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NCTUns Simulation model for IEEE 802.16j Mobile multi hop Relay (MMR) WIMAX networks

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Abstract

IEEE 802.16j Mobile multi hop relay (MMR) network was approved in the year 2009, by the IEEE 802.16 working committee. In IEEE 802.16j Relay station with same capacity as that of Base station is used to extend the coverage area of base station or used to increase the Throughput capacity of base station.

In this paper we have given a simulation model for IEEE 802.16j MMR networks using the NCTUns - 6.0 network simulator. The simulation model can be used for carry out IEEE 802.16j WiMAX simulations. The NCTUns network simulator is an open source simulator, and it used real time data to carry out the simulation. NCTUns uses a distributed architecture to support remote and concurrent simulations. The NCTUns has 8 components such as GUI, simulation engine, dispatcher, coordinator, kernel level modification, User level demean, parallel simulations for carry out IEEE 802.16j MMR network simulation.

Key-Words: - Relay modes, IEEE 802.16j, NCTUns-6.0, transparent mode, non-transparent mode, etc

1. Introduction

IEEE802.16 standard was authorized in year 1999. An amendment 802.16-e (mobile WIMAX also called m-WIMAX) operates both in licensed and unlicensed band and was designed mainly to point to multipoint access. 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. WIMAX is designed to support emerging applications such as voice over IP (VOIP), media streaming, multicast, broad cast service, online gaming etc IEEE 802.16-e Mobile WIMAX air interface adopts Orthogonal frequency division multiple access (OFDMA) for improved multi-path performance in non Loss of sight(NLOS). An amendment to the 802.16-e standard namely 802.16-j specifying relay station(RS) and multi-hop relay base station(MR-BS) 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. 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. 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 relay project, the RS adds MAC protocol to support multi-hop communication between RS and also BS must support multiple RS.

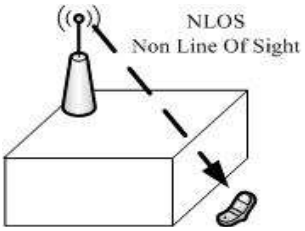

Figure 1: NLOS in 802.16j

The above figure 1 shows the NLOS (non Loss of sight) in IEEE 892.16 networks.

2. IEEE 802.16j Standard

Multi hop wireless Networks such as adhoc networks, sensor networks wireless mesh networks and relay based networks, have different characterizes, mobility rates power constrains scale form factor etc. Relay based networks are subject of interest at present due to small form factor and low cost relays. In this network relays are used to extend coverage of BS and increase the capacity of wireless systems. IEEE 802.16j (WIMAX mobile relay network) is a multi hop relay based network, provides broad band wireless IP to fixed and mobile terminal. Here relays are used to fill holes enhance coverage and data rate and also it operates in AF or DF. We have referred several papers and web sites solve hand over issues in IEEE 802.16j networks. To meet the paper length limitation, we listed below.

The IEEE 802.16 standard is Wireless Metropolitan area network (WMAN) technology. It supports real time applications such as voice and video and non real time applications such as large file transfer.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 .

The IEEE 802.16j provides increased coverage and capacity enhancement by using multi hop techniques and it address coverage hole problem. Traffic aggregation is done by multi hop path. It is backward compatible with 802.16e base stations. As IEEE 802.16j operates in two modes, transparent mode and non transparent mode and it is given in table 1.

IEEE 802.16j standard defines two types of relay station (RS) modes, transparent mode and non transparent mode. The RS uses centralized or distributed scheduling based on particular mode.

In transparent mode, RS are used to facilitate capacity increase within the base station (BS). It is used where Mobile station (MS) signal is affected by signal fading and interference level etc. when it moves to non line of sight (NLOS). It operates only in centralized mode, as all the scheduling of nodes takes place in BS. The number of hops is limited to 2 only as RS operated within the coverage area of base station. Relays used here are of lower complexity when compared to non transparent mode. In this mode relays do not transmit frame header information. In Non transparent mode, relays are used to provide increase coverage area of BS. It operates in centralized or distributed mode. It uses topologies larger than two hops, and uses different level of complexity.

3. Relay Transmission schemes

Three types of 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.

4. Hand Over Process.

The hard hand over mechanism uses the principle of break before make. This is the MS will break the connection with the original BS before making a new connection with another BS. Although it may lower the handover quality.

TABLE 1

S. No	Transparent Mode	Non Transparent Mode
1.	Centralized scheduling - as scheduling done only in BS	Centralized or Distributed scheduling- as scheduling done in BS or RS
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.

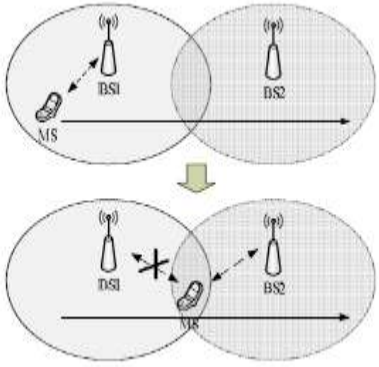

Figure 2: The hard handover mechanism.

When the MS moves from BS1 to BS2, it has to disconnect the original connection with BS1 before it can make a new connection with BS2.

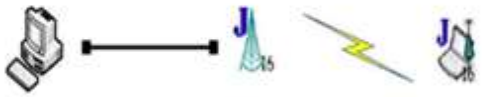

Figure 3: MS communicate with BS

The above figure 3 shows the topology for the MS to communicate directly with BS.

The Hand over process is composed of several phases: network topology advertisement, Mobile station scanning, cell Reselection, Hand over decision and initiation, network reentry (ranging, reselection re-registration), and normal operation. The criteria for Hand over decision and initiation is , channel quality indicators such as CINR(Carrier to interface and noise Ration) or the signal strength can be exchanged and Qos is characterized by service level prediction of MS and BS. Other criteria such as bit error rate (BER0, packet delay/jitter, service pricing, MS velocity, Ms location can also be used.

The Hand over stages are.

Stage1: The MS collects information about BSs in the neighborhood.

Stage2: While scanning MS seeks for suitable BS that is added in the diversity set.

Stage3: Two types of report are send by MS, event triggered report and periodic reporting.

In event triggered report Ms send reports after each measurement of Relative delay, round trip delay, receive signal strength report and CINR, but in periodic reporting reports are send at periodic intervals.

Stage4: Cell Reselection

Stage 5; MS Hand over is initialized based on the comparison of signal level of the current BS and new BS.

Stage 6; MS Network Re-entry consist of three stages: ranging (obtaining information about uplink channel), Re-authorization and Re-registration.

Stage 7: MS Normal operation;

5. Thresholds in MDHO and FBSS.

Two thresholds are defined in MDHO and FBSS hand over, add threshold and delete threshold. Add Threshold defines absolute signal level for adding of the BS into the diversity set. Delete threshold for deleting a BS from the diversity set. These threshold values are updated in the diversity set, and updating process is same for MDHO and FBSS.

6. IEEE 802.16j Frame structure.

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.[9],[10] These frames have two different structure, transparent mode frame structure and non transparent mode frame structure.

7. Mechanisms to update BS.

Updating of BS is done the two mechanisms, Hand over MAC management method and Fast BS selection mechanism. The former method uses five messages and later uses fast feedback channel for updating of BS.

8. OFDMA.

WIMAX systems use OFDM for multipath and non line of sight conditions. 802.16j supports scalable OFDMA which support terminal mobility and multiple accesses.

OFDMA parameters

1. FFT size= 128,512,1024,2048
2. Channel bandwidth(MHz)=1.25, 5,10,20
3. Subcarrier frequency (kHz)spacing:10.94
4. Useful symbol period:=91.4(micr0 sec)
5. Grand time=1/32, 1/16, 1/8, 1/4.

The 802.16j standard builds on the principles of

OFDM by adopting a Scalable OFDMA-based PHY layer

(SOFDMA). SOFDMA supports a wide range of operating bandwidths to flexibly address the need for various spectrum allocation and application requirements. When the operating bandwidth increases, the FFT size is also increased to maintain a fixed subcarrier frequency spacing of 10.94 kHz.

9. Tunneling and aggregation.

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, secondary management tunnel[7]

Two different MPDU construction methods namely encapsulation mode and burst mode used in relay system.

10. IEEE 802.16j MAC Layer.

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 seduling decisions in distributed scheduling[6],[7]. But in centralized scheduling the BS informs to RS about relay link channel characterizes.

The tunnel based scheme provides support for tunnels characterized by the unique CID, two specific end points and QoS parameters. The CID based scheme has no tunnels and does not support traffic aggregation; it only supports legacy management and transport connections.

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. His layer also defines network entry.

The MAC layer handover 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.

11. Simulation Model

The transparent mode network consists of three types of nodes : the transparent Mobile relay base station(TMR_BS), Transparent –Relay station(T_RS) and Trasparent –Mobile station(T-MS).. The T-RS simply forwards the incoming packet. The basic siumulation parameters that are assumed while performing the simulation is shown below. Here the frequencu used us 2300MHz, some of the other parameters are.

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

An IEEE 802.16j mobile WIMAX relay network is constructed using network topology of NCTUns as shown in the below figure. Here GUI tool nctunsclient is started to use the GUI platform for performing simulations. Here coordinator and dispatcher programs are used to do emulation studies. We have shown how to carry out transparent mode IEEE 802.16j network simulations. A single host is connected with two 802.16j base stations through three bridges and three links as shown in the figure. Each Link band width is set as 50 Mbps. The BS1 and MS form a subnet 1, BS2 form subnet 2. We

have simulated the transparent mode IEEE 802.16j network, here the channel mode parameters are set and the respective model is chosen . We have used TWO ray ground channel model, other empirical channel parameters can also be used to further examine the system.

Figure 4: Transparent mode simulation model

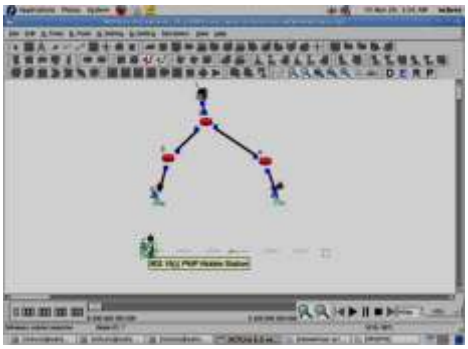

Figure 5: IEEE 802.16j Hard hand over simulation model

A single mobile station is connected to the base station 1(BS1) through wireless subnet. The speed of the MS is set as 20 m/sec[2], thus the MS will be moving along the horizontal path from point (x1y1) to point (x2,Y2) as shown in the figure. Here point (x1, Y1) is within the base coverage region of BS1, and point (x2.Y2) is in the base coverage region of BS2.

The 802.16j base station 1(BS1) is connected to the host and mobile station as shown above

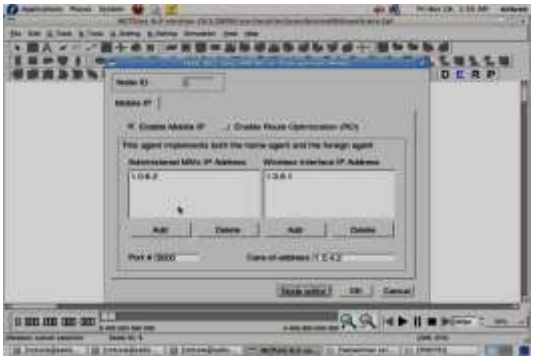

Figure 6: Base station 1 IP address

BS1 IP address for wired connection is set as 1.0.6.1 for wired connection to the link, and set as 1.0.7.1 for wireless connection to the MS. The node editor for 802.16j Base station is shown in the figure 8, it consists of various modules like ARP , FIFO, Mac8023 OFDMA interface and physical layer modules, the parameters of each module is set as shown above. The propagation channel mode can be set ttheoretical by specifying the parameters for path loss or fading model. In empirical channel model it defines 22 types of model. We have chosen empirical channel model.

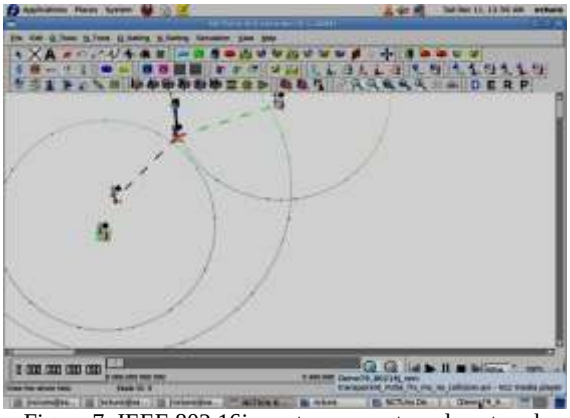

Figure 7: IEEE 802.16j non transparent mode network

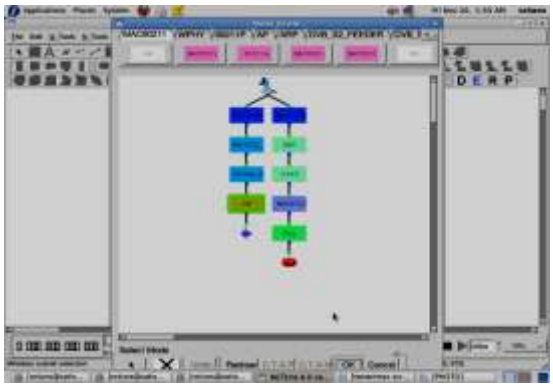

Figure 8: IEEE 802.16j BS node editor

Then the simulation is executed using as shown in below figure, all the related files of simulation is placed in the directory /usr/local/nctuns/bin/ as shown below, and all the log files are also placed in the same directory .

11. Conclusions and Future Works

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. We have shown how to conduct simulation using NCTUns an open source network simulator, which supports IEEE 802.16j multihop relay WIMAX networks, as no other simulator is available in the market to carry out simulations of IEEE 802.16j. NCTUns supports both transparent mode and non transparent mode simulation. No other simulator is available in the market to carry out IEEE 802.16j WIMAX simulations as OPNET and QUALNET supports only IEEE 802.16e WIMAX. This is the only simulator available to carry out simulations in IEEE 802.16j WIMAX networks

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