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Performance Analysis of Transparent Relays in 802.16j MMR Network by Implementing Relay Concept using C++ in QualNet Simulator

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Abstract: Wireless multi-hop relay systems play an important role in upcoming broadband wireless networks like WiMAX. Such relay can be used either to increase a cell's capacity or expand a cell's coverage, all at much lower cost compared to the alternative solution of using more Base Stations (BSs). The IEEE 802.16j is an amendment to the IEEE 802.16e standard, which introduces the multi-hop relay concept into existing point to point mode of communication. IEEE 802.16j mobile multi-hop relay (MMR) standard introduces two types of relays, transparent and non-transparent relays. This work has focused on studying the impact of having transparent relay stations on overall system throughput in an MMR WiMAX network and studying the impact of a number of transparent relay stations on overall system throughput in an MMR WiMAX network by implementing a transparent relay station concept in QualNet simulator. Simulation studies have been carried out using the QualNet simulator by considering the throughput as performances metric for constant bit rate (CBR) and variable bit rate (VBR) traffic individually. From the simulation results it is observed that introducing transparent relay stations in the MMR WiMAX network enhance the performance of the network. Furthermore, it was found the performance enhancement exclusively depends on its deployment. Much further work is necessary to realize useful gains from these systems.

Keywords: 802.16j MMR, Transparent Relay, Performance, QualNet.

I. INTRODUCTION

IEEE 802.16 - based technologies are presently the subject of much interest within the society. There are several activities connecting to this technology in the business world, with operators rolling out systems which are compliant with current versions of the standards. Nevertheless, the number of subscribers is still low and there will be much growth in upcoming years as the technology evolves. While the business world is addressing one set of problems, whereas the research community is addressing on the longer term issues. Several activities within the research community to resolve issues with the current technologies, making them more efficient and/or easier to work with have been done. One 802.16 - related issue which is the subject of much attention currently is how to realise 802.16 - based relay network solutions which are companionable with old equipment. Relay network architectures can provide significant advantages over classical cellular architectures (Fig. 1). An important motivation for such systems is that they can be leveraged to realize a much lower cost network rollout than a BS-only solution, particularly in the beginning stages of network deployments. While this is a very important, compelling use case, there are others which are also attractive. They can be used to provide a solution for holes in coverage area or shadows of buildings where coverage is reduced. The 802.16 standardization activity is expending significant energy on issues concerned to relay networks.

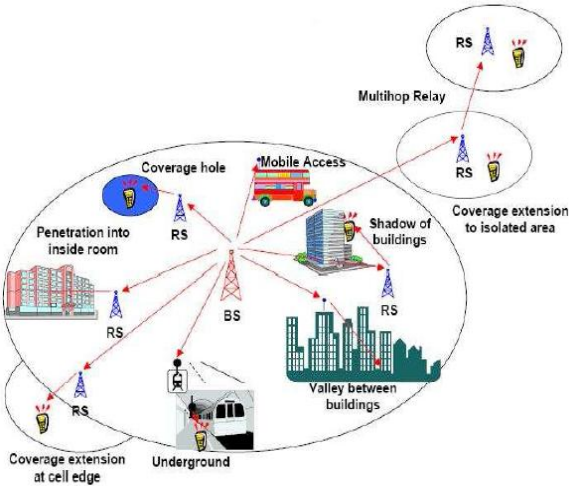

Fig 1: 802.16j Concept

The objective of this work, then, is to answer some questions regarding the performance gains that can be obtained through the use of relay architectures on the MMR WiMAX network. The study key aspect is on studying the impact of having transparent relay stations on overall system throughput in an MMR WiMAX network and studying the impact of a number of transparent relay stations on overall system throughput in an MMR WiMAX network by implementing a transparent relay station concept in QualNet simulator. Simulation studies have been carried out using the QualNet simulator by

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considering the throughput as performances metric for constant bit rate (CBR) and variable bit rate (VBR) traffic individually.

II. RELATED WORK

Currently, a small amount of research work has been carried out, especially on 802.16j MMR WiMAX system and moreover as the multi-hop relay networks have emerged as a new cutting edge technology in wireless access networks, many researchers are interested in this field. Authors in [1] have explained the IEEE 802.16j standard in detail, it can be considered as a tutorial for 16j standard. Paper [2] explains and analyses decentrally controlled non transparent relay. Authors in [3] have worked on the different time frame analysis for non-transparent relays. In [4] the IEEE 802.16j MMR networks concept to improve the QoS of WiMAX cell edge user is been discussed. An effort is presented in [5] to compare the efficiency of the multi-frame structure with the single frame structure. In [6] and [7] the authors study frequency reuse and relay planning schemes accordingly, which can lead to maximization of the system throughput. In [8] the authors study the utilization of multiple antenna systems to allocate resources in a relay network versus the omni directional antenna system. The study concludes that the directional antenna system significantly improves throughput and at the same time eliminates interference among Relay Stations (RSs) in the system. In [9] performance of the single frame and multi-frame system in multi-hop relay environments is analysed.

III. IMPLEMENTATION DETAILS OF T-RS IN QUALNET SIMULATOR

In this work the source code of QualNet simulator has been modified in order to support transparent relay station concept in QualNet. The QualNet simulator has the advanced wireless library for Mobile WiMAX (IEEE 802.16e) and a contributed model for IEEE 802.16j standard. In contributed model, basic 802.16j MAC, and MR-BS are implemented. The contributed model does not support Transparent Relay Stations (T-RS). Hence, in this work the QualNet IEEE 802.16j source code is modified in order to include T-RS. In the implemented work, the source code of MR-BS is modified to trigger the path selection for the Subscriber Stations (SSs) which are connected to the mobile T-RS.

IV. SIMULATION AND RESULTS

This work has focused on the following two aspects:

- Impact of having transparent relay stations on overall System throughput in an MMR WiMAX network using QualNet simulator.
- Impact of Number of transparent relay stations on overall System throughput in an MMR WiMAX network using QualNet simulator.

In order to evaluate the above two, two WiMAX scenarios have been designed in the simulation area of 1500 m X 1500 m, consisting of 20 nodes. Furthermore, the performance of the overall system has been studied by considering constant bit rate (CBR) and variable bit rate (VBR) traffic individually.

First scenario consists of 19 Subscriber Stations being served by a single MR-BS without transparent relay stations as shown in Fig. 2

V. CONCLUSION

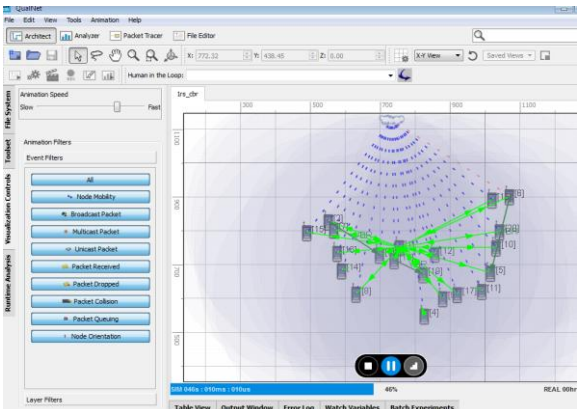

Fig2: First scenario Without Transparent Relay Stations

A second scenario consists of 19 Subscriber Stations being served by a single MR-BS with five transparent relay stations namely node 21, node 22, node 23, node 24 and node 25 as shown in Fig. 3.

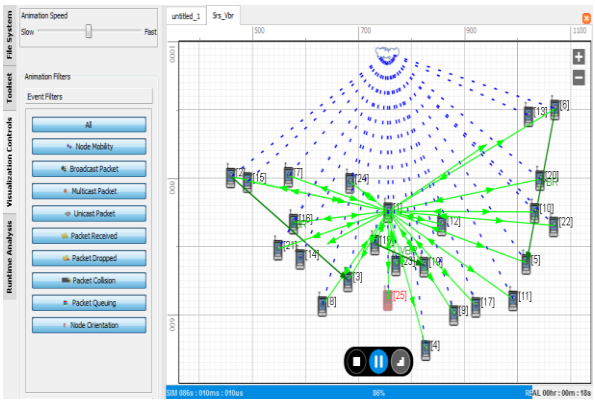

Fig 3:Second scenario With Transparent Relay Stations

For CBR Traffic:

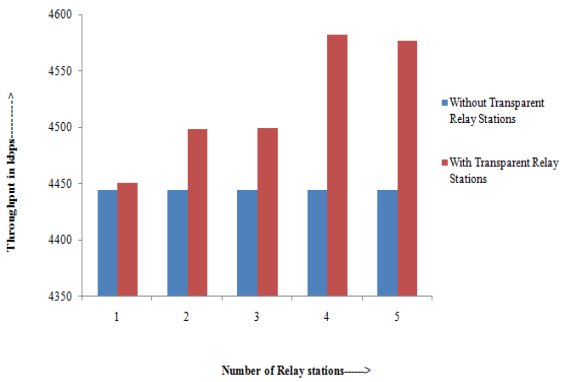

Fig 4: Impact of having Transparent Relay Stations on overall system throughput for CBR traffic

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Here, in order to study the impact of a number of transparent relay stations on overall system throughput, the number of transparent relay stations has been increased from one to five by adding one transparent relay station in each case, so that in the fifth iteration the scenario will have five transparent relay stations with the 20 nodes. In each case, we got different results based on the number of transparent relay stations as shown in Fig. 4.

As shown in Fig. 4, we can observe that placing at least one transparent relay station in an MMR WiMAX network increases the overall system throughput when compared with the throughput of the overall system without placing the transparent relay stations in an MMR WiMAX network for CBR traffic.

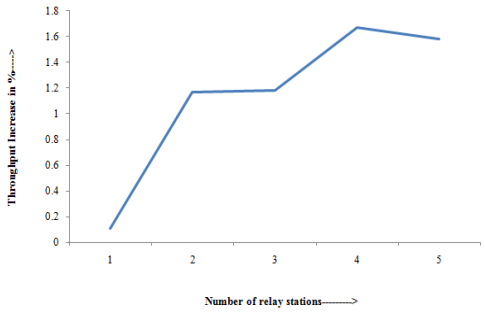

Fig 5: Throughput Increase in % on overall System throughput for CBR traffic

As shown in Fig. 5, it can be seen that for CBR traffic, the system throughput increase stabilizes when four transparent relays are deployed. Thus, the MR-BS cell is properly covered by this amount of relays and additional relays does not have a significant impact on the system capacity.

For VBR Traffic:

As shown in Fig. 6, we can observe that placing at least one transparent relay station in an MMR WiMAX network increases the overall system throughput when compared with the throughput of the overall system without placing the transparent relay stations in an MMR WiMAX network for VBR traffic.

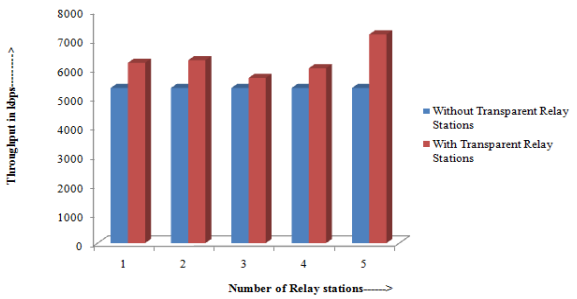

Fig 6: Impact of having Transparent Relay Stations on overall System throughput for VBR traffic

As shown in Fig. 7, it can be seen that for VBR traffic, the system throughput increases when five transparent relays are deployed. Thus, the MR-BS cell is properly covered by this amount of relays and additional relays does not have a significant impact on the system capacity.

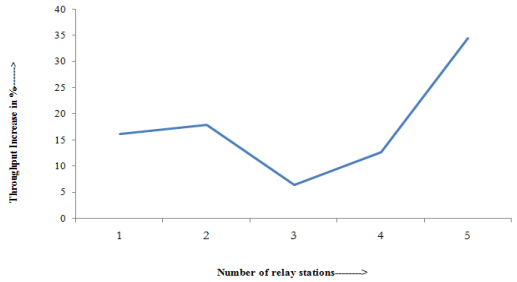

Fig 7: Throughput Increase in % on overall System throughput for VBR traffic

V. CONCLUSION

In this paper enhancement of the system throughput that can be obtained by the deployment of transparent relays in a WiMAX network is investigated. The paper is based on the latest specifications of the IEEE 802.16j MMR standard and more especially in the transparent mode for throughput enhancement purposes. The simulation results show that placing at least one transparent relay station in an MMR WiMAX network increases the overall system throughput when compared with the throughput of the overall system without placing the transparent relay stations in an MMR WiMAX network for CBR trafiic as well as for VBR traffic. Furthermore, it was found the performance enhancement exclusively depends on deployment of transparent relay stations in an MMR WiMAX network. Much further work is necessary to realize useful gains from these systems.

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