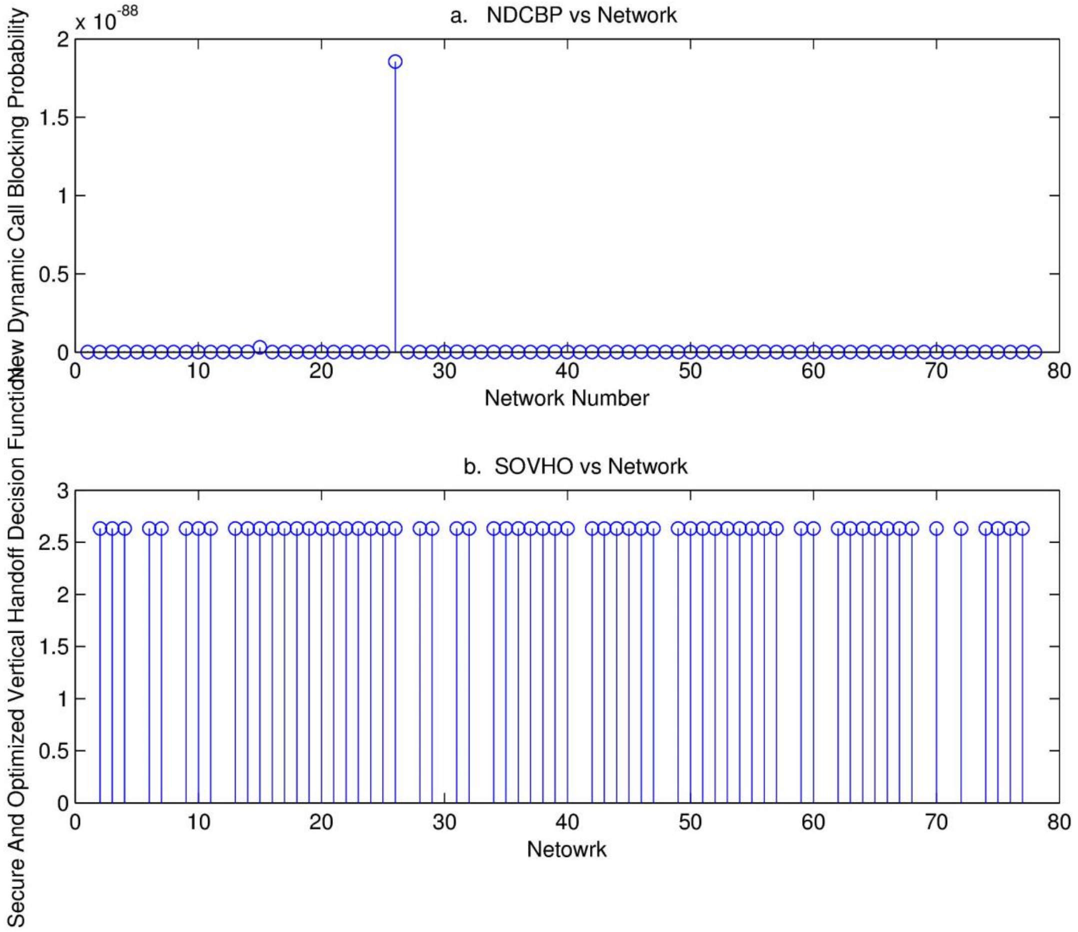


Figure 5.3: Model withN=78, Resources Rich Mobile Node

5.3.4When No. of Networks are 57 , Resources Poor Mobile Node, then NO HANDOFF

No. of heterogeneous are taken 57 randomly, mobile node is considered as resources rich. So in this simulation , handoff is not taken place because all parameter values of all remaining networks are not greater than threshold and from currently connected network that have been taken as randomly. So handoff is not done.

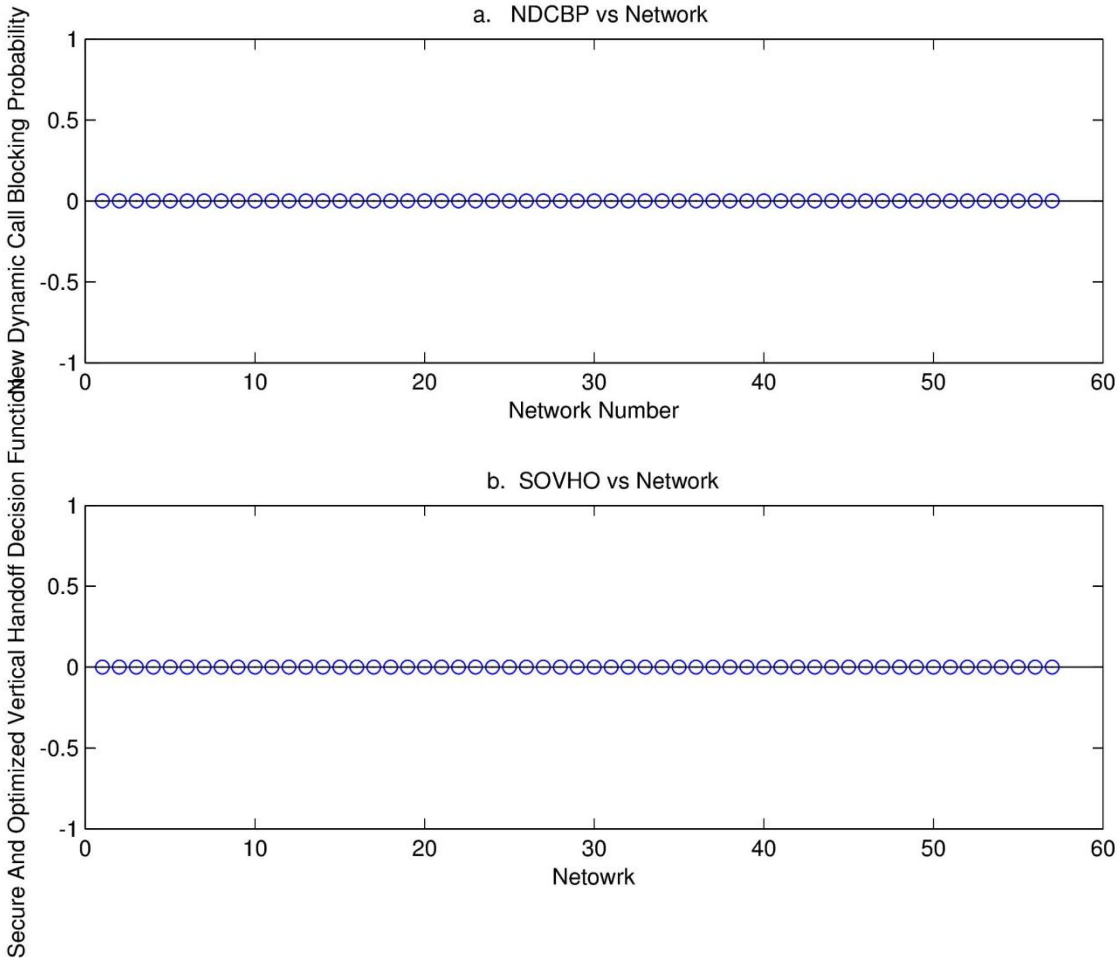


Figure 5.4: Model withN=54, Resources Poor Mobile Node

5.3.5When No. of Networks are 57 , Resources Poor Mobile Node, then NO HANDOFF because currently connected network is best network for MN

In this section no of heterogeneous are taken 57 randomly, mobile node is considered as resources rich. So in this simulation , handoff is not taken place because all parameter values of all remaining network are not greater than threshold and from currently connected network that have been taken as randomly. So currently network is best network and handoff is not done.

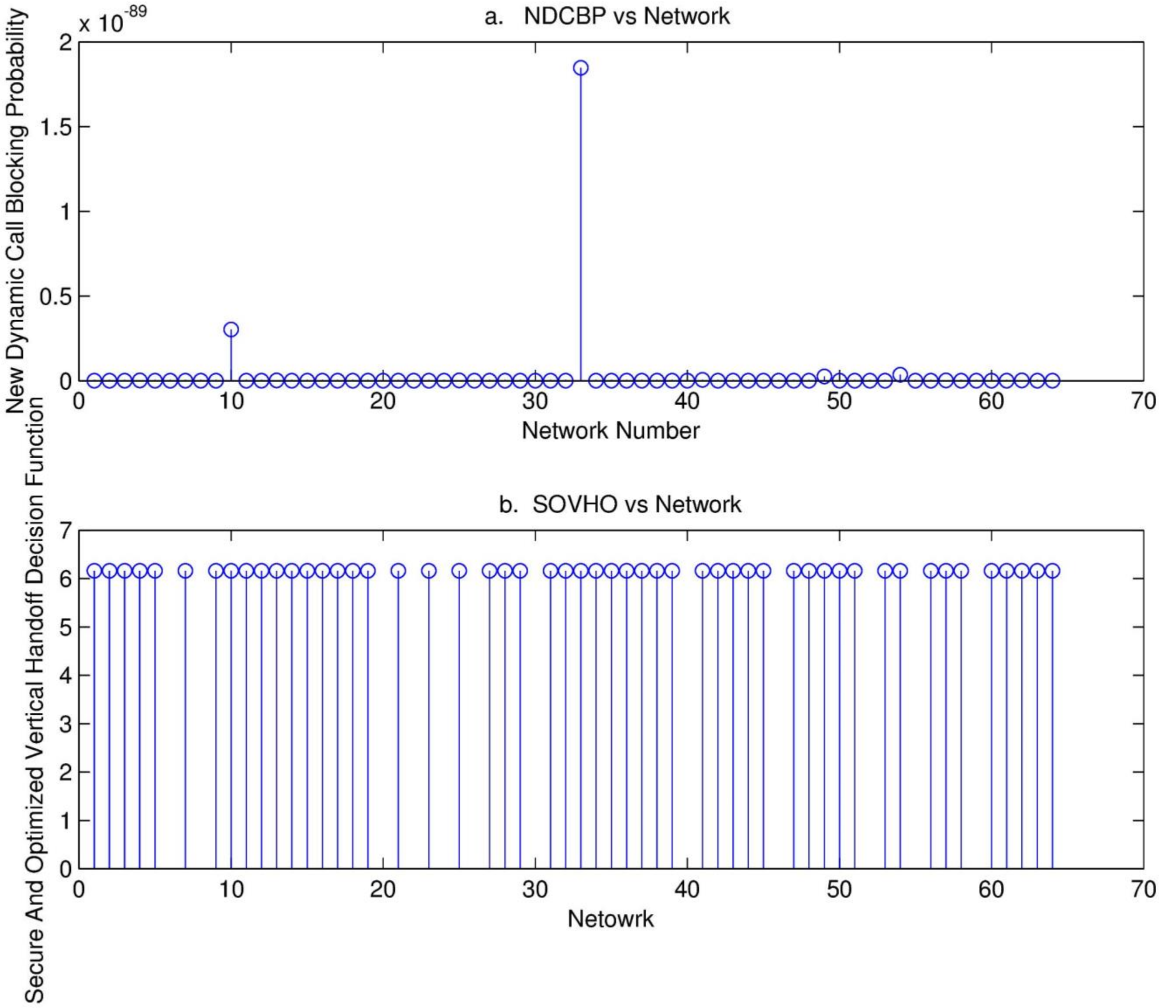


Figure 5.5: Model withN=57, Resources Poor Mobile Node

5.3.6When No. of Networks are 74 , Resources Rich Mobile Node, then NO HANDOFF because currently connected network is best network for MN

In this section no of heterogeneous are taken 74 randomly, mobile node is considered as resources rich. So in this simulation , handoff is not taken place because all parameter values of all remaining network are not greater than threshold and from currently connected network that have been taken as randomly. So currently network is best network and handoff is not done.

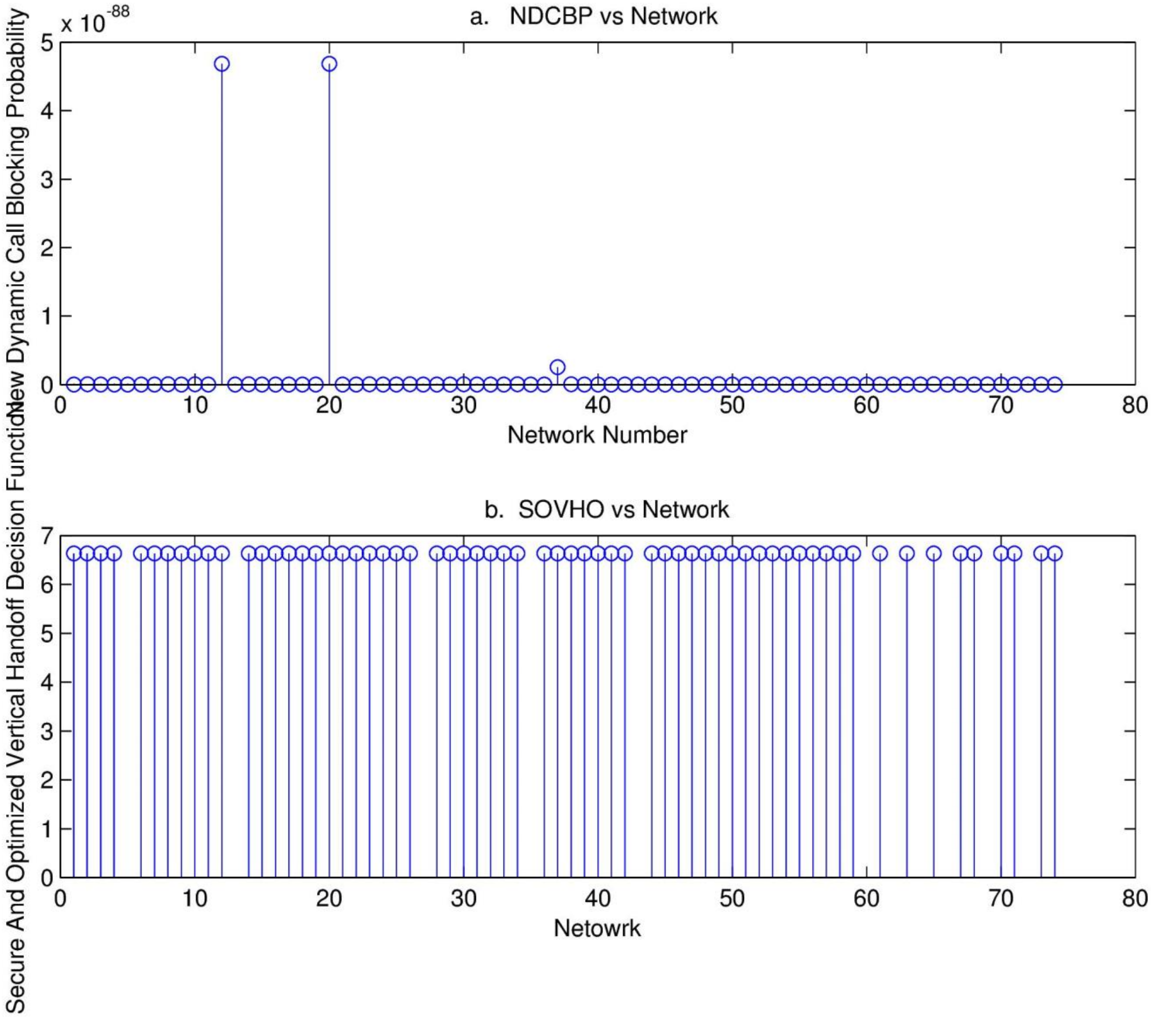


Figure 5.6: Model withN=74, Resources Rich Mobile Node

5.3. 7 When No. of Networks are 97 , Resources Rich Mobile Node, then NO HANDOFF because currently connected network is best network for MN

In this section no of heterogeneous are taken 97 randomly, mobile node is considered as resources rich. So in this simulation , handoff is not taken place because all parameter values of all remaining network are not greater than threshold and from currently connected network that have been taken as randomly. So currently network is best network and handoff is not done.

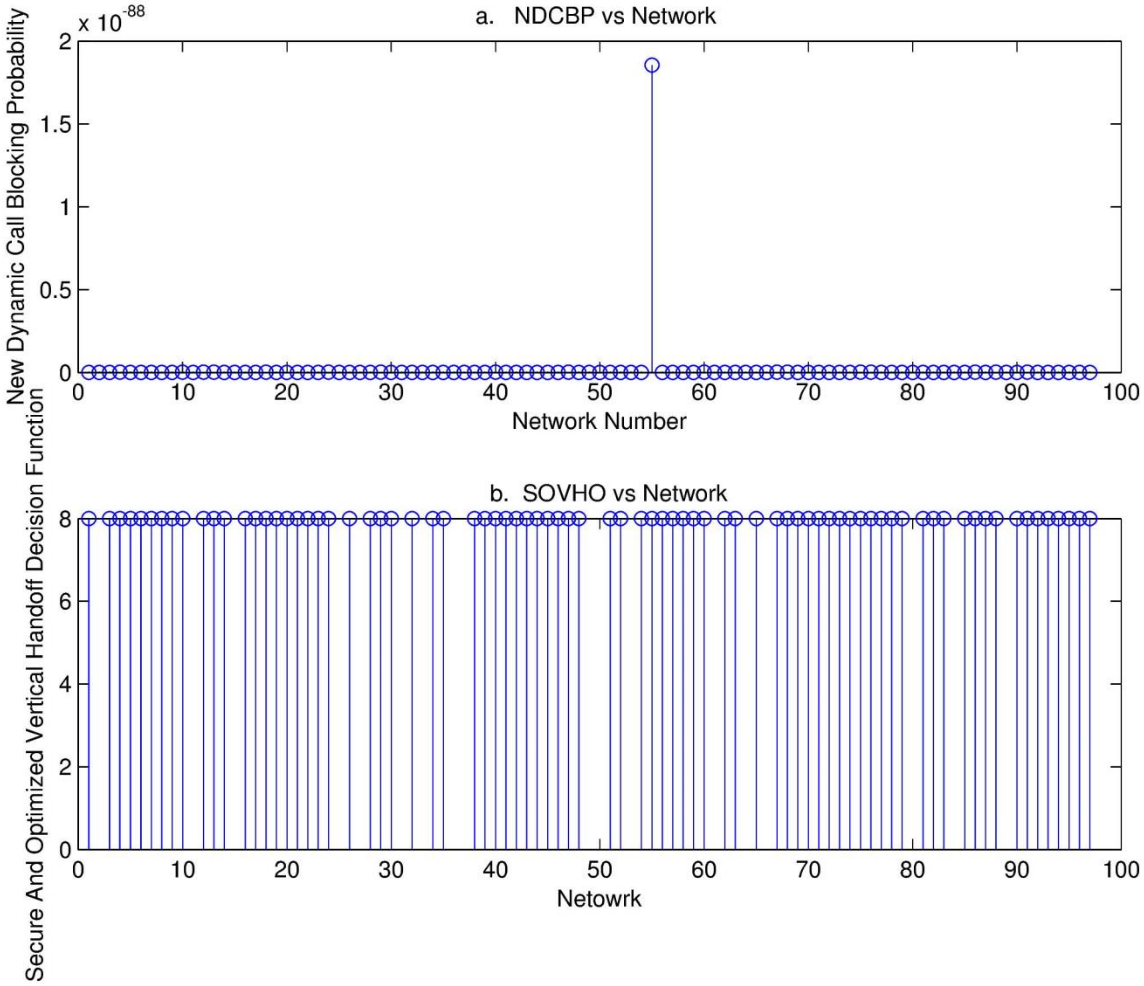


Figure 5.7: Model withN=97, Resources Rich Mobile Node

5.3.8 When No. of Networks are 86 , Resources Rich Mobile Node, then HANDOFF to 2nd Network

No. of heterogeneous are taken 86 randomly, mobile node is considered as resources rich. So in this simulation, Vertical handoff is taken place to 2nd Network because all parameters value of 2nd network is greater than threshold from remaining networks and currently connected network that have been taken as randomly. 2nd network is best network for mobile node to be connected for roaming and handoff is done.

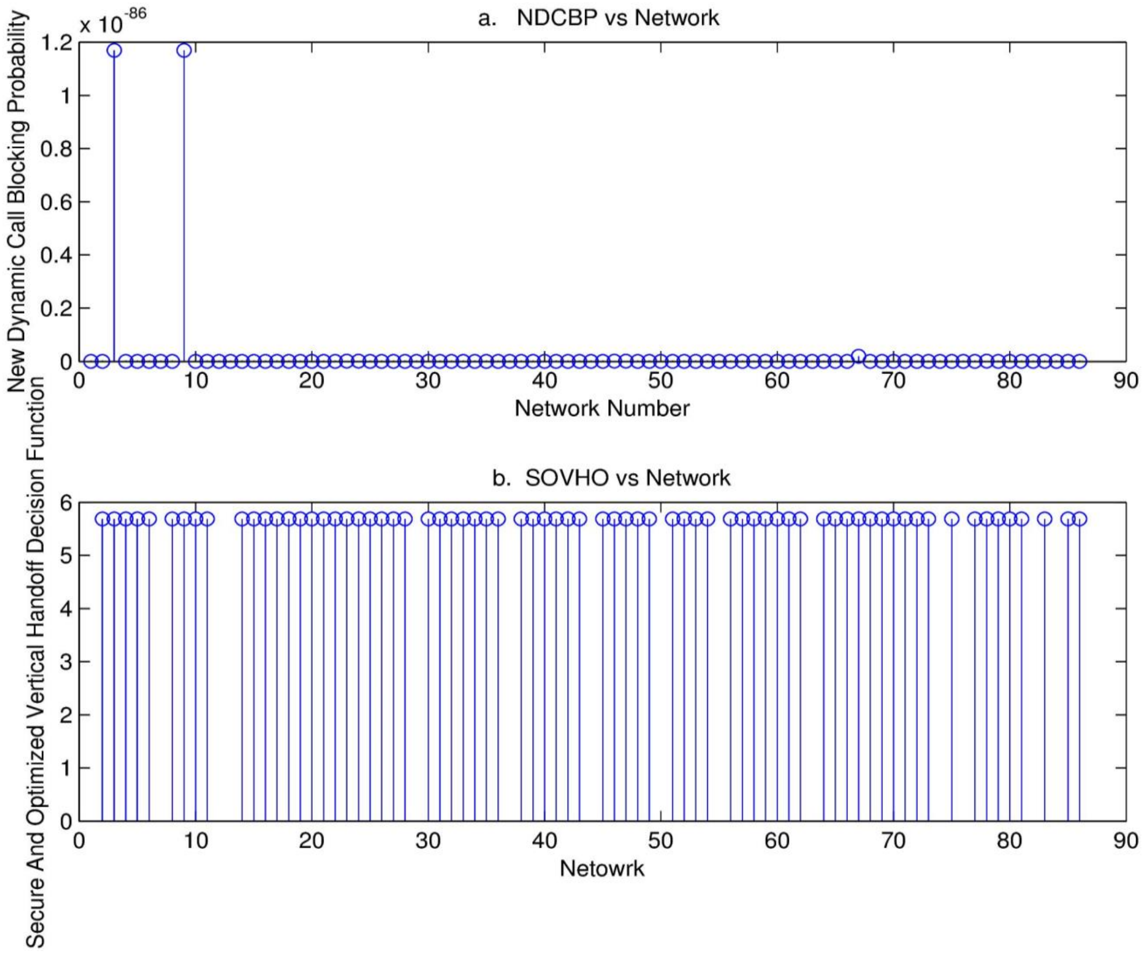


Figure 5.8: Model withN=86, Resources Rich Mobile Node

CHAPTER – 6

CONCLUSION AND FUTURE WORK

We dedicated our research work across wireless network. There are two kinds of wireless network called Homogenous Wireless Network and second one is Heterogeneous Wireless Network. Mainly we have done focus over Heterogeneous Wireless Network. HWN is having different in nature of working from each other, differs in properties in hardware configuration, range and characteristics.Basically one mobile node is connected to specific range based cell. During talking to someone, it gets outside of its coverage area; there are chances of call termination because no RSS is being received to mobile node. So this call should be transferred to target network[6, 7] whose lies in it's currently area where it is talking that can provide the best RSS value to mobile. This process is called Vertical Handoff Problem. We have studied various research papers and algorithms about VHO. We have dealt with shortcomings in precious research work in vertical handoffs. We have proposed a model of VHO that deals with security of network that prevents the leaking information from mobile node, sets the priority for subscriber's nodes when both non- subscribers and subscribers are requesting to be handed off that makes reliability to subscriber's users.

Another feature is to reduction the unnecessary handoffs using removing slow fading and fast fading from Received signal Strength that leads to reduction of unnecessary handoffs. Last one feature we have proposed in this model is to connect nearest network (shortest distance) when more than two networks are having subscriber Ids are same. This feature leads to reduce the connection establishment delay during handoff. The future work can be extended over this problem to cover types of services (real time vs non real times) like videoconversational class (e.g., voice), streaming class (e.g., streaming video), interactive class (e.g., web browsing) and background class (e.g., telemetry, emails). Packet losses parameter can beaddedto extend this model to take decision of handoff along smoothening of received signal.

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