

# Vertical Handoff in Heterogeneous Network Using Relay Technology in Mobile WiMax

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**Abstract:** Mobile WiMAX (Worldwide Interoperability for Microwave Access) is the most recent technology that is used for broadband wireless access over long distances. Handoff is necessary in order to support mobility and continuous network connectivity in Mobile WiMAX. Handoff is the process of changing the channel (frequency, time slot, spreading code, or combination of all these parameters) associated with the current connection while a call is in progress. With increasing demand for wireless applications and data rates associated with it, the use of WiMAX is explored as a wireless technology for large deployments. This paper is presented here an overview of Handoff and Mobile WiMAX, Relay Technology, its features and applications.

**Keywords:** Handoff, WLAN, LTE, Mobility/Mobile Connectivity, Mobile WiMAX.

## 1. Introduction

The problem of spectral congestion and user capacity has been solved by the cellular concept. It provides very high capacity in a limited frequency band with minimum restrictions. Processing handoffs is an important factor in any cellular system. The basic definition of handoff is given as: the process of transferring a mobile station from one channel to another [1]. Depending on the access network, the handoff can be either horizontal or vertical. Vertical handoff refers to switching between stations that belong to different networks.[3] Vertical handoffs are implemented across heterogeneous cells in access systems, which differ in several aspects such as bandwidth, data rate, frequency of operation, etc.

Whenever the handoff takes place between two base stations (BSs) of the same system it is known as horizontal handoff. It includes a terminal device in order to change cells within the similar type of network. Link-layer handoff and Intra-system handoff are further classifications of horizontal handoff. Horizontal handoff between two base stations, below same foreign agent (FA) is called as Link-layer handoff. Under intra-system handoff, horizontal handoff happens between two base stations which belong to two different foreign agent and both foreign agents belong to the same system and to the same gateway[1].

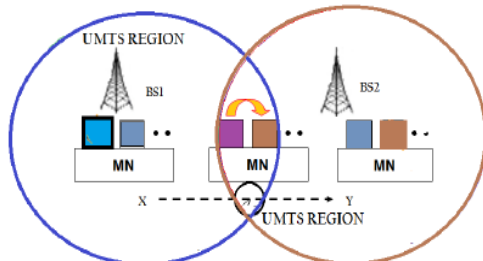


Figure 1: Horizontal Handover scenario

A heterogeneous wireless network is a network that has different access technologies, different network architectures and different protocols to connect mobile users with other devices and to make decisions for routing and mobility issues between mobile users. Nowadays, mobile users

demand to be connected with the Internet while they move freely demanding ABC (Always Best Connected). It has become a very important service for mobile users to get high quality services with high data rates[2][3]. There are different techniques to realize handoff strategies, eg. WLAN, LTE, WiMAX. WLAN (Wireless Local Area Network) is most popular communication technology which is used for short or medium distances having low infrastructure cost. IEEE 802.11 standard is used in WLAN. LTE(Long Term Evaluation) offering easier access and use with greater security and privacy, enabling high-performance mobile computing. WiMAX is a telecommunications protocol that provides fixed and fully mobile Internet access. It supports a large coverage area with minimum range of 30 miles or 48 km[4].

## 1.1 WiMAX Evolution

The IEEE 802.16 standard forms the basis of WiMAX technology. Over the past few years, the 802.16 standard has evolved as follows:

- IEEE Std 802.16–2001: Line-of-sight fixed operation in 10 to 66 GHz.
- IEEE Std 802.16a–2003: Air interface support for 2 to 11 GHz.
- IEEE Std 802.16d–2004: High-speed data rates for fixed wireless and nomadic access.
- IEEE Std 802.16e–2005: Improved air interface and capability for limited mobility.[5]

It is depicted in fig. 2 below:

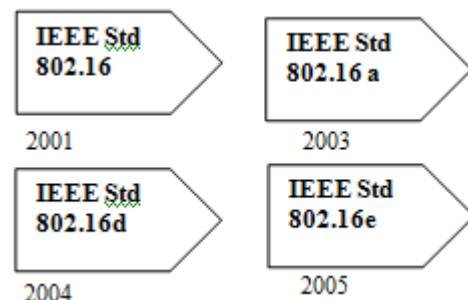


Figure 2: Evolution

## 1.2 IEEE WiMAX Standards

There are two different types:

- Fixed WiMAX(802.16d)
- Mobile WiMAX(802.16e)

The fixed WiMAX which use 802.16d standard, does not support mobile connectivity i.e. when a user is in motion and cannot easily access wireless network. To overcome the problem of mobile connectivity a new standard developed named as IEEE 802.16e 2005 or Mobile WiMAX. It has full support of mobility. Mobile WiMAX system offers scalability in radio access technology and network architecture also [4].

In mobile WiMAX network when a mobile node(MN) moves from one channel to another channel, there is a need of support to provide continuous network connectivity to satisfy high level of mobile service quality. The main factor related to implementation of mobile WiMAX is to provide effective handoff. It provides the support for ongoing videocall or voice over internet protocols(IP). In general we found that different researchers work on different algorithms with different strategies but having a common motto, to improve handoff performance in mobile WiMAX. All the handoff techniques implemented such as they can support short interruption time, low handoff latency, high speed and cost effective [3].

## 2. Benefits of Mobile WiMAX

### 2.1 Mobile WiMAX vs WLAN

Mobile WiMAX has many competitors in the market, including cellular 3G and LTE specifications, WLAN. The Wireless Local Area Network (WLAN) is an unlicensed band of 802.11 ISM frequency band. While the WiMAX is a licensed band of 802.16 IEEE frequency band. Unlike WLAN, WiMAX provides a media access control (MAC) layer that uses a grant-request mechanism to authorize the exchange of data. WiMAX support real time applications. WLAN had the poor security feature but WiMAX proposes the full range of security features to ensure secured data exchange as Terminal authentication by exchanging certificates to prevent rogue devices and User authentication using the Extensible Authentication Protocol (EAP). IEEE 802.11 WLAN standard provides less cost, effective services, high speed network in coverage of 100 m. WiMAX base stations can offer greater coverage area about 8 km with data rate of 70Mbps. WLAN provide large capacity for metro networks while mobile WiMAX provide high speed data rates with limited mobility [6].

### 2.2 Mobile WiMAX vs LTE

LTE and WiMAX have many features and functions in common. Both are 4G wireless technologies and all-IP technologies. Mobile WiMAX and LTE both use packet data and VoIP services. Both are very flexible and LTE is available at preferred low Frequency Bands. Mobile WiMAX focus on TDD while LTE has focus on FDD. LTE provides higher efficiency than Mobile WiMAX. LTE use MIMO technology using OFDM scheme in downlink and

SC-FDMA in uplink. Mobile WiMAX also use MIMO technology using OFDM scheme both in uplink and downlink [7][8].

## 3. Vertical Handoff in Mobile WiMAX

Mobility is the most important issue in wireless cellular communication. When user moves one channel to another so to provide effective mobility, the minimum requirements are reliability, efficient and continuous services across the air interface. Handoff is a process with change of mobile node without any data loss while call is in progress. Handoff between different networks is known as vertical handoff. Process of vertical handoff can be divided into three steps, namely system discovery, handoff decision and handoff execution. In system discovery, firstly checked the networks and then available service in each network. During handoff decision phase MN determines which network should be connected to which depending on effective cost, bandwidth, delay etc. In handoff execution phase connections are transferred from current network to another new network which involve in authentication and authorization [3].

### 3.1 Reasons of handoff

Telecommunication reasons for conducting handoff can vary. Some of these are given below:

- To avoid call termination.
- To provide enough signal strength to maintain a proper call.
- To enhancement the capacity of a cell.
- To avoid interference in handoff to take place.
- To achieve advantage in vertical handoff as faster network is occasionally available so phone changes its network to cheaper one[9].

### 3.2 Hard and Soft handoffs:

Generally handoffs classified in two main categories:

- Hard handoff(break before make)
- Soft handoff(make before make)

In hard handoff, old connections are broken before new connections are created. IEEE 802.16e define three type of handoffs: Hard Handoff(HHO), Macro diversity handoff(MDHO) and Fast Base Station Switching(FBSS). Hard handoff is mandatory for mobile WiMAX while other two are optional. During the process of hard handoff, a minimum threshold is specified and call transfer take place only when signal strength of serving call reach upto its threshold. Soft handoff both existing and new connections are used during handoff process. In this case the connection to the target is established before the connection to the source is broken, hence this handover is called make-before-break[3][10].

### 3.3 Salient features of Mobile WiMAX:

- **High Data Rates** : MIMO technique which has advance coding and modulation scheme to facilitate mobile

WiMAX to support maximum data rate for downlink and uplink.

- **Quality of Service (QoS):** The fundamental premise of the IEEE 802.16e MAC architecture is QoS. Sub channelization schemes provide a flexible mechanism for frequency and time resources over the air interface.
- **Scalability:** Mobile WiMAX technology therefore, is designed to be able to scale to work in different channelizations from 1.25 to 20 MHz which provide internet access in rural areas in comparison with increasing the capacity of mobile broadband access in metro and suburban areas.
- **Security:** It supports SIM cards, Smart Cards providing security with the help of encryption and decryption.
- **Mobility:** Mobile WiMAX provides handoff schemes with minimum latencies to ensure real time applications.

### Applications

- **Corporate Networking:** WiMAX plays an important role in user access and data center connectivity. With the help of this technology, not only email and basic applications can access, but the user can do upload or download large files. WiMAX provides secure and reliable capability for audio or video conference. WiMAX also provides back up connection with the help of which WiMAX will continue to operate even if all cable links to the central office have been cut or damaged.
- **Medical and medical telemetry:** WiMAX can support these applications more reliably which provide coverage both inside and outside the facility. Medical telemetry can be used both when the patient is in the hospital and after he/she returns home.
- **Security Monitoring:** It support video cameras and other remote devices without the cost and complexity.
- **Customized Applications:** With the help of WiMAX technology, it is very easy to make a secure and reliable connection between number of different devices with any other device like laptop, computer etc. with high speed capability. This capability can extend upto entire city[4][11].

### Relay Technology in Mobile WiMAX:

According to the 3GPP LTE-Advanced technical report [2] and IEEE 802.16j technical specification [3–5], an RS should act as the BS for legacy UE units and should have its own physical cell Identifier but it works ideally only for WiMAX not for 3GPP LTE. It should be able to transmit its own synchronization channels, reference symbols and downlink control information. So an RS shall have the full functions of an eNB/BS (except for traffic backhauling), including the capabilities of knowing the radio bearer of received data packets and performing traffic aggregation to reduce signaling overhead. There should be no difference between the cell controlled by an RS and that controlled by a normal eNB.

### 4. Simulation and Result

Simulation results are plotted for WiMAX and LTE system network using Relay Technology. Simulation is performed

using OFDM modulation technique in MATLAB. An extensive study of WiMAX system has been presented in this paper. Fig. 3 shows relative signal strength between WiMAX and LTE network. Fig. 4 shows state of mobile station in two networks. This work has done with the help of Relay Technology Mechanism in Mobile WiMAX.

### 5. Conclusion

It is shown that relay technologies can effectively improve the relative signal strength, diameter range of BS, service coverage and system throughput of IEEE 802.16j, especially when multiple RSs are deployed.

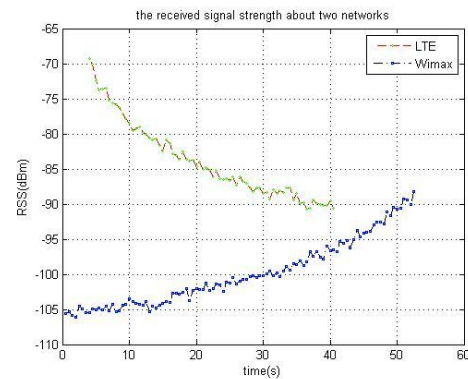


Figure 3: Received signal strength about two networks

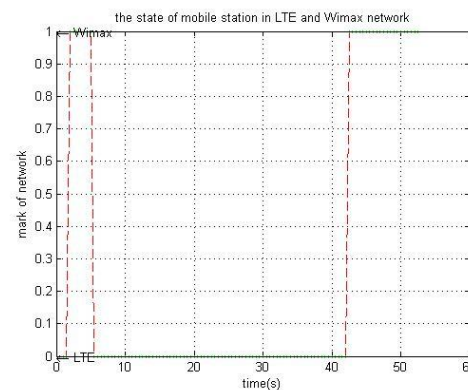


Figure 4: State of mobile station in two networks

3GPP LTE-Advanced supports multihop communications in a cell and generates longer delay in relay transmissions which results into BS diameter range decreased upto three times from previous diameter range of BS. RSS offered by 3GPP LTE Advanced decreased with time because of decreased diameter range of BS. IEEE 802.16j supports only two hop relay transmissions with smaller latency which results into BS diameter increased upto four times from previous diameter range representing the increased diameter range of BS having WiMAX signal. RSS offered by IEEE 802.16j increased with time because of increased diameter range of BS. Number of Handovers gets decreased using Relay Technology in Mobile WiMAX and finally Mobile Unit remains in WiMAX region.

### 6. Future Scope

With this technology due to reliable and efficient data by virtue of efficient handovers, of medical transcription, it will be possible to cure/operate a patient even in remote

places suffering from a chronic disease or in a trauma, requiring a robotic operation for which the expert doctor/surgeon/physician is available elsewhere in the world. Moreover, It can be used in nomadic scenario, in which the terminals can access an operator's WiMAX network via different access points. But during each session, a user terminal can only access point-by-point, and it cannot be switched over different BSs.

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