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Simulation of Relay modes in IEEE 802.16j Mobile Multi-hop Relay (MMR) WIMAX Networks

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Abstract

Two different relay modes are defined in IEEE 802.16j WIMAX standard: transparent mode and non-transparent mode. The non transparent mode is used to extend the coverage area of base stations, where low cost relay station of equal capacity as that of base station is placed at suitable position. Time taken to accept mobile stations and Bandwidth allocation are main problems in non transparent mode.

In this we have studied the IEEE 802.16j standard multi hop relay WIMAX networks. We have used relay stations to extend the coverage of base stations. We have also analyzed the throughput between mobile stations with in the coverage area and outside coverage area of base stations. We have simulated the IEEE 802.16j transparent and non transparent mode multi hop WIMAX relay networks using NCTUns Tool

Keywords: IEEE 802.16j, relay modes, non transparent mode, WIMAX, NCTUns, throughput etc

Contents

1. Introduction

WiMAX (Worldwide interoperability for micro wave access technology) will be the most significant technology to date in making wireless access ubiquitous, as free spectrum is opened up. It was developed by IEEE802.16 standards committee, acts as broad band access solutions for wireless communications. WIMAX has been regarded as a promising alternative for constructing the next broadband wireless metropolitan area networks (WMAN).

Generally there are two types of the WIMAX, namely the fixed WIMAX and mobile WIMAX, Fixed WIMAX which is based on IEEE 802.16d standard targets fixed application form its base stations. IEEE 802.16-e (mobile WIMAX also called m-WIMAX) targets mobile application allow mobile nodes (also called mobile station) to move from one place to other. It operates both in licensed and unlicensed band and was designed mainly to point to multipoint access. OFDM is widely adopted in WLAN and WMAN. Here original frequency carrier is divided in to group of sub carriers that are orthogonal to each other. In OFDM each sub channel is accessed to only one user at a given time slot. As OFDM does not specify multiple user access, so OFDMA was adopted this supports multiple users to share logical sub channels simultaneously. IEEE 802.16e WIMAX air interface

adopts orthogonal frequency division multiple access (OFDMA) for improved multi-path performance in non Loss of sight (NLOS).

In this paper, we investigate IEEE 802.16j WIMAX system. We first introduce IEEE 802.16j systems. Then, we analyze the WIMAX in transparent mode and non transparent mode of operation. The remainder of the paper is organized as follows. Section 2 introduces the IEEE 802.16j standards. Section 3 defines the relay modes in IEEE 802.16j .Section 4 gives the simulation of Transparent mode section 5 gives the simulation of non transparent mode.. Finally, section 6 concludes with a discussion of future studies.

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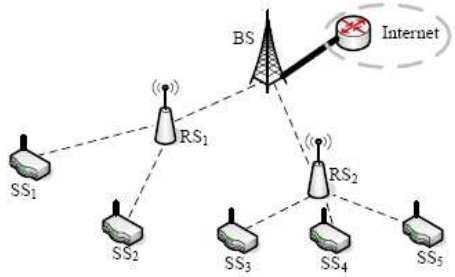

Fig 1: IEEE 802.16j Mobile multi hop relay (MMR) network

2. IEEE 802.16j Standard.

An amendment to the 802.16e standard namely IEEE 802.16j specifying relay station (RS) and multi-hop relay base station (MR-BS) was approved in year 2006 supports Mobile multi-hop Relay networks. (MMR). It provides coverage extension to isolated area and throughput enhancement by specifying relay stations. This system enables mobile stations to communicate with a base station through intermediate relay station. IEEE 802.16j [1][2][3][4][5][6][7][8][9][10][11][13] operates in two modes, transparent mode and non transparent mode. Transparent mode is used to increase the capacity of BS. Non transparent mode is used to increase the coverage area of BS. It supports real time applications such as voice and video and non real time applications such as large file transfer.

2.1 IEEE 802.16j services:

In 802.16 four types of services are used (1)Unsolicited grand service (2) Real time Polling service (3) non real time polling service(3) Best effort service .

2.2 IEEE 802.16j Relay transmission schemes:

Three types of Relay transmission schemes are used (1) Amplify and forward (AF) (2) Selective decode and forward (DCF) (3) demodulation and forward (DMF). In AF scheme the signal is processed and undergoes amplification and is then passed over to the mobile station. This scheme has simple operation and very short delay and also amplifies noise. No cyclic redundancy check (CRC) technique is performed in this scheme, as it amplifies noise it is not used in practice. In DCF scheme decoding of received signal and cyclic redundancy check (CRC) is performed to check for errors. This scheme has long processing delay. In DMF scheme demodulation and modulation is performed on received signal without decoding. This scheme is simple and processing delay is simple. A new scheme called as tunneling introduced in IEEE 802.16j networks, which is designed specially to leverage the inherent notion of aggregation in relay links.

2.3 IEEE 802.16j MAC layer

The base station would use the standard medium access control layer (MAC) a common interface that makes the networks interoperable to nearly instantaneously allocate uplink and downlink bandwidth to subscribers according to their needs. In IEEE 802.16j, the RS adds MAC protocol to support multi-hop communication between RS, and also BS must support multiple RS. In 802.16j frame structure frame is divided in to two sub frames, downlink sub frame and uplink sub frame. These sub frames are divided in two zones called as DL/UL access zone and DL transparent zone /UL relay zone. These frames have two different structure, transparent mode frame structure and non transparent mode frame structure.

2.4 IEEE 802.16j PHY layer

The physical (PHY) layer of WIMAX IEEE 802.16j standard is based on the IEEE 802.16-2004 and IEEE 802.16e-2005 standards and was designed from IEEE 802.11a. In the IEEE 802.16-2009 standard, an adaptive

burst profile mechanism is used, so that WIMAX systems are able to flexibly adjust the modulation and power scheme for individual SSs depending on the radio conditions.

2.5 IEEE 802.16j Modulation schemes

Four modulation schemes are defined in burst profiles to suit different SNR situations: Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK), 16 Quadrature Amplitude Modulation (16QAM) and 64QAM. Some other techniques and technologies, such as Forward Error Correction (FEC), Multiple Input Multiple Output (MIMO) antennas, Adaptive Antenna Systems (AAS), Automatic Repeat Request (ARQ) and etc, are also defined to improve performance.

2.6 IEEE 802.16j Forwarding schemes.

The MAC layer uses two different forwarding schemes, tunnel based scheme and CID based scheme. In tunnel based scheme the tunnel adds relay MAC header to a packet and it is removed at the RS. Centralized or distributed scheduling modes are used in this scheme. The forwarding is done based on the CID of the tunnel. In CID based scheme packets are forwarded based on the CID of the destination. This scheme uses centralized or distributed scheduling. RS has the knowledge of QoS requirements and take their own scheduling decisions in distributed scheduling. But in centralized scheduling the BS informs to RS about relay link channel characterizes.

2.7 IEEE 802.16j tunneling.

A tunnel connection is a unidirectional connection between the BS and RS established to aggregate management and transport traffic. To identify the tunnel service flow identifier (SFID), tunnel connection identifier (T-CID), management tunnel identifier (MT-CID) is used. Transport and management tunneling mechanism is used in IEEE 802.16j networks. Three different management tunnels is used, basic management tunnel, primary management tunnel, and secondary management tunnel. Two different MPDU construction methods namely encapsulation mode and burst mode used in relay system. MAC layer provides routing and path management. As 802.16j network comprises multi-hop paths between the BS and MS, the standard defines two approaches for path management, embedded and explicit path management. It also defines network entry management.

2.8 IEEE 802.16j Network topology acquisition.

The MAC layer of IEEE 802.16j includes the following phases: 1) network topology acquisition before handover, which includes network topology advertisement, and MS scanning or association of neighbor BSs. 2) handover execution phase, which mainly includes cell reselection, handover initialization and handshake process, connection release, and target network reentry.

2.9 IEEE 802.16j parameters

Host channel parameters.

1. Bandwidth= 50 Mbps
2. Bit error rate=0
3. Propagation delay=0.0 Micro seconds.
4. IP address = 1.0.1.1
5. Net mask=255.255.255.0
6. ARP protocol.

802.16j Base station channel parameters.

1. Fading variance=10
2. Average building height=10m
3. Average Building distance=80m
4. Street width=30m
5. Pass loss exponent=2.0
6. Shadowing standard deviation=4.0
7. Close in reference distance(m)=1.0
8. System loss=1.0
9. Antenna height=30m
10. Ricean factor (k)=10.0 db

OFDMA parameters for BS

1. Channel ID=5
2. Frequency=2300 MHz
3. Transmission power = 35 dbm
4. Receive sensitivity=-99dbm

802.16j Mobile station channel parameters

1. Frequency=2300 MHz
2. Transmission power = 35 dbm
3. Receive sensitivity=-99dbm
4. Speed= 20 m/sec

2.10 Definition and Examples.

We first give simple definitions for key terms as they will be used in the rest of this paper:

IEEE 802.16j: It is the standard for IEEE 802.16j Mobile WIMAX relay networks, It is an amendment to IEEE 802.16e-2005

TMR-BS: IT is the transparent mode mobile relay base station for IEEE 802.16j Mobile WIMAX relay networks.

T-MS: It is the transparent mode mobile station, which is an wireless interface to TMR -BS.

T-RS: It is the transparent mode relay station, which is an interface to TMR -BS.

OFDMA**:** It is modulation scheme called orthogonal Frequency division multiple access (OFDMA) used in IEEE 802.16j.

TABLE-1

S.No	Transparent Mode	Non Transparent Mode
1.	Supports Centralized scheduling - as scheduling done only in base station	Supports Centralized or Distributed scheduling- as scheduling done in base and relay station
2.	Use CID based forwarding scheme	Use Tunnel based or CID based forwarding scheme
3.	Use only 2 hops	Use 2 or more Hops
4.	Does not provide coverage extension	Provides BS coverage extension.
5.	Low Relay station cost.	High Relay station cost.

3. RELAY MODES

Two different relay modes are defined in this standard, transparent mode and Non- transparent mode.

a. Transparent Mode

The transparent relay mode increases the throughput which facilities capacity increases within the Bs coverage area. It has no support to coverage extension because it does not forward framing information to BS. It is operated in two hop network topology and supports centralized scheduling only as scheduling is done only in BS. It uses CID based forwarding scheme and supports embedded and explicit mode of path management.

b. Non transparent relay mode

The Non transparent relay mode as in fig 3 is to increase the coverage extension of BS, here RS generate its own framing information and forward it to SSs. It operates is 2 or more hops and uses centralized or distributed scheduling mode, as scheduling is done in BS and RSs. It used CID and Tunnel based forwarding scheme and supports embedded and explicit mode of path management. The channel parameters are shown in fig 2

The transparent relay station does not transmit control message, permeable, FCH (frame control header, and DL/UL-MAP, as it only increases system throughput. The non transparent relay station transmit control message, permeable, FCH (frame control header, and DL/UL-MAP, as it increases system throughput and

increases cell coverage. Table 1 shows the difference between transparent and non transparent mode of operation.

4. Simulation of IEEE 802.16j Transparent mode

An IEEE 802.16j multi hop mobile WIMAX relay network "C. So-In, R. Jain (2010) and A. Al-Tamimi (2010)"is constructed using topology editor of NCtuns as shown in the below figure.

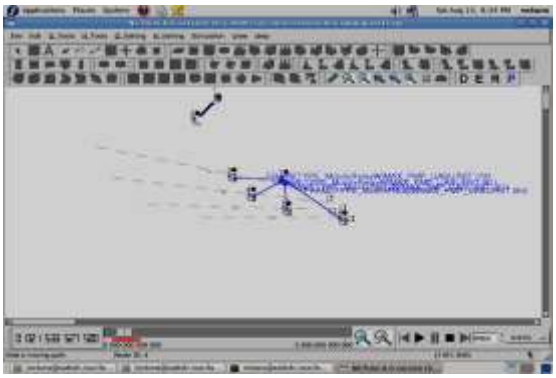

Fig 5 : Adaptive model topology construction

The TMR-BS connects with the host (on the backhaul network) through a wired link and it communicates with other nodes in this topology through an IEEE 802.16j wireless interface. The GUI needs to generate an IP address for each node in the topology. To help the GUI know that Node 2 (MR-BS), Node 3 (T-RS), Node 4, 5, 6, 7 (T-MS), are on the same IP subnet, we need to group them together in the GUI. We use the following steps to form a subnet

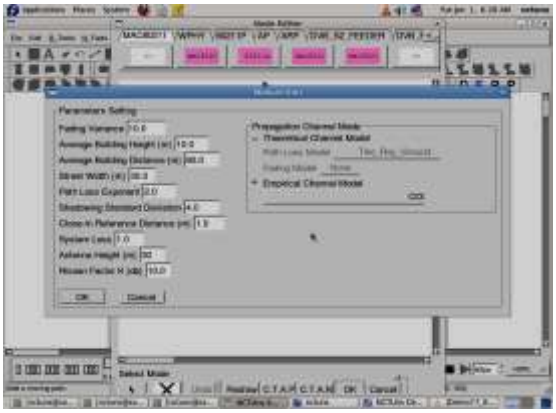

Fig 6 : power setting for adaptive model

In the NCTUns design, the default channel ID chosen for the TMR-BS is the same as its Node ID. To ensure that T-RSs and T-MSs can communicate with the TMR-BS on the same channel, one should set the channel ID of T-RSs and T-MSs to the channel ID of their TMR-BS. In the "**Node Editor**" window, double-clicking the PHY module box. The name of the PHY module box is OFDMA_PMPXX_MR_WIMAX, where XX may be "BS," "RS," or "MS," depending on the node type. A dialog box for this PHY module will pop up and inside this dialog box one can specify or modify the channel ID or other parameter values

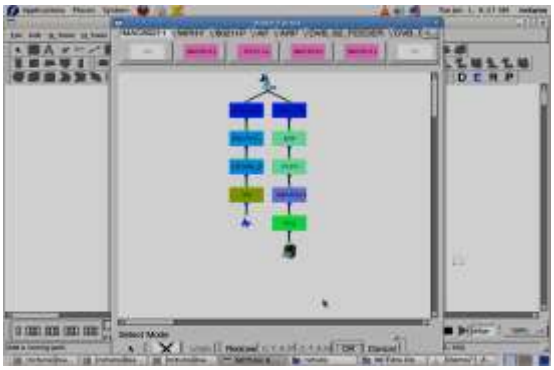

Fig 7: Node Editor of TMR-BS

The Network topology "C. So-In, R. Jain (2010) and A. Al-Tamimi (2010)"consists of not only nodes but also links between them. Links can be added to the network topology easily. When nodes and links are added to the network topology, a node ID and the ID of its ports will be automatically assigned and adjusted by the GUI program. The Node editor of TMR-BS consists of the following modules CM, OFDMA, MAC FIFO, ARQ PHY, interface. The CM is used to set channel ID for the TMR-BS, frequency, transmission power and receive sensitivity. According to the IEEE 802.16j standard, the communications among all the transparent mode stations within the same cell should take place on the same channel. Therefore one must make sure that the used channel Ids of the T-RS and T-MSs are set to the channel ID used by the TMR-BS.

The Node editor of T-BS consists of the following modules CM, OFDMA, MAC, and interface as shown in fig 7. The IEEE 802.16j standard defines five scheduling services: (1) Unsolicited Grant Service (UGS), (2) Real-time Polling Service (rtPS), (3) Non-real-time Polling Service (nrtPS), (4) Best Effort (BE), and (5) Extended real-time Polling Service (ertPS), respectively..

At present, NCTUns only supports Best Effort (BE), which provides a uplink bandwidth for a T-MS. Here we illustrate how to set the QoS provisions for T-MSs.. In the popped-up dialog box, one can click the "Add" button to set the maximum uplink sustained rate (in Kbps) for every T-MS. NCTUns Tool for IEEE 802.16j Mobile WiMAX Relay Network Simulations.

IEEE 802.16j standard supports MS mobility. The standard defines three kinds of handover mechanism: hard handover, macro diversity handover (MDHO), and fast BS switching (FBSS). Since the hard handover mechanism is mandatory and the macro diversity handover mechanism and the fast BS switching mechanism are optional in the IEEE 802.16j standard, at present NCTUns only supports the hard handover mechanism for IEEE 802.16j networks.

The Topology is constructed without using a T-RS relay station where four T-MS mobile stations are connected to TMR-BS base stations through a wired back haul to sever host. The four T-MS mobile stations are moving at a without using a T-RS, the TMR-BS and a T-MS need to exchange their packets directly. This may result in a low throughput between them when the transmission path between them is non-line-of sight (NLOS). The reason is that in such a condition the signal received by the T-MS and TMR-BS is very weak and this forces them to use a more robust but lower efficiency modulation/coding scheme to transmit data

The T-MSs are connected to TMR-BS as shown in the fig, the T-MSs are moving at a speed of 20 m/sec, and the path is specified as shown above figure. The throughput of the T-MSs decreases when it moves away from the TMR-BS

The T-MSs and T-RS are connected to TMR-BS as shown in the fig"C. So-In, R. Jain (2010) and A. Al-Tamimi (2010)", the T-MSs are moving at a speed of 20 m/sec, and the path is specified as shown above figure. The throughput of the T-MSs on an average remains steady when it moves away from the TMR-BS. As shown above the T-RS is also connected to TMR-BS through fifth link, as initially all the nodes are connected to the TMR-BS. The T-MSs are exchanging their Bandwidth information with the T-RS as shown in fig , here they select the T-RS based on the Optimal relay selection procedure, the distance (x_s) between T-RS and T-MS is optimally calculated in PHY layer before assigning the T-RS to T-MSs. as shown in fig 14,

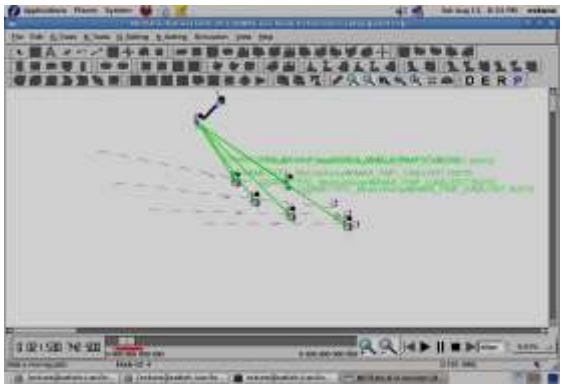

Fig 15: Data transfer through TMR-BS and T-RS

The mobile stations which are away from the TMR-BS are connected through T-RS as shown in fig and it is shown in fig.

5. Simulation of IEEE 802.16j non Transparent mode

An IEEE 802.16j multi hop mobile WIMAX relay networkis shown in the figure"C. So-In, R. Jain (2010) and A. Al-Tamimi (2010)". An IEEE 802.16j base station is connected to all mobile stations and relay stations as shown in figure. The base station is connected to the server through a link, where all the data are stored in the server. The Base station will provide coverage area to certain distance; here the Base station coverage area is set as 300 meters. Mobile stations are placed inside the coverage area as shown in below figure. Some of the mobile stations are placed outside the coverage area of base station and they are connected to the base station through relay stations.

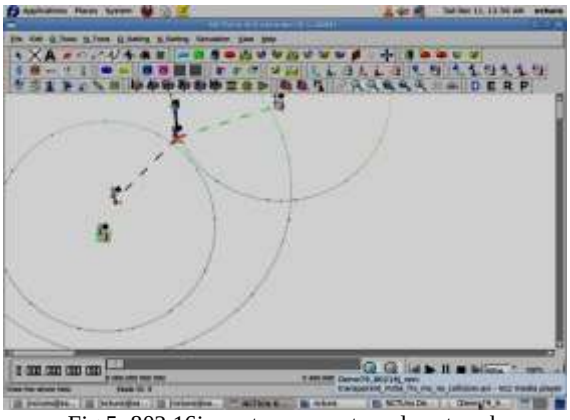

Fig 5: 802.16j non transparent mode network

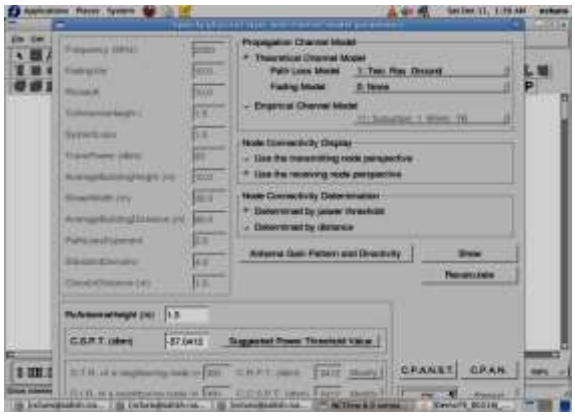

Fig 7: Channel parameters

The relay station is of same capacity as that of the base station but it is less costly, it will provide only coverage extension to the base station. The relay station provides link to the mobile stations and it is backward connected to base station, as all the mobile stations and relay stations are included in the subnet of base station. The mobile stations are generally moving through a particular path with a speed of 20 to 50 m/sec. As we are only

concentration on Throughput analysis in this network. We have not set the speed of mobile station. The Mobile stations are set at a particular point only. Here a mobile station is placed at a distance of 470.98 meters away from the base station. Some of the parameters we used in our simulation is given in the table-2 below.

The simulation parameters are given above, here the physical layer of 802.16j parameters are set as shown in the table. The channel chosen transmitting mode as all the stations are transmitting packets to other stations.

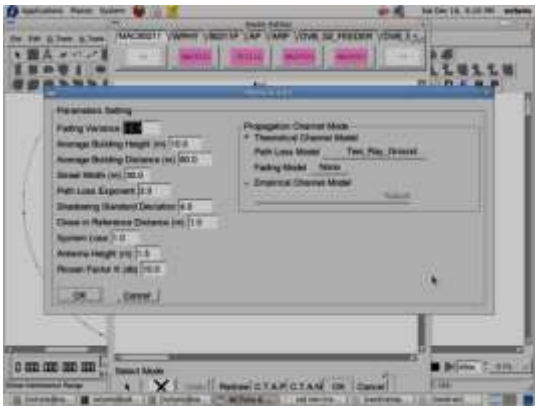

Figure 10: Channel Parameters

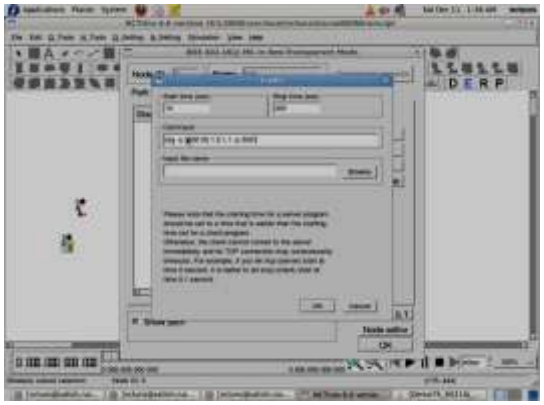

Figure 11: IP address setting

The data transfer rate can be set in the process. First it is checked that the base station coverage area will cover mobile station and relay station or it is adjusted with so that it covers all areas, and there will be no collusion with other stations. As collusion occurs in mobile stations when it moves from one coverage area to other coverage area, we have checked and adjusted the station coverage area such that it does not interfere with other stations, such that no collusion occurs.

The Node editor is shon above where the OFDMA parameters are set to access multiple users . Here both the base station and relay station coverage area is set as 300 meters, they are of equal capacity, the coverage area of mobile station is 150 meters, as shown in figure 1 the circle indicates the coverage area of base station, relay station and mobile station. The Base station has two interfaces one for wired server and other for wireless nodes. In wired interface ARP protocol is running with time interval of 3000 msec.

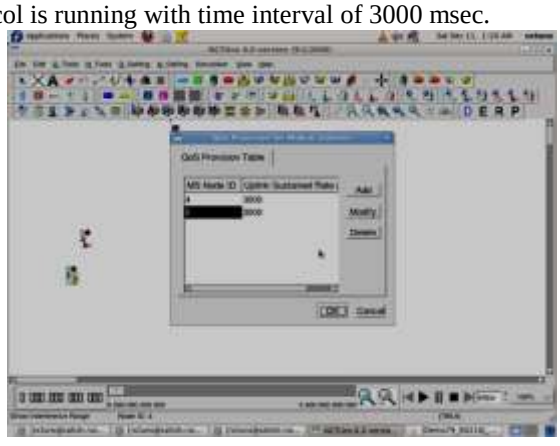

Figure 12: QoS provisioning

The simulation model shown above, where frames exchanged with the base station by the mobile station is shown. Here the coverage area is also shown by a circle, where three circles represent each coverage area. Packets are transmitted through the base station to all mobile stations. The frame type is NT_PMP_OLFP () as shown in the diagram.

6. Conclusion and Future Works

Multi hop WIMAX networks increase the capacity and coverage area of single hop WIMAX networks .In this paper we have studied the IEEE 802.16j standard using NCTUns simulator.. It offers solutions to future mobile networks. It operates in two modes, transparent mode and non transparent mode. As IEEE 802.16j network uses centralized or distributed scheduling, an efficient scheduling algorithm that maximizes the network throughput and minimizes overhead must be designed for IEEE 802.16j standard

IEEE 802.16j non transparent mode networks is used to extend the coverage area of base stations, where the relay station are of equal capacity as that of the base station, so the relay station transmits data at same throughput as that of the base station.

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