

# A New Handover Mechanism for IEEE 802.16e

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**ABSTRACT** – The IEEE 802.16e (WiMAX) is a broadband wireless technology that supports mobility of mobile station (MS). When the mobile station moves and needs to change the base station. Three handoff methods are supported in IEEE 802.16e standard - Hard Handoff (HHO), Fast Base Station Switching (FBSS) and Macro Diversity Handover (MDHO). In this paper we have proposed a new Macro Diversity Handover mechanism. A new handover mechanism supports Quality of service (QoS) such as Unsolicited grant service (UGS), Extended real-time polling service (ertPS), Real-time polling service (rtPS), Non-real-time polling service (nrtPS) and Best effort (BE). A new handover mechanism reduces handover time more than IEEE 802.16e standard.

**KEYWORDS** -- WiMAX, Macro Diversity Handover (MDHO)

## 1. Introduction

The IEEE 802.16e (WiMAX) is a broadband wireless technology that supports mobility of mobile station (MS). In year 2004, IEEE 802.16 [1] defines the WirelessMAN (WMAN) air interface specification for wireless metropolitan area network. IEEE 802.16 [1] supporting the fixed and nomadic. In year 2005, IEEE 802.16e [2], including support for QoS, OFDMA and mobility. There are three handover methods - Hand Handoff (HHO), Fast Base Station Switching (FBSS) and Macro Diversity Handover (MDHO). In handover process, a MS connected to the serving BS. When the MS moves and needs to change the BS. The MS is able to search and select target BS from subset BSs and start connection.

In the literature, the technique in [3] adding a new downlink management message to reduces handover time for real-time traffic stream. The algorithm in [4] reduces handover time by selecting one target BS and performing synchronization and DL-MAP. The method in [5] considers handover from layer-3. The method in [6] considers handover process for load balance by modified the management message in the IEEE 802.16e standard. The HHO algorithm in [7] considers service flows at BS and supporting QoS.

In this paper, we have proposed a new handover mechanism by used technique of Macro Diversity Handover (MDHO) and Multiple Input Multiple Output (MIMO). The new handover algorithm is able to support service flow at the MS. We used standard of IEEE 802.16e-2005 [2]. This paper organized as follows: In section 2, standard of IEEE 802.16e. In section 3, related work. In section 4, propose new

handover mechanism. In section 5, results and conclusion in last section.

## 2. IEEE 802.16e Standard

Handover (HO) process is supporting the MS to change from the serving BS to the other BSs. Figure 1, shows a basic of a HO procedure in the IEEE 802.16e [2]. An HO process including. Cell reselection, HO decision and initiation, HO cancellation, Synchronization to target BS downlink, use of scanning and association results, Ranging, Termination with the serving BS, Drops during HO and Network entry/reentry. The messages of an HO process are follows. A MOB\_MSHO-REQ message, it sends by the MS to initiate a HO. It contains the information about the recommended neighboring BSs. A MOB\_BSHO-RSP message, it sends by the BS for response to reception of a MOB\_MSHO-REQ message. It delivers the information about the recommended neighboring BSs for a HO. A MOB\_BSHO-REQ message, it sends by the BS for initiate a HO. The MS receiving this message and scan the recommended neighboring BSs. In the IEEE 802.16e are three handover methods. Hand Handoff (HHO), Fast Base Station Switching (FBSS) and Macro Diversity Handover (MDHO).

### 2.1 Hard Handoff (HHO)

The serving BS sends a MOB\_NER-ADV management message to MSs. This message contains BS ID, radiation power, frequency assignment and BS scheduling service supported (UGS, nrtPS, ertPS, rtPS and BE), mobility, Ho process, UCD/DCD of

neighbor BSs. When the MS moves and needs to change the BS, it can start a scanning and association procedure to target BS. The MS sends a MOB\_SCAN-REQ message and receive a MOB\_SCAN-RSP message from the serving BS. During the scanning process, the MS cannot process with downlink and uplink transmissions. After MS selected target BS. The MS can process with downlink and uplink transmissions again.

### 2.2 Fast Base Station Switching (FBSS)

When operating in FBSS, the MS only communicates with the anchor BS. The MS receives downlink and uplink transmission. The anchor BS updating the MS when the MS sends a MOB\_MSHO-REQ message or the anchor BS sends a MOB\_BSHO-REQ message. The MS select a new anchor BS by measurement RSSI and reports it to the serving BS by using the MOB\_MSHO-REQ message.

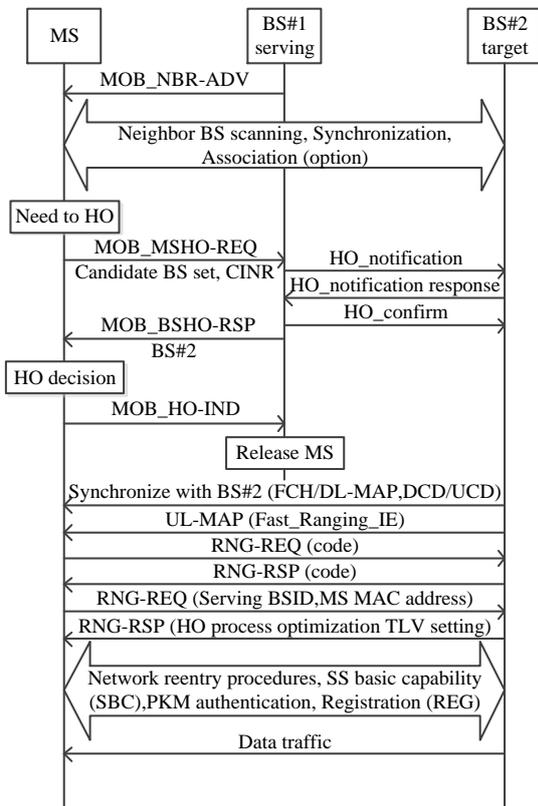


Figure 1. Basic Handover Process.

### 2.3 Macro Diversity Handover (MDHO)

In MDHO process, an MS and the anchor BS manage a diversity set. When operating in MDHO, the MS is able to communicate with all BSs in the diversity set for downlink and uplink traffic. For downlink, two or more BSs provide synchronized transmission of a

MS downlink data. For uplink, the MS sends data to multiple BSs. In Figure 2 shows a procedure of MDHO. In Figure 2, if CINR of a neighbor BSs higher than the H\_Add threshold. The MS sends a MOB\_MSHO-REQ message to the serving BS#1. When BS#1 sending an MOB\_BSHO-RSP to the MS. The BS#1 provides a list of BSs recommended for the MS diversity set. In Figure 2, if the MS receives a MOB\_BSHO-RSP message, it chooses the actual update by considering the received diversity set. Then the MS sends a MOB\_HO-IND message that contains the type field of confirm diversity set update. Finally, the MS is able to receive DL-MAP/UL-MAP from BS#2 as well as from BS#1.

### 2.4 Multiple Input Multiple Output (MIMO)

MIMO systems use multiple inputs and multiple outputs from a single channel. These systems defined by spatial diversity and spatial multiplexing. Spatial diversity is known as Rx and Tx diversity. Signal copies transferred from another antenna or received at more than one antenna. With spatial multiplexing the system is able to carry more than one spatial data stream over one frequency simultaneously. MIMO established in IEEE 802.11n, IEEE 802.16-2004 and IEEE 802.16e-2005.

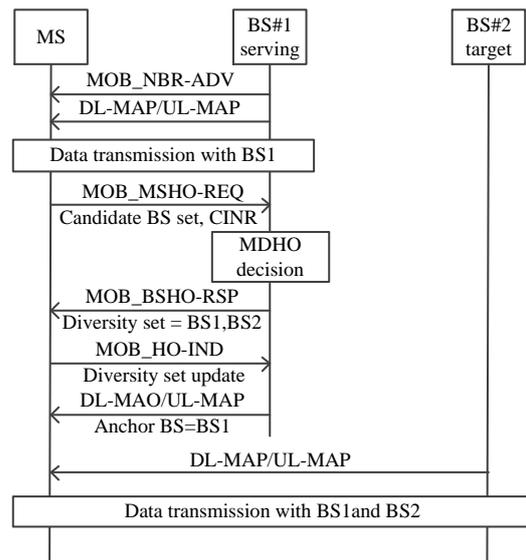


Figure 2. Macro Diversity Handover (MDHO) Process.

### 2.5 Service flow in IEEE 802.16e

In IEEE 802.16e is supported by allocating each connection between the MS and BS to a specific QoS class (called a service flow). There are five classes. Unsolicited grant service (UGS), Extended real-time

polling service (ertPS), Real-time polling service (rtPS), Non-real-time polling service (nrtPS) and Best effort (BE).

### 3. Related Work

In year 2005, D. Lee, K. Kyamakya, and J. Umondi, from KAIST [3] propose an enhanced handover scheme. The MSS is able to receive downlink data through specified message from the target BS after the MSS synchronization during handover process. It does not need uplink synchronization with the target BS.

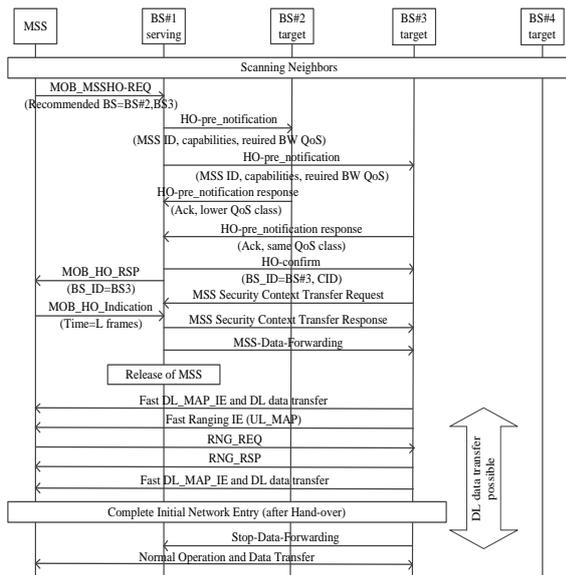


Figure 3. Message sequence chart of handover process by MSS request.

In Figure 3, shows a message sequence chart of handover process by MSS request with Fast DL\_MAP-IE. The MSS sends a MOB\_MSSHO-REQ message to the serving BS. The MSS recommends two neighbor BSs (BS#2, BS#3). The serving BS transfers handover information to neighbor BSs through backbone network. The MSS receives handover response message. The MSS sends handover indication message to the serving BS and releases the connection with the serving BS. In year 2008, H. Fattah, and H. Alnuweiri, [7] proposes a handover algorithm, that minimizing the handover time and selecting the best possible target BS within the framework of IEEE 802.16e standard. During operation, the MS receiving a MOB\_NBR-ADV message and make a list of the BSs order by QoS. When the MS detects that the RSSI of the serving BS is less than a threshold. The MS used the BS list, which saved when a MOB\_NBR-ADV message receive. The MS starts to build a short list containing

neighbor BSs that support the current active service flows.

The MS scanned the BSs in the short list order by RSSIs. If one or more of neighbor BSs have RSSI values above the threshold, their IDs of neighbor BSs will be sent by the MS in a MOB\_MSHO-REQ message to the serving BS. When the MS receives a MOB\_BSHO-RSP, it selects target BS and sends a MOB\_HO-IND to the serving BS.

### 4. New Handover Mechanism Proposed

In this section, we have proposed a new handover algorithm by used MDHO process that compliant with the IEEE 802.16e standard. A new MDHO algorithm is able to support the QoS requirements for service flow at MS. The algorithm shows in Figure 4.

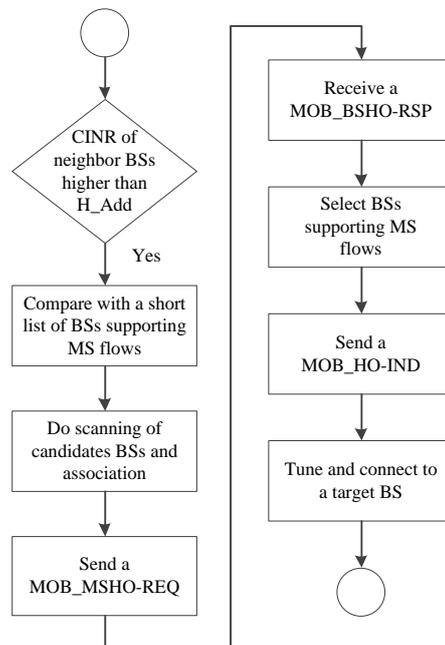


Figure 4. New MDHO algorithm.

#### 4.1 Network Topology Acquisition

Typically, an MS have different service flows (Scheduling service) to communicate with the anchor BS. The MS scheduling service running one or more services. If the MS need to handover to target BS, a new MDHO process in this proposes is able to support communication with multi BSs. The MS choose handover to target BS by select from short list of recommend BSs, there are support all MS service flows. If target BS does not support all MS service flows. The MS should choose the service in the following order: UGS, ertPS, rtPS, nrtPS and BE. In this proposed, if CINR of a neighbor BSs is higher than the H\_Add threshold. The MS compare

neighbor BSs with a short list of BSs supporting MS service flows, then the MS sends a MOB\_MSHO-REQ message to the anchor BS. The MS have candidate neighbor BSs whose CINR value is higher than the H\_Add and QoS support MS service flows. The BSs shot list shows in Figure 5. In Figure 5, The MS make a short list by receive a MOB\_NBR-ADV from the anchor BS. A MOB\_NBR-ADV message including neighbor BSs information and neighbor BSs channel. The anchor BS sends a MOB\_NBR-ADV message according to the broadcast CID or the primary management CID.

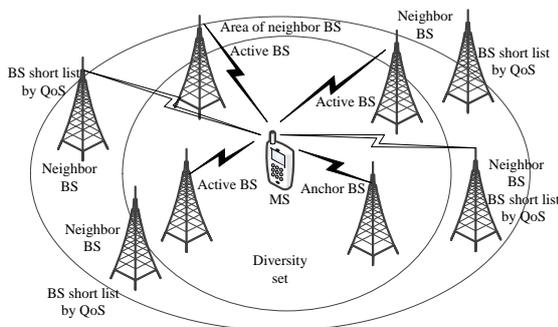


Figure 5. BSs short list.

### 4.2 HO Process

From the network topology acquisition, the MS have candidate neighbor BSs whose CINR value is higher than the H\_Add and QoS support MS service flows. If the MS initiates the handover process, it sends a MOB\_MSHO-REQ message with a list of possible neighbor BSs. The MS can generate this list of possible neighbor BSs for the diversity set by compare with a short list and CINR measurement, scanning, synchronization, association. Then the MS should wait for a response from the anchor BS by receiving a MOB\_BSHO-RSP message. When the MS receives a MOB BSHO-RSP message, it transmits a MOB HO-IND message to the anchor BS indicating the target BS. Finally, the MS is able to receive DL-MAP/UL-MAP from the anchor BS and the target BS. The message sequence chart shows in Figure 6. In Figure 6, If CINR of neighbor BS higher than H\_Add, the MS make list of neighbor BSs from a MOB\_NBR-ADV message and order by QoS support MS service flows. The MS sending a MOB\_SCAN-REQ for scanning neighbor BS from a list, in this case scanning BS#2 and BS#3. After scanning, the MS have candidate BS (BS#2), the BS#2 support MS service flows and larger CINR. When, the MS need to handover. The MS sends a MOB\_MSHO-REQ message to the anchor BS including candidate BS (BS#2). The MS receives a MOB\_BSHO-RSP message from the anchor BS. In this message including data of diversity set (BS#1 and BS#2). If the MS receives a MOB\_BSHO-RSP

message, it chooses the actual update by considering the received diversity set. The MS sends a MOB\_HO-IND message that contains the type field of confirm diversity set update. Finally, the MS can receive DL-MAP/UL-MAP from BS#2 as well as from BS#1.

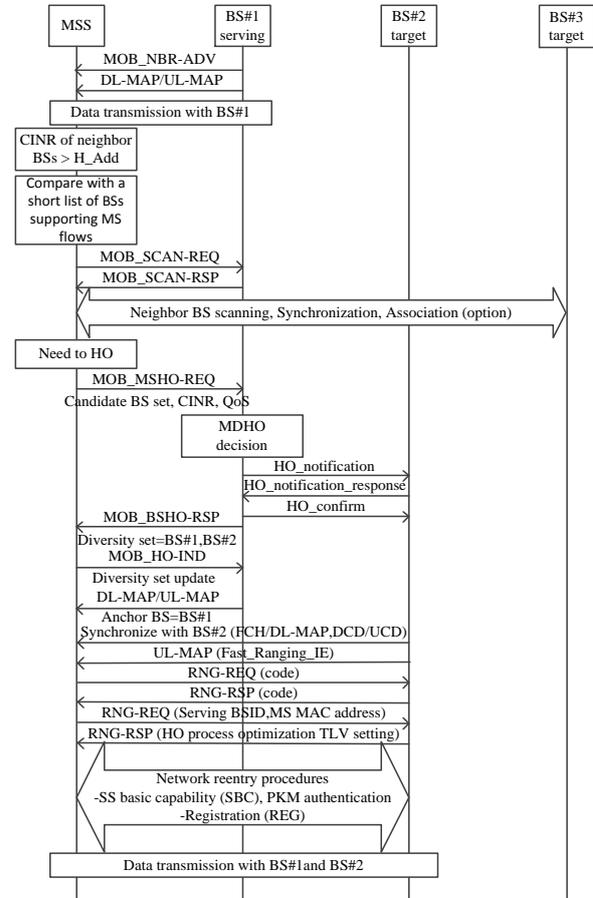


Figure 6. Message sequence chart of new MDHO process.

### 5. Results of Numerical Analysis

In this section, we present the results of various processes of handover times. We compared handover time in the each process. Period used time in handover process will start from trigger until the MS can connect to the new BS. We define the following parameters for a MS.

- $T1 =$  Required time to perform neighbor BS scanning [7],
- $T2 =$  Required time to perform neighbor BS synchronization [7],
- $T3 =$  Required time to perform connection-base ranging [7],
- $T4 =$  Required time to perform connection-free ranging [7],

$T5$  = Required time to perform basic capability negotiation [7],  
 $T6$  = Required time to perform authentication and key exchange [7],  
 $T7$  = Required time to perform registration [7],

For time values give in Table 1 (in millisecond).

**Table 1.** Time Parameter Values [7]

	0% cell loading	50% cell loading
parameter	value (ms)	value (ms)
T1	20	20
T2	10	10
T3	75	150
T4	25	50
T5	30	30
T6	50	50
T7	35	35

In handover process, we consider a 0% and 50% cell loading factor. We define handover time at ten types.

- $HT_{HF1}$  = Contention-base ranging to all neighbor BSs [7],
- $HT_{HF2}$  = Contention-base ranging to target neighbor BS only [7],
- $HT_{HF3}$  = Contention-free ranging to all neighbor BSs [7],
- $HT_{HF4}$  = Contention-free ranging to target neighbour BS only [7],
- $HHO_1$  = Hard Handoff Contention-base ranging to target BS,
- $HHO_2$  = Hard Handoff Contention-free ranging to target BS,
- $FBSS_1$  = Fast Base Station Switching Contention-base ranging to all BSs,
- $FBSS_2$  = Fast Base Station Switching Contention-free ranging to all BSs,
- $MDHO_1$  = Macro Diversity Handover Contention-base ranging to all BSs,
- $MDHO_{NEW}$  = Macro Diversity Handover Contention-base ranging to target BS,

### 5.1 Scenario One

In this scenario, the MS will perform as basic capability negotiation, authentication, key establishment, and registration. The handover time for each type is as follow.

$$HT_{HF1} = (T1+T2+T3)n+T5+T6+T7 [7],$$

$$HT_{HF2} = (T1+T2)n+T3+T5+T6+T7 [7],$$

$$HT_{HF3} = (T1+T2+T4)n+T5+T6+T7 [7],$$

$$HT_{HF4} = (T1+T2)n+T4+T5+T6+T7 [7],$$

$$HHO_1 = T1n+T2+T3+T5+T6+T7,$$

$$HHO_2 = T1n+T2+T4+T5+T6+T7,$$

$$FBSS_1 = T1n+T2x+T3+T5+T6+T7,$$

$$FBSS_2 = T1n+T2x+T4+T5+T6+T7,$$

$$MDHO_1 = T1n+T2x+T3x+T5+T6+T7,$$

$$MDHO_{NEW} = T1x+T2x+T4x+T5+T6+T7,$$

When  $n$  = all neighbor BSs and  $x$  = target BSs. In this scenario,  $MDHO_{NEW}$  shows total handover time included time values of  $T1x$  (Required time to perform target BS scanning) +  $T2x$  (Required time to perform target BS synchronization) +  $T4x$  (Required time to perform connection-free ranging) +  $T5$  (Required time to perform basic capability negotiation) +  $T6$  (Required time to perform authentication and key exchange) +  $T7$  (Required time to perform registration).

### 5.2 Scenario Two

In this scenario, the MS is not needed to perform as basic capability negotiation, authentication and registration. The information of neighbor BSs is available over the backbone network. The handover time for each type is as follow.

$$HT_{HF1} = (T1+T2+T3)n [7],$$

$$HT_{HF2} = (T1+T2)n+T3 [7],$$

$$HT_{HF3} = (T1+T2+T4)n [7],$$

$$HT_{HF4} = (T1+T2)n+T4 [7],$$

$$HHO_1 = T1n+T2+T3,$$

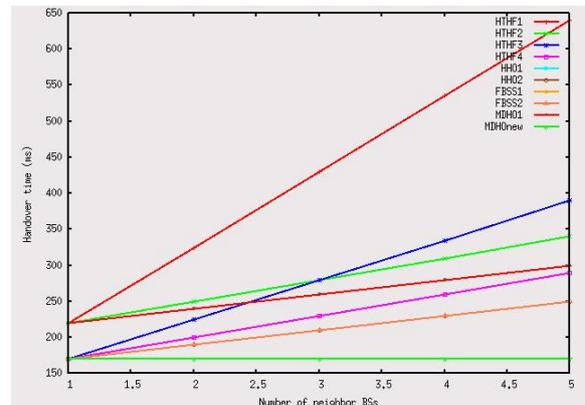
$$HHO_2 = T1n+T2+T4,$$

$$FBSS_1 = T1n+T2x+T3,$$

$$FBSS_2 = T1n+T2x+T4,$$

$$MDHO_1 = T1n+T2x+T3x,$$

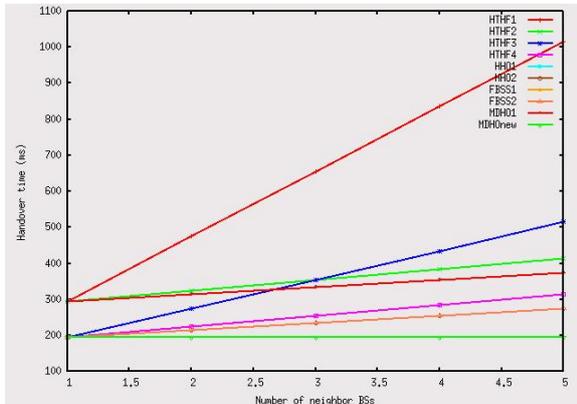
$$MDHO_{NEW} = T1x+T2x+T4x,$$



**Figure 7.** Handover time scenario one at 0% cell loading.

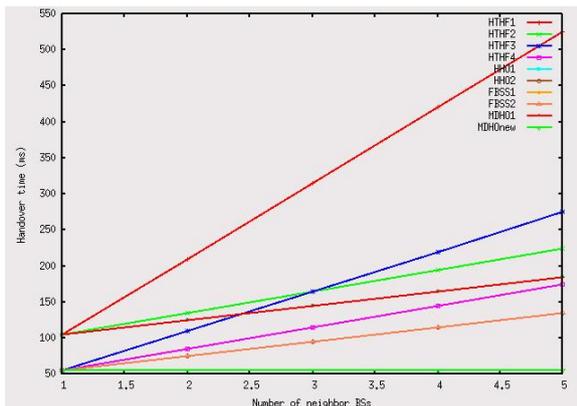
When  $n =$  all neighbor BSs and  $x =$  target BSs. In this scenario,  $MDHO_{NEW}$  shows total handover time included time values of  $T1x$  (Required time to perform target BS scanning) +  $T2x$  (Required time to perform target BS synchronization) +  $T4x$  (Required time to perform connection-free ranging).

In Figure 7 shows handover time using scenario one at 0% cell loading.



**Figure 8.** Handover time scenario one at 50% cell loading.

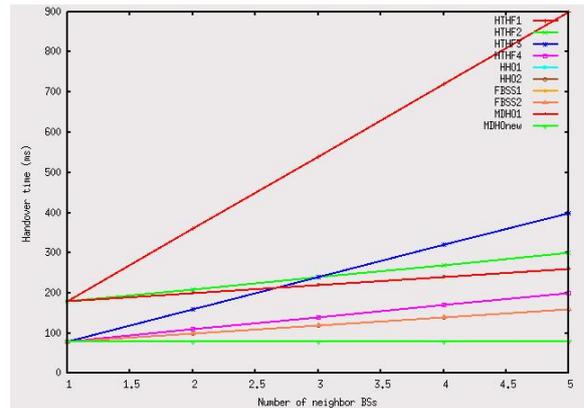
In Figure 8 shows handover time using scenario one at 50% cell loading.



**Figure 9.** Handover time scenario two at 0% cell loading.

In Figure 9 shows handover time using scenario two at 0% cell loading.

In Figure 10 shows handover time using scenario two at 50% cell loading.



**Figure 10.** Handover time scenario two at 50% cell loading.

## 6. Conclusion

In this paper, we have proposed a new handover algorithm by used IEEE 802.16e standard. The focus of a new MDHO algorithm is reduce handover time and selecting the best possible target BS. In scenario one and two, we used handover time less than HHO, FBSS and MDHO standard by selecting the possible target BS, which supports service flow at the MS.

For future work, we are investigated to resolve handover time for OFDM and OFDMA in IEEE 802.16e standard. More research should be focusing to packet loss and delay.

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