

## An Effectively Deploying of Relay Stations (Rs) In WIMAX Networks

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**Abstract**—The relay stations are widely used in major wireless technologies i.e. WiMAX (Worldwide Interoperability for Microwave Access) and LTE (Long term evolution) which provides cost efficient service to the operators and end subscribers. It is quite challenging to provide guaranteed Quality of Service (QoS) in WiMAX networks in cost efficient way. The primary aim is to reduce the total deployment cost in relay stations and use the existing spectral resources as effectively as possible to increase throughput for end users with high demanding applications i.e. voice and video. Keeping in mind the cost and the increasingly more demanding applications with growing large number of users, primary consideration of this paper is to increase throughput in a cost effective way. This paper shows the study of cell coverage and usage capacity by varying distances between a relay node and a base station in a WiMAX cell. For the Simulation purpose we have employed OPNET (Optimized Network Engineering Tool) MODELER 14.5. The performance of network is measured with respect to the QoS parameters like Throughput.

**Keywords**- QoS, OPNET, WiMAX, Relay Station

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### I. INTRODUCTION

In telecommunication field, Wireless communication has contributed a great revolution in the modern communication world. WIMAX allows the broadband service providers to offer fast and reliable wireless broadband connectivity at minimum cost. However, In WiMAX2 or IEEE 802.16m, several new features are added, such as increased VoIP capacity with less latency, handover and extension on mobility support to 350 km/h. To improve the throughput and capacity, single user and multi user MIMO, RS are used. Some other techniques are also employed to further improve WiMAX2 capabilities such as multiple types of antennas, modulation and coding schemes to increase throughput and cell coverage. Although these techniques are effective, there is still need of improvement. Relay Stations are very effective and largely used to enhance the cell capacity and coverage area. In WIMAX, limitations like coverage holes, throughput and capacity enhancement are pointed out with the use of RS. The RS is employed as a cost effective solution to provide services to users outside the coverage of BS. Relay nodes can enhance the coverage area and the capacity by using point to multi-point connections between users base stations. There are three types of relay nodes, Amplify and Forward (AF), Selective Decode and Forward (DCF), and Demodulation and forward (DMF). A DCF relay has the transmission performance better than other relay types of relay nodes under different radio channel condition. Three forms of physical modification to use relay are, transparent, non-transparent, and cooperative relays. Multi-hop relays can increase the coverage area well as usage capacity.

The main guidelines of WiMAX Architecture are as under

- It support packet switched structure. WiMAX technology involving IEEE 802.16 standard and its modification, appropriate for IETF and Ethernet.

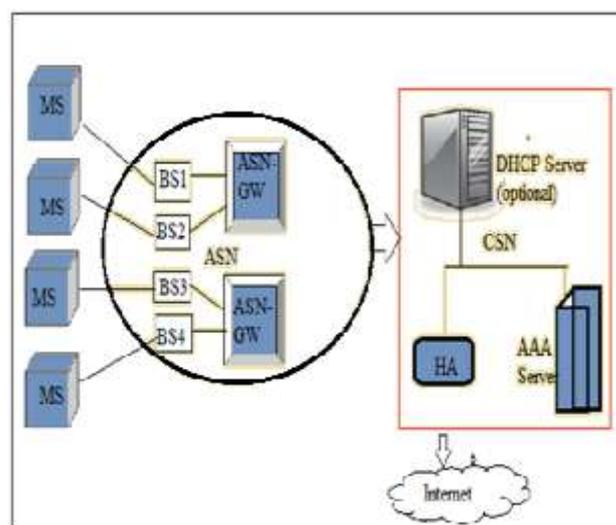


Figure 1. General Structure of WIMAX Architecture

- Provides flexibility to accommodate a broad range of deployment i.e. small to large scale. WiMAX also support rural, urban radio propagation. The usage of mesh topologies make it more flexible. It is the best coexistence of several models.
- Provides several services and applications i.e. Voice, multimedia, described dogmatic services as emergency and lawful interception. Offers a variety of functions i.e. mobile telephony, ASP, interface with multi internetworking, media gateway, delivery of IP broadcasting i.e. SMS, MMS, WAP over IP.
- Supports roaming and Internet working. It support wireless network i.e. 3GPP and 3GPP2. It support wired network as ADSL.
- Supports global roaming, consistent usage of AAA for digital certificates, billing purposes, USIM, subscriber module, and RUIIM.

## II. RELAY TRANSMISSION SCHEMES

There are many relay transmission schemes proposed to establish two-hop communication between an eNB and a UE unit by RS.

### A. Amplify and Forward

A relay node receives the signal from the eNB (or UE) at the initial phase. This amplifies the received signal and forwards it to the UE (or eNB) at the next phase. This Amplify and Forward (AF) scheme is very simple and has very less delay, but it also amplifies noise.

### B. Selective Decode and Forward

A relay node decodes the received signal from the eNB (UE) at the initial phase. If the decoded data is exact using cyclic redundancy check (CRC), then RS will do channel coding and forward the new signal to the UE (eNB) at the next phase. DCF scheme can effectively neglects error propagation by using RS, but the processing delay is quite large.

### C. Demodulation and Forward

A relay node demodulates the received signal from the eNB (UE) and perform a hard decision at the initial phase. This modulates and forwards the new signal to the UE (eNB) at the next phase. This Demodulation and Forward (DMF) scheme provide simple operation and minimum processing delay, but it cannot neglect error propagation due to the hard decisions done at the symbol level in phase one.

### D. Compress and Forward

In this technique RS compress the data before sending to EN or subscribers. It is considered that MS also have direct transmission from BS. This mechanism can perform better if there is direct transmission from BS to EN without utilizing RS.

### E. Adaptive Forwarding

This is extra technique employed in new wireless standard i.e. 3GPP LTE and IEEE802.16m. In this technique the processes of transmission can be changed based on the channel state information of both relay link and access link.

### F. Pairing Schemes For Selection of Relay

There are two kinds of pairing mechanisms which can be utilized in selection procedure of RS when more than two RS available in the same cell.

### G. Centralized Pairing Scheme

The BS gathers information from all the neighboring RS and user stations for pairing of RS with mobile stations because BS have full access to all the RS and subscriber stations within the cell and range of BS

### H. Distributed Pairing Scheme

In this technique, RS utilized two mechanisms for pairing with subscriber stations which are

- Contention based mechanism local channel information in this pairing.
- Technique BS has no fully access on all the subscriber stations because in this technique pairing scheme managed by non transparent RS for selection and communication.

## III. RELAYING IN WIMAX

IEEE 802.16m specified a non-transparent relay standard wherein the advanced relay station (ARS) has the features of different physical layer cell IDs in every sector it controls. The 16m Relay works well by using the “decode and forward” paradigm while an ARS controls its functioning with its own cell with a wireless backhaul connection to the access service network gateway (ASN-GW) by the advanced base station (ABS). For relaying WIMAX supports both time-division duplex (TDD) as well as frequency-division duplex (FDD) modes. Fig. 1.1 shows the interface architecture of a 16m relay [5]. R1 interface has radio link between base station and mobile stations. R6 and R8 reference points have the ABS ↔ ASN-GW and ABS ↔ ABS interfaces respectively. R3 reference point provides IP connectivity for the ASN-GW from the Connectivity Service Network (CSN). The Relay Station uses both ABS as well as AMS functions. The AMS part of the relay station provides an R1r interface with the ABS while the ABS part of the relay station has R8 and R6 logical connections with the ABS and ASN-GW respectively. The ARS-AMS PMP connectivity is done by the ABS part of the relay station through R1a interface. The relay station make use of R6 interface for the purpose of communication with the ASN-GW.

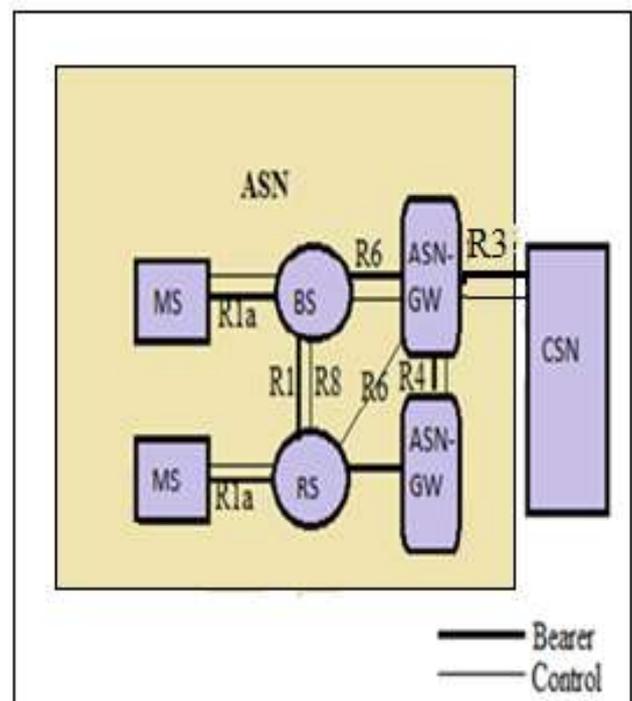


Figure 2. IEEE 802.16m Interface Architecture for Relay Station

As there is no physical link between the relay station and the ASN-GW, the relay uses the two hop ARS-ABS-ASN-GW physical link for communicating with the network. The access and relay R1 links are referenced using the notations R1a and R1r respectively. One of the key features of the IEEE 802.16m Relay architecture is that the relay station works for all the control mechanisms of all the associated mobile stations such as handoff, idle, security and sleep operations, etc.

#### IV. SIMULATION ENVIRONMENT

##### A. Simulation tool used:

OPNET modeler v14.5 is extensive and a very powerful simulation tool with large variety of possibilities. It is a strong tool, which provides an excellent graphical user interface (GUI) facility to subscriber. The complete heterogeneous networks with large number of relay nodes can be simulated using OPNET. High level of user interface is used in OPNET which is constructed from C and C++ source code blocks.

##### B. Simulation Setup:

The simulation work focuses on analyzing the performance of WIMAX using relay nodes. Therefore an Integrated approach is used to analyze the network performance under of WIMAX by employing relay nodes. This approach includes the following steps needed to generate the WiMAX network in OPNET Version 14.5

- generating the initial Topology
- generating WiMAX deployment scenario
- Adding Traffic to the WiMAX Network Model
- Configuring, BS, SS and WiMAX Parameters
- Simulating and examining results

In order to run the class and some other parameters required to be specified. To do the analysis of the WiMAX, the statics can be gathered globally and individually.

##### C. Proposed Simulation Step For Wimax

1. Start Opnet Modeler by double-clicking on the Opnet Modeler 14.5 icon.
2. Select File > New.
3. A new window appears. Select Project from the menu and click OK.
4. Another window appears and asks for project name and scenario name. Enter project name as WiMAX\_OPNET and scenario name as Static. Uncheck the check box to not use the start up wizard and click OK.
5. Select Topology > Deploy Wireless Network. This launches the Wireless Network Deployment Wizard.
6. Click Continue and next until the Technology tab is reached. Select the technology as WiMAX and set the Subscriber node transmission power as 0.10 W and Base Station transmission power as 10 W. Click next and move to the next Tab of Topology.
7. In the topology tab enter the cell radius to be 30 km and from the drop down menu select the node placement to be circular. This is because circular nodes are located equidistantly from the base stations.
8. On clicking next the second tab of topology appears. Select the Subscriber Station as wimax\_ss\_wkstn\_adv from the dropdown list. This node allows SIP configuration .Click Next.
9. The node mobility tab appears. Since we are deploying a static network click on the row and click on delete row. Click Next.

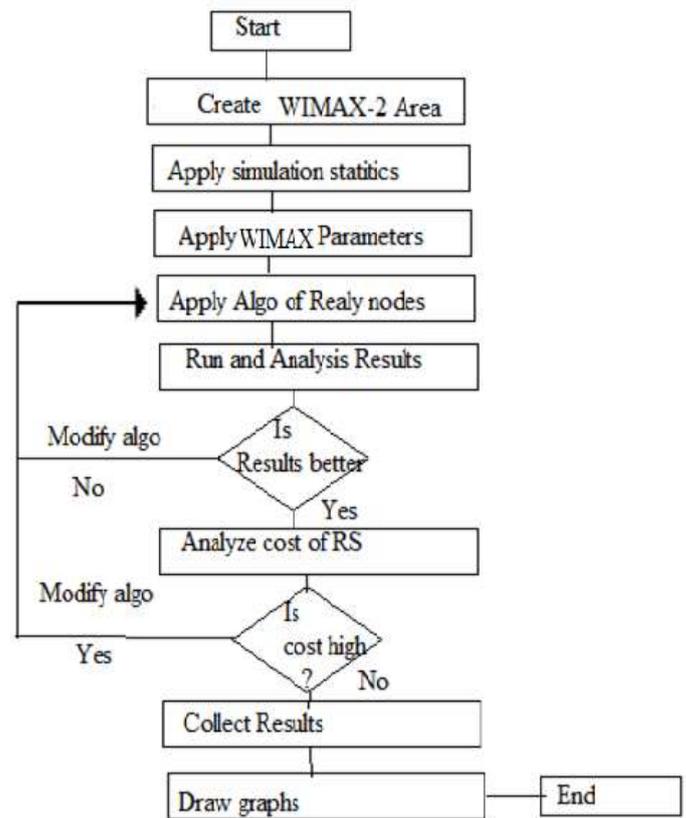


Figure 3. Flowchart of WIMAX with relay nodes.

10. The configuration summary appears as follows.
11. Click Finish. The deployed scenario consists of 7 celled WiMAX network with the 7 BSs connected to a backbone.
12. To select Free Space as the pathloss model, Right-click on any of the mobile nodes, and then choose Select Similar Nodes. Right-click on any node again, and select Edit Attributes on any selected node in the scenario space.
13. Check Apply changes to selected objects.
14. Expand WiMAX Parameters/SS Parameters and set Path loss Parameters to Free Space.
15. Click OK needed to apply changes to all selected nodes.
16. Click Yes to dismiss the compound attribute warning. You should see the message “35 objects changed” in the status bar.
17. Click on the palette icon , scroll up to the ppp\_server and drag and drop it on the work space. Similarly, drag an ip32\_cloud and drop it on the workspace. Rename the ppp\_server as the Voice\_Server.
18. Now scroll up to the Links\_PPP and drag a PPP\_SONET\_OC1 link to connect the ppp\_server and the IP cloud. Similarly select a PPP\_SONET\_OC\_12 link and connect the IP cloud to the node called backbone. The scenario now looks as follows. Right-click in the project Work space after connecting the link to deactivate the handler

19. Close the Object Palette.
20. From the object palette bring a Application Config and a Profile Config node to configure the application.
21. Right click on the Application Config and select Edit Attributes (advanced).
22. Under Application Definition add a row.
23. Enter Application Name as voice.
24. Expand the Description menu select the value of voice menu to edit.
25. Select the encoding scheme.
26. The voice codecs with (silence) implies silence suppression. By default Opnet takes 65% of the communication period as silence and 35% as the talk spurt.
27. The Profile Config node is configured as shown in the following figure.28. Now with the application and profile configured, we need to deploy the application.
29. Select Protocols > Applications > Deploy Defined Applications.
30. On the right-hand pane, expand Profile:"voice\_profile" > Source and click on Source. On the left-hand pane, while pressing Ctrl, select all nodes of Cell 2. Once all of these nodes are selected, click on the assignment arrow (>>) between the two panes.
31. similarly, on the right-hand pane, expand Application:"voice" > Tier:" Voice Destination" and click on "Voice Destination." On the left-hand pane, select all nodes of cell 3, and click on the assignment arrow between the two panes. Click OK.
32. The deployed voice application will be given strong QoS guarantees in WiMAX network. For this reason, we will choose a service class using ertPS scheduling.
33. Go to View/Show Network Browser; in the network browser pane, right click to Edit Attributes on the WiMAX\_Config node. This node contains the global parameters of the WiMAX network and is deployed automatically when a WiMAX network is deployed.  
  
Edit the MAC Service Class Definitions attribute by double-clicking in the corresponding value field.
34. In the first row, modify the Gold service class by setting:
  - Scheduling Type to ertPS
  - Maximum Sustained Traffic Rate (bps) to 96000
  - Minimum Reserved Traffic Rate (bps) to 96000
  - Maximum Latency(milliseconds) to 10
35. Click OK once to accept changes.
36. On the WiMAX\_Config node, set the Efficiency Mode to Physical Layer Enabled.
37. Then click OK to accept the changes.
38. Right-click on any Mobile node in the network browser pane. The wireless deployment wizard always deploys the WiMAX\_Config node in the top subnet, which explains its position outside the current subnet.
39. Deploy service flows and classifiers on the WiMAX mobile nodes.
40. Opnet provides a rich set of statistics to examine traffic performance from the application as well as WiMAX perspective. In this scenario, we collect global voice application and node level WiMAX connection statistics.
41. Click on the Configure/Run Discrete Event Simulation button in the Project Editor. The Configure/Run DES dialog box appears. Notice the simulation is configured to run for 600 seconds. Click Run to launch the simulation. When the execution completes, click Close.
42. To view the results Select DES > Results > View Results.
43. To setup VoIP using Session Initiation Protocol (SIP), right click on the voice server, expand the Edit Attributes (advanced) > SIP > SIP Proxy Server Parameters and set Proxy Service to Enabled and then Enter the Server Address as Proxy and Click OK.
44. Now select the mobile nodes among which the application is deployed. Expand Edit Attributes > SIP > SIP UAC Parameters and set SIP UAC Service to Enabled. Expand Proxy Server Specification and Select the Proxy Server Name as Proxy. This is the name assigned to the Proxy Server set in the Voice Server. Apply changes to the selected nodes and Click OK.

## V. RESULTS AND ANALYSIS

There are two scenarios and deployment possibilities with RS to manage the total network capabilities as well as user satisfaction. The first scenario shows throughput without relay nodes. In the second scenario throughput parameters considered to evaluate the performance of WIMAX using RS with various deployment environments, it depends on cost effective solution for RS deployment where total cost can be decreased and keep QoS standard.

### A. Throughput Analysis of normal scenario

The throughput evaluated below is for WIMAX technology without RS deployment scenarios which is as follows

#### 1) Throughput without relay nodes

Throughput can be defined as the ratio of the total amount of data reaches a destination from the source. The time it taken by the destination to receive the last message is called as throughput. It can be expressed as bytes or bits per seconds (byte/sec or bit/sec). There are the factors that affect the throughput such as; changes in topology, availability of limited bandwidth, unreliable communication between nodes and limited energy. A high throughput is absolute and required choice in every network. The default and improved average values of delay for different nodes are

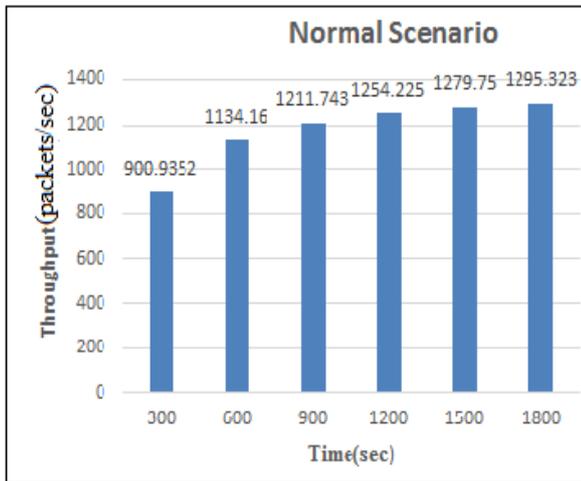


Figure 4. Throughput of normal Scenario

Shown in the Table 1, In figure 4, the graph represents the throughput in bits per seconds. The x-axis denotes the simulation time in minutes and the y-axis denotes throughput in bits per seconds to our approach.

**B. Throughput Analysis of improved scenario**

The throughput evaluated below is based on various RS deployment scenarios which are as follows:

**1) Throughput with relay nodes**

In figure 5, the graph represents the throughput in bits per seconds. The x-axis denotes the simulation time in minutes and the y-axis denotes throughput in bits per seconds.

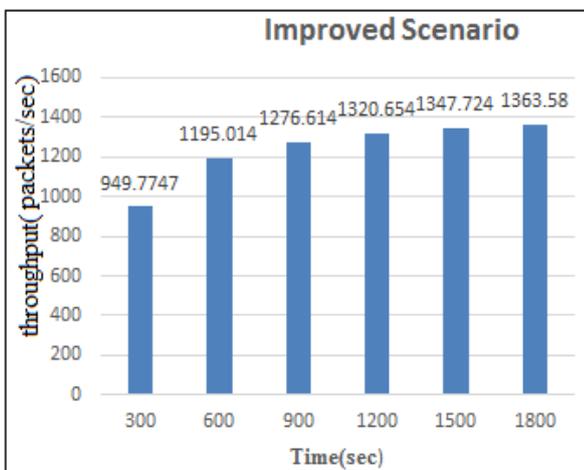


Figure 5. Throughput of improved Scenario

In first scenario of 100 nodes of our experimentation, packets travels are shown as throughput with peak value of approx. 82 bits per seconds. In second scenario packets transfer rate increases too high due to our approach. In third scenario of 150 nodes of our experimentation, packets travels are shown as throughput with peak value of approx. 55 bits per seconds at pause time 100 and active route time 1 sec, and hello interval (1,1,1). This figure shows the throughput at different intervals for example at 300 sec time the value of throughput is 949.7747 and at 600 sec the value is 1195.014. The simulation time is taken upto 1800 sec which shows the throughput value at 1800 sec is 1363.58. This graph shows all

values are higher than the values of throughput in figure of normal scenario.

**C. Comparison of normal and improved throughput**

The figure 6 shows the comparison of normal and improved scenario of LTE and WIMAX without or with relay nodes respectively. Graph shows that the values of throughput is higher in improved scenario.

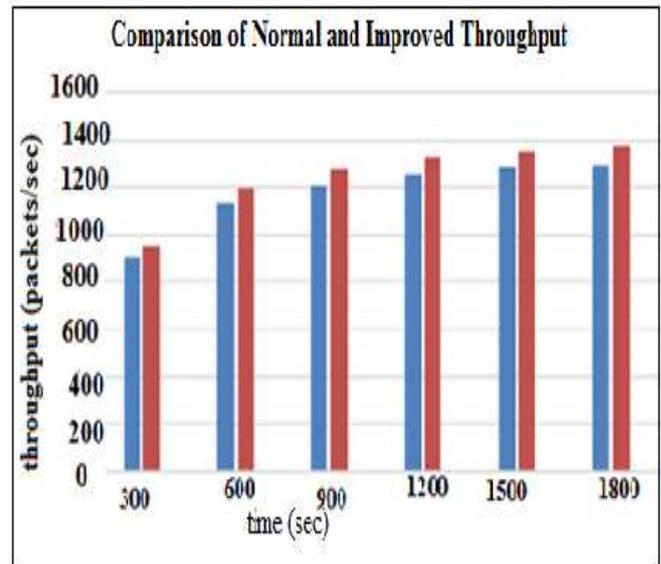


Figure 6. Throughput of normal Scenario

Table 1 shows the comparison of throughput values obtained for normal and improved scenario.

Table 1. Throughput values obtained for normal and improved scenario

Time (sec)	Throughput of Normal Scenario	Throughput of Improved Scenario
300	900.9352	949.7747
600	1134.16	1195.014
900	1211.743	1276.614
1200	1254.225	1320.654
1500	1279.75	1347.724
1800	1295.323	1363.58

**VI. CONCLUSION**

IEEE802.16m or WiMAX2 is the 4th generation mobile and internet communication technology which provides better throughput and smaller delay for VoIP users with large expectation on speed. This paper presents architecture of WIMAX and various relaying techniques. In this paper we have analysed throughput for efficient deployment of relay stations in IEEE802.16m for cost effective performance. In our simulation results, we have presented results for WIMAX without and with using relay stations and compared values of throughput.

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