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# Implementation of Soft Handover in IEEE 802.16e

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***Abstract*— The demand for high data rates is increasing day by day, so to fulfill this requirement a new technology is introduced named WiMAX IEEE 802.16e standard. IEEE 802.16e standard is the enhanced version of IEEE 802.16 standard. WiMAX is based on Wireless Metropolitan Area Networking (WMAN) standards developed by the IEEE 802.16 group. WIMAX enables the delivery of broadband wireless services anytime, anywhere. In this paper we are discussing about different handover schemes and generating performance parameters mainly throughput, end to end delay, packet delivery fraction for Soft handover and Hard handover using network simulator NS-2.**

***Index Terms*— WiMAX IEEE 802.16e, QOS, hard handover, soft handover, throughput, end to end delay, packet delivery fraction.**

## I. Introduction

Wireless LAN based on or Wi-Fi standards have been a resounding success and now the focus in wireless is shifting to the wide area. Wi-Fi is a wireless LAN technology and it can only reach few meters in the open air. On the other hand WiMAX is designed to be a MAN wireless internet access technology, it can cover an area of some 50 miles in diameter WiMAX is an acronym meaning Worldwide Interoperability for Microwave Access .WiMAX is a new technology and is a revolution in wireless data transfer between client and server. WiMAX is a revolutionary technology after Wi-Fi. Mobile WiMAX is an emerging technology that provides high speed wireless broadband access. WiMAX is capable of providing high data rates, cover large coverage areas. WIMAX systems can be expected to deliver capacity of up to 40 Mbps per channel. This is enough bandwidth to simultaneously support hundreds of businesses with T-1 speed connectivity and thousands of residences with DSL (Digital Subscriber Line) speed connectivity. The WIMAX solution has a number of hooks built into the physical-layer design, which allows for the use of multiple-antenna techniques [1], such as beam forming, space-time coding, and spatial multiplexing. WIMAX is capable of supporting very high peak data rates. In fact, the peak PHY data rate can be as high as 74Mbps when operating using a 20MHz wide spectrum. The WIMAX MAC layer has a connection-oriented architecture that is designed to support a variety of applications, including voice and multimedia services. WIMAX based on IEEE 802.16e attempts to bring quality of services, high data rates and coverage to wireless data networks and to work as a “last mile” solution for end user access. The system offers support for QOS parameters [2] such as constant bit rate, variable bit rate, real-time, and non-real-time traffic flows, in addition to best-effort data traffic. An amendment to 802.16-2004, IEEE 802.16e-2005 (formerly known as IEEE 802.16e), addressing mobility, was concluded in December 2005. The basic characteristics of various IEEE 802.16 standards are as follow:

TABLE I. Basic characteristics of various IEEE 802.16 standards [2]

| parameters | 802.16 | 802.16-2004 | 802.16e-2005 |
|---|---|---|---|
| Gross data rate | 32-134.4 Mbps | 1-75 Mbps | 1-75 Mbps |
| Multiplexing | Burst TDM/TDMA | Burst TDM/TDMA/ OFDMA | Burst TDM/TDMA/ OFDMA |
| Duplexing | TDD, FDD | TDD, FDD | TDD, FDD |
| Channel bandwidth | 20,25, 28 | 1.25,1.75,3.5,5,7,8.75,10,14,15 | 1.25,1.75,3.5,5, 7,8.75,10,14,15 |
| Application | Fixed LOS | Fixed NLOS | Fixed and mobile NLOS |
| Frequency band | 10-66 GHZ | 2 GHZ-11 GHZ | 2-11 GHZ for Fixed<br>2-6 GHZ for Mobile |

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The IEEE 802.16e-2005 forms the basis for the WIMAX solution for nomadic and mobile applications and is often referred to Mobile WIMAX [3]. Major issue concerning implementation of WIMAX is to provide effective handover. Considering current broadband options such as DSL, Cable, and Wi-Fi promises to rapidly provide broadband QOS parameters it becomes necessary to provide handover process to be as fast as possible.

## II. HANDOVERS IN MOBILE WIMAX

Mobile WiMAX takes the fixed wireless application a step further and enables cell phone-like applications on a much larger scale. For example, mobile WiMAX enables streaming video to be broadcast from a speeding police or other emergency vehicle at over 70 MPH. It potentially replaces cell phones and mobile data offerings from cell phone operators such as EvDo and HSDPA (High speed downlink packet access) In addition to being the final leg in a quadruple play, it offers superior building penetration and improved security measures over fixed WiMAX. Mobile WiMAX will be very valuable for emerging services such as mobile TV and gaming Nomadic access provides movement among the cells, but there is no handover support. It means that moving user must establish a new network connection after each cell boarder run.

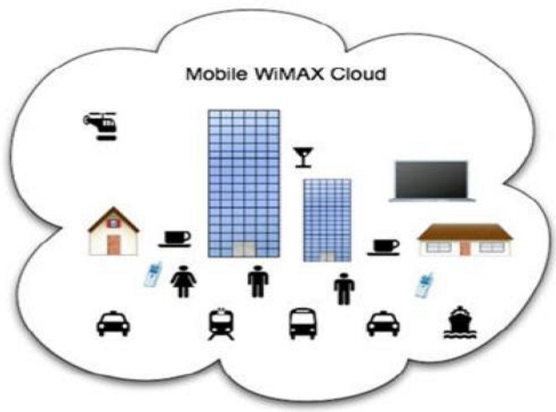


Figure 1. Mobile WiMAX [3].

Usually a handover is understood as a change of physical connection point through which the terminal communicates with network services. Handover is one of the critical operations in mobile WiMAX. The mechanism by which an ongoing connection between base station and mobile station is transferred from one base station to another is referred as handover or the term handover refers to the process of transferring an ongoing call or data session from one channel connected to the core network to another. The main target of handover in cellular mobile networks is to provide the continuity of services during a Mobile Station (MS) traveling across the cell boundaries of Base Stations. Soft Handover: In this a new link is made and service is transferred before the original link is broken. While this handover type is faster, it is more complex and requires the serving and target base stations to communicate with each other via the core network. Two types of optional soft handover are fast base station switching and Mobile diversity handover [4]. Mobile diversity handover: In this type of handover the mobile station has simultaneous communication links to more than one base station for both uplink and downlink transmissions. When MDHO is supported by mobile station and by base station, the "Diversity Set" is maintained by MS and BS. Diversity set is a list of the BS's, which are involved in the handover procedure. Diversity set is defined for each of mobile stations in network. Mobile station communicates with all base stations in the diversity set.

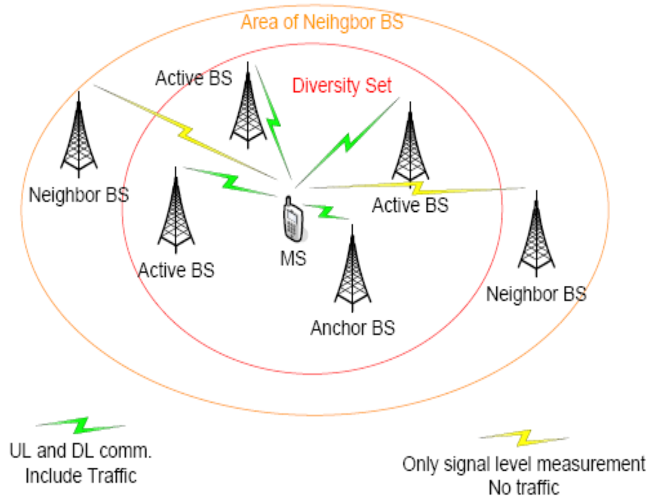


Figure 2. Mobile diversity handover[4].

For downlink in MDHO, two or more base station's transmit data to mobile station such that diversity combining can be performed at the mobile station For uplink in MDHO, MS transmission is received by multiple BS's where selection diversity of the received information is performed. The base station, which can receive communication among MS's and other base station's, but the level of signal strength is not sufficient is noted as "Neighbor BS". Fast base station switching: This is a rapid handover where the mobile station is able to change base stations within a set of base stations without completing the entire network entry procedure. The soft Handover - FBSS (Fast Base Station Switching) is like the MDHO, except that the mobile defines an Anchor BS among BSs which it is connected to, and communicates all traffic including the management and signaling messages with only the Anchor BS. The mobile can changes its Anchor BS when he wants as long as it is connected with. We are considering fast base station switching technique. In this method a diversity set is maintained for each mobile station. The serving base station and mobile station monitors the neighboring base stations that can be added in diversity set. Diversity set is maintained by both mobile station and serving base station. Diversity set is collection of base stations that can choose as target base station for a handover. The mobile station selects one base station from diversity set as anchor base station sends its current location to it which is sent to base station controller for decision of a handover. Whenever there is a need of handover base station controller sends handover initiation message to mobile station. Handover decision can be taken by mobile station, base station or base station controller depending upon the implementation [5]

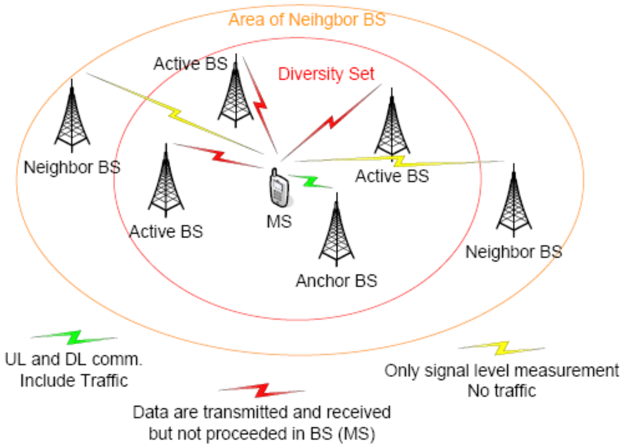


Figure 3. Fast base station switching[5].

In FBSS, the mobile station and base station diversity set is maintained similar as in MDHO. Mobile station continuously monitors the base stations in the diversity set and defines an "Anchor BS". Anchor BS is only one base station of the diversity set that MS communicates with for all uplink and downlink traffic including management messages. This is the BS where MS is registered, synchronized, performs ranging and there is monitored downlink channel for control information. The Anchor BS can be changed from frame to frame depending on base station selection scheme. This means every frame can be sent via different BS in diversity set. When operating in FBSS, the MU only communicates with the Anchor BS for uplink and downlink messages including management and traffic connections.

## III. PROPOSED TECHNIQUE AND IMPLEMENTATION

The proposed scheme is to define a procedure that can select the target base station for soft handover faster and efficiently:
Step 1: maintain the diversity set for each mobile station which is updated regularly according to current location of mobile station.
Step 2: Select an anchor base station for mobile station for monitoring the neighboring base stations.
Step 3: Define a threshold level below which handover will be initiated by the mobile station, this threshold level will depend upon following parameters:

- Signal strength of base station
- Traffic at base station
- Distance of a base station from mobile station

Step 4. The target base station is selected from diversity set by anchor base station that continuously monitors the neighboring base stations for a base station.

Step 5: As scanning procedures are already completed the mobile station will do the range selection with the target base station and when the link is properly established, then it breaks the connection with serving base station.

In the proposed technique, we are trying to modify the FBSS procedure to optimize target base station selection for soft handovers in WIMAX. We have introduced monitor base station which is selected from diversity set of mobile station. The function of monitor base station (MBS) is to communicate with mobile station and maintain the database of potential target base stations for a handover for mobile station. Another advantage of MBS is that whenever ABS fails, mobile station can start data communication with MBS without any loss of data by sending register message.
The mobile station sends its current location to MBS and according to history of mobile station movement and its current location, MBS sorts the TBS's having maximum div parameter.
Div= s/w- d
s= received signal strength
w= work load
d= distance between mobile station and base station

$$d=\sqrt{(x_s - x_i)^2 + (y_s - y_i)^2}$$

Where ($x_s$ , $y_s$) are coordinates of mobile station and ($x_i$ , $y_i$ ) are coordinates of i'th base station where i=1,2,3…. N
N = total number of base station in diversity set
$s= (k^* s^t)/d$
Where $s^t$= transmitted signal strength
k= other factors affecting signal (interference)
The MBS scans the neighboring base stations and calculates div parameter for each base station. Then MBS sorts the BS's in diversity set using sorting algorithm in descending order such that the BS having maximum value of div is on the top of diversity set.

## IV. METHODOLOGY

The simulation we have used to simulate WIMAX network is Network Simulator 2(ns-2.34 version). We have added MAC 802.16e layer to NS 2.34 Simulator. The trace files and nam files are generated according to the need. Nodes in simulation move according to "random way mobility model". NS-2 supports: TCP family, UDP, CBR, FTP, HTTP, Pareto, Exponential protocols, wires, wireless, unicast, multicast[6]
NS2 is based on two languages: C++ and TCL and it is using TCL/OTCL (Tool Command Language/ Object Oriented TCL) as a command & configuration interface.
There are 3 types of files of NS2:

- .Tcl or .ns, which have common subsets of commands but not exactly compatible between each other.
- While simulator runs on .tcl or .ns file, simulation trace file (.tr) and animation file (.nam) are created during the session.
- Network Animator (.nam) files are used to visualize the behavior of network protocols and traffic the model.

The communication pattern randomly created by the setdest tool defined in ns2 simulator. The tool contains following arguments:

- No. of Nodes-

- Pause Time
- Maximum Speed
- Simulation Time
- Maximum X-coordinate value
- Maximum Y-coordinate value
- Path of output file in which movement pattern is created

### *A. Steps for involving WIMAX procedure in ns2*

- File system → ns2-34-all-in-one→ ns2.24
- Paste WIMAX.tcl file in the in ns2-34-all-in-one →ns2.24 →WIMAX (new folder)
- Then in compile above procedure with make command.
  $ ns 2.34 allinone/ns2.34 make
- Then execute the tcl file using the command:

  $ ns2.34 allinone/ns2.34 ./ns WIMAX/WIMAX.tcl
- Nam file is generated as output of execution of tcl file which can be viewed by NAM tool.

  $ ns 2.34 allinone/bin ./nam

We have added various files in ns2.34allinone:

- distance.h
- geographic.h
- packet.h
- MAC 802.16 e layer
- tcp.cc
- WIMAX.tcl
- softhandover.rtt

### *B. Parameters used for simulation*

*C.*

The values of number of packets sent and received were measured for both the handover techniques. The duration of handover is considered to be the time difference between the last packet received from old base station and the first packet received from new base station. Data is sent at constant rate.

- Packet size : 512 bytes
- Time interval of data sent : 10 ms
- Total Number of nodes : 50
- Routing Protocol: AODV
- MAC layer : 802.16
- Traffic type: CBR(constant bit rate)
- Max. no of packets: 10,000
- NS Version: NS 2.34

### *D. Performance parameters*

- THROUGHPUT**:** The rate at which the data is transferred or maximum data transferred per second i.e. number of bits per second. Throughput of soft handover is higher than hard handover as data loss is much lesser in case of soft handover.
- END TO END DELAY: It is the time difference between the packet received and packet sent i.e.
  Packet sent= Time 1
  Packet Received = Time 2
  End to end delay= Time 2 – Time 1

  Average end to end delay includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times of data packets
- PACKET DELIVERY FRACTION**:** The ratio of the data packets delivered to the destinations to those Generated by the CBR sources is known as packet delivery fraction

## V. SIMULATION RESULTS

The proposed technique is implemented in NS-2.34 Simulator in Linux environment. We have modified ns-2.34 by adding mac802.16-e layer to it for supporting WIMAX. The WIMAX.tcl file is coded on C++, when executed it generates a .nam file which can be viewed in Network Animator tool of ns2 simulator. This simulation.nam file visualizes the soft handover procedure.

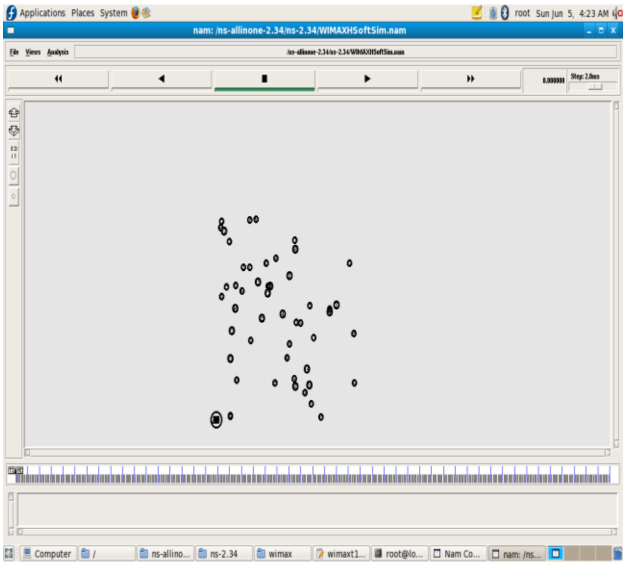

Figure 4. Various Nodes Used in Simulation.

Fig 4 shows 50 nodes used in simulation of base station selection procedure for soft handover. Here node 1 is mobile station and all the other nodes are base stations. The simulation shows the handover procedure as mobile station changes its position.

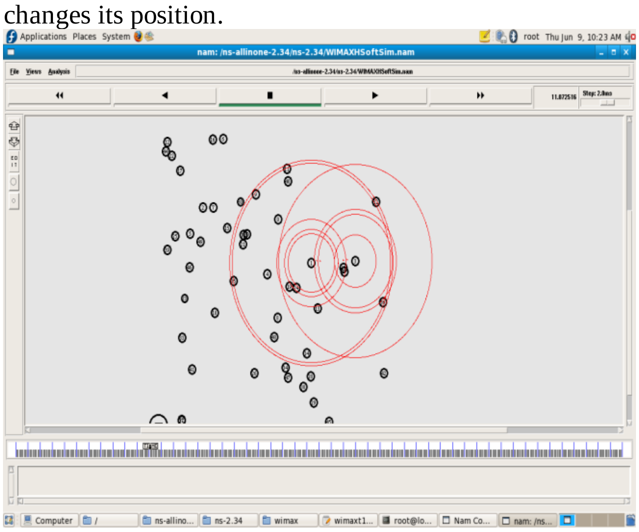

Figure 5. Signaling With Serving Base Station.

Above figure shows the ranging between node 1 and node 3. The node 3 acts as serving base station for mobile station (node 1). The node 1 starts data communication with node 3.The red arrows showing data transfer between node 1 and node 3.

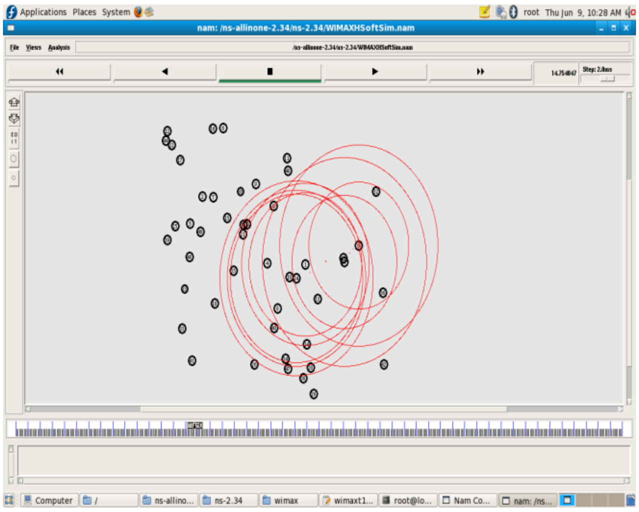

Figure 6. Signaling of mobile station with target base station.

As the mobile station moves, its distance from serving base station increases and the mobile station looks for another base station for soft handover i.e. Target Base Station. The above figure shows handover when the mobile station connects with target base station. Node 43 is target base station.

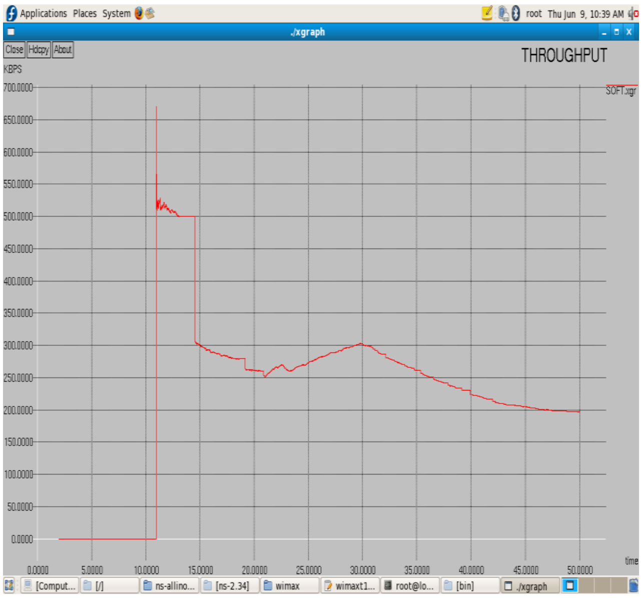


Figure 7. Throughput in soft handover.

Average Throughput: 260 KBPS
Start time: 10.94 seconds
Stop time: 49.9 seconds

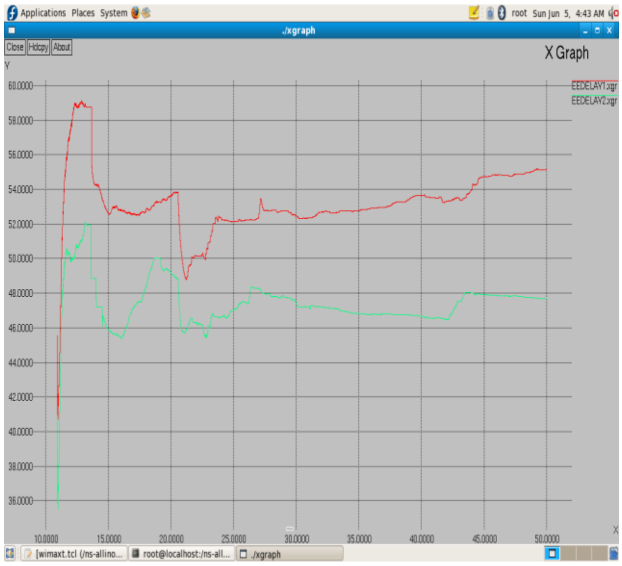


Figure 8. Comparison of end to end delay in hard and soft handover.

End to end delay (hard handover) = 55.141053 ms
End to end delay (soft handover) = 47.714 ms

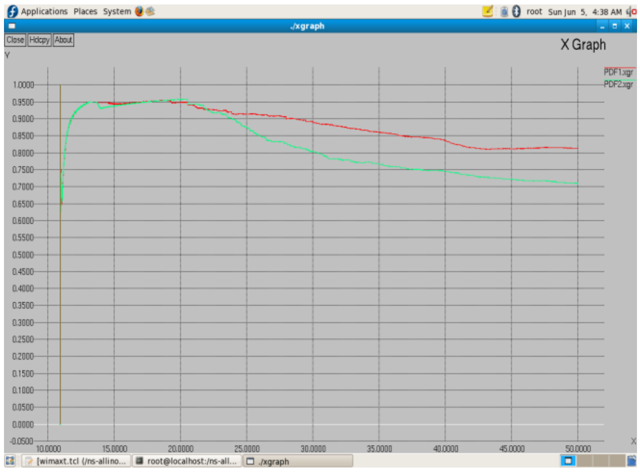


Figure 9. Comparison of packet delivery fraction in hard and soft handover.

PACKET DELIVERY FRACTION (HARD HANDOVER)
CBR S: 6775, R=4807, R/S=0.7095
% PDF= 70.95 %
PACKET DELIVERY FRACTION (SOFT HANDOVER)
CBR S= 4863, R=3954, R/S=0.8131
% PDF= 81.31%

## VI. CONCLUSION

The purpose of this work is to address the handover issue of WIMAX with focus on time. Currently the WIMAX standard states that hard handover is compulsory. Macro diversity handover and fast base station switching are both optional. Also the current work is restricted to hard handover only. Possibilities of extending this work to macro-diversity and fast base station switching (soft handover techniques) can be worthy of an investigation. Although these are soft handover techniques and currently optional in the WIMAX standard, the BS selection procedure based on location prediction algorithms and current load factors of the target BSs give an

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alternative way of deciding the target BS. Hard handover allows only low speed mobility while for high speed mobility FBSS and MDHO are preferred. In HHO the handover delay time is large so performance is not so good while in SHO the handover delay time is very small so performance is better than HHO. In HHO the throughput is less as compare to SHO as in HHO MS communicates with only one base station at a time and handover is not effective. However if the performance is not important the hard-handover can be used and network resources will be spared .For simple mobility hard handover is preferred while for full mobility FBSS and MDHO is preferred.

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