International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 8 Issue 2, February -2019, Impact Factor: 4.059

Performance Analysis of Handover Mechanism of Mobile Multi-Hop Relay MMR Network

Boniface Ushaka Adie[1], Mohammed A. Ben-Mubarak[2]

[1]Networking Department, Faculty of Creative Media and Innovative Technology, Infrastructure University Kuala Lumpur, Malaysia
[2]Department of Computer Science and Information, Faculty of Science and Art, Jouf University, Saudi Arabia

ABSTRACT

Relays are very important in Mobile Multi-Hop Relay MMR Network such as WiMAX based on IEEE 802.16j standard as they help in increasing the capacity of the network in the case of transparent relays or help in network coverage extension for non-transparent relays. For the relay system to be effective, the mobile station or mobile node has to be mobile, moving from one relay to another or from one base station to another. Handover occurs when the MS moves from one RS to another RS or from the SBS to the TBS. This movement is very inevitable in the MMR system due to the mobility of the MS. We have seen and determined through simulated results how the use of RS increases the capacity of the network in terms of throughput, it became however important for us to determine the effect of the handover process on the network throughput, packet drop and packet delay to be able to determine the effectiveness of the relay system as it affects our QoS requirements. This was done by a network simulation process carried out with NCTUns to evaluate the Mobile Multi-Hop Relay MMR Network in the transparent mode. It was discovered upon simulation that during the time of handover, the throughput of the MMR system drops drastically to up to 40% for relays belonging to the same BS and to almost 0% when more than one BSs are involved as there is a total cut off when the MS moves from the RS of the SBS to the RS of the TBS. Packet delay is between the ranges of 1 to 2 seconds for handover occurring within relays of the same BS but more delay is recorded when more than one BS is involved. Packet drop could not be recorded because the relays are in transparent mode to the BSs and a connection-oriented protocol is used.

Keywords: Mobile Multi-Hop Relay, MMR, IEEE802.16j, WiMAX, Handover, Mobility Management, Transparent Mode.

HOW TO CITE THIS ARTICLE

Boniface Ushaka Adie1, Mohammed A. Ben-Mubarak, "Performance Analysis of Handover Mechanism of Mobile Multi-Hop Relay MMR Network", International Journal of Enhanced Research in Science, Technology & Engineering, ISSN: 2319-7463, Vol. 8 Issue 2, February -2019.

1. INTRODUCTION

WiMAX is a broadband technology that can support today's multimedia services such as the triply play services of voice, data and video [1]. It is a broadband wireless technology that is used to provide last mile solutions used for supporting multimedia services which has various qualities of service requirements. It provides these last mile solutions at low cost which can support up to 75Mbps data rate (single channel) and cover up to 30 miles (last mile). This is a huge advantage when compared to DSL which covers just 3miles and WiFi which can only cover up to 30 meters [2-3]. The IEEE 802.16e system is also called the mobile WiMAX, which in addition to its working group the WiMAX Forum was formed by group of companies in the industry [3-5].

To be able to achieve this mobility, handover or handoff plays a very important and critical role in the WiMAX system. Handover can be defined as a process when MS (Mobile Station) migrates or moves from its previous connected BS (Base

Station) to another BS for mobility purposes. This handover is very important to maintain uninterrupted transmission and prevent signal straining and distortion. The process helps to maintain the communication connection as MS moves from one location to another between the coverage areas of two BS. It handles MS for switching from the current or serving base station (SBS) to the target base station (TBS) [6-7].

Instead of using many BSs for coverage and mobility, relays can be used as they are cheaper to implement due to low cost, they can be used to provide coverage for places where network coverage is low and they can be used to increase the capacity and range of a cell [8]. With the advancement in technology and the need for more multimedia services and applications, IEEE 802.16j standard was introduced to help with the demand of capacity and coverage extension without the need of additional backhaul or BS deployment or installation [9]. The RS (relay stations) are in most cases build, owned and controlled by the service provider and it is not directly connected to wire infrastructure, but has the ability to provide multi-hop communication. There are also particularly necessary for coverage holes or shadow of buildings where network coverage is poor in which case they can be used for capacity increase and increase in the range of a cell [10-11].

The RSs may be classified into two broad areas, the first which has to do with the position of the RS has the fixed, nomadic and mobile relays, while the second which deals with the utilization of the RS has the transparent and non-transparent relay classifications. Fixed and nomadic relays are by their operation assumed to be fixed, while mobile relays are used for moving object like buses or trains [10]. The transparent relays are designed to primarily increase or enhance system capacity (throughput) within the coverage area of the BS, while the non-transparent relays are designed to provide coverage extension outside the primary coverage area of the BS and of course to some lesser extend provide system throughput as well [12]. It is therefore very important that we study the performance of the RSs in terms of packet delay, packet loss and throughput as they hand over SSs or MSs among themselves.

Studies have gone into the IEEE 802.16j, some to determine the position of the relays, some to determine the performance of transparent and non-transparent relays, others dealt with the throughput or the design of the relays; but not much is really known about the handover performance of the MMR system especially using packet drop, delay and throughput as network performance parameters at different MS velocities.

Researchers in [8] evaluated the performance of RSs in terms of capacity gains in throughput using the QualNet simulator and discovered that there is a capacity increase based on the position of the RSs and the signaling overhead increased when compared to the 802.16 systems. Other parameter could also be considered not limited to gain in throughput and effect on signaling overhead. In [13], a different analysis was carried out, as researcher tried to find out the effect of Relay Station usage in the improvement of per user applications. The throughput of UGS (Unsolicited Grant Service, e.g. VOIP) and Real-time polling service (rtps, e.g. streaming audio/video) was considered using the OPNET Modeler 16.0 simulator.

It was discovered that throughput increased with the deployment of the RSs for SS which is located within the coverage area and NLOS of the BS. The throughput of the Subscribe Station (SS) located at the edge of the cells still deteriorates. Other types of applications and other parameters apart from throughput could also be used. The research in [14] shows that delay is influenced by traffic load and traffic correlation based on a simulation carried out in MATLAB/SIMULNK simulator. The end-to-end delay matrix was considered, although throughput, packet lost and other parameters might as well be considered. In [15] researchers investigated the performance of Transparent RSs and how it improves the network throughput and the user throughput using the OPNET Modeler simulator.

Results showed that transparent relays improve the SS throughput that is far from the BS and also extended the coverage area of the BS. Researchers in [16] tried to find the effects of throughput and packet transferred during the hard handover of the transparent mode MMR using NCTUns and results showed a decrease in downlink throughput as MS moves out of the coverage area of BS1 too BS2. Handover time discovered is 2 seconds, during which no packet is transferred. Other parameters apart from throughput and packet behavior could also be considered. In [17] analysis of the handover behavior in terms of throughput, handover time and relay placement of transparent relays in WiMAX using NCTUns was carried out and results showed an increase by at least 14.39% in throughput for transparent relays. It was also discovered that efficient relay placements helps in the reduction of packet lost and latency due to handover. The effects of packet loss and packet delay on the throughput and overall performance of the handover process could also be considered.

This paper aims to simulate the handover mechanism in Multi-hop relay (MMR)system using NCTUns6.0, in order to evaluate the effect of hard handover process over packet drop, packet delay and throughput of the MMR system.

The rest of this paper is organized as follows: section 2 introduces the IEEE 802.16j Mobile Multi-hop Relay (MMR). Section 3 describes the simulation design. Results have been discussed on Section 4 and finally, the paper is summarized in last section.

2. IEEE 802.16J MOBILE MULTI-HOP RELAY (MMR)

The 802.16j standard which is also known as the Relay technology or the MMR was developed to solve some of the issues with the 802.16e technology; chief among them was the need for increase in system capacity, signal strength, throughput and coverage extension especially for shadow areas and this is achieved without compromising the backward compatibility with the legacy standards or MSs and incurring high infrastructure deployment cost [18-21].

The relaying model is a network consisting of a MMR-BS, a RS and a MS with the radio links between these entities called Access Links for connections between the MS and RS and Relay Links for connection between the RS and the BS [22]. This is therefore a kind of multi-hop communication where we have the RS transfer or forward information from the MS or RMS (Relay Mobile Stations) to the BS which is connected to the core network or backhaul using wired infrastructure [23]. According to [24], the MMR is seen as an improvement of the PMP mode where relay stations are deployed in a standard PMP 802.16 cell but with the overall enhancements and benefits to both the MS and the SS as shown in Figure 1.

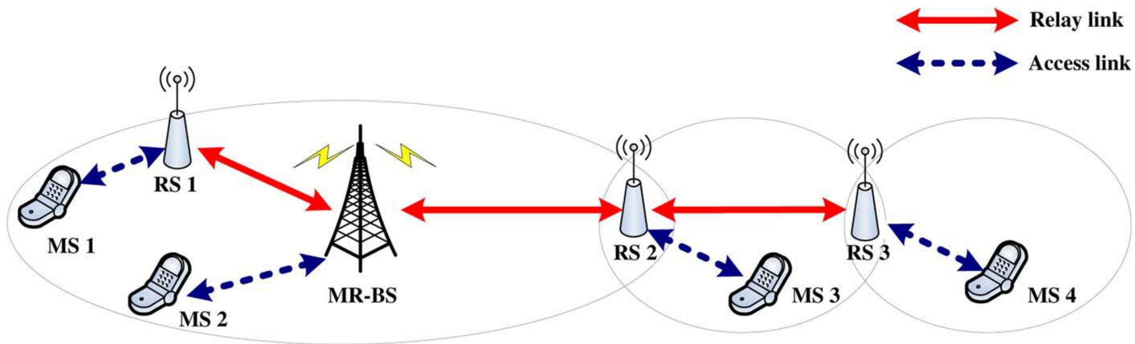

Figure 1: Simple MMR topology (source: [20]).

The benefits of using a relay network are numerous. First it can be used to bring internet access to people in remote areas where the wired infrastructure cannot get to [25]. It can be used to provide high broadband speed at low cost [26]. It can also be used in the initial stages of network roll-out to provide network coverage and increase in capacity when the network is fully utilized [27-28]. The relays according to [29] are more eco-friendly as they produce low power due to the fact that they are may only cover a region of diameter between 200 – 500m, hence requiring less power to run as compared to the BS that can cover kilometers and require more power to run them. Based on the 802.16j standard, there are two different Relay modes which are Transparent and Non-Transparent Modes. However this paper will be focused on the Transparent Mode only

2.1 Transparent Relay Mode

In this mode, there is no forwarding of framing information by the RSs. This means they do not increase the coverage area but can be used to enhance the network capacity within the BS coverage as shown in Figure 2. This relay is therefore of low complexity compared to the non-transparent relay and operates in a centralized scheduling mode for up to two hops [27, 30].

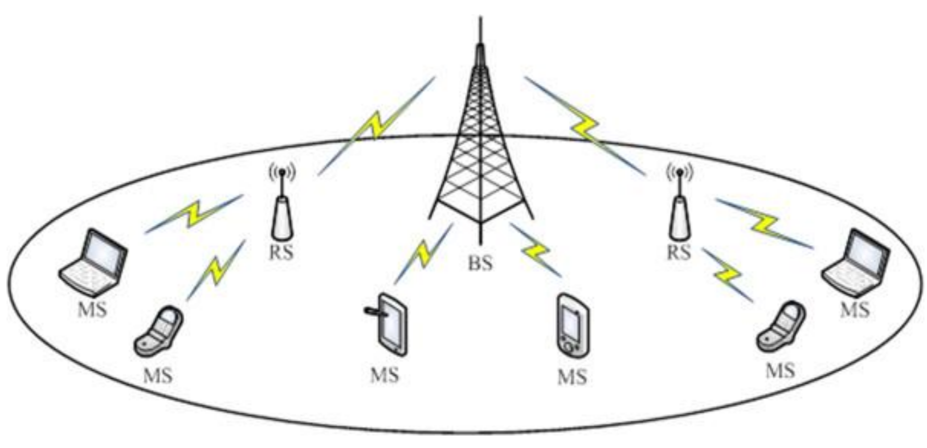

Figure 2: Transparent Relay mode network

2.2 Non-Transparent Relay Mode

This is the opposite of the transparent mode relay, as the RSs generate their own framing or forward those generated by the BSs. They operate in topologies that are larger than just two hops and either in centralized or distributed scheduling mode, hence leading to more complexity compared to the transparent mode as shown in Figure 3. This relay is therefore used mostly for increase in network coverage [27, 30].

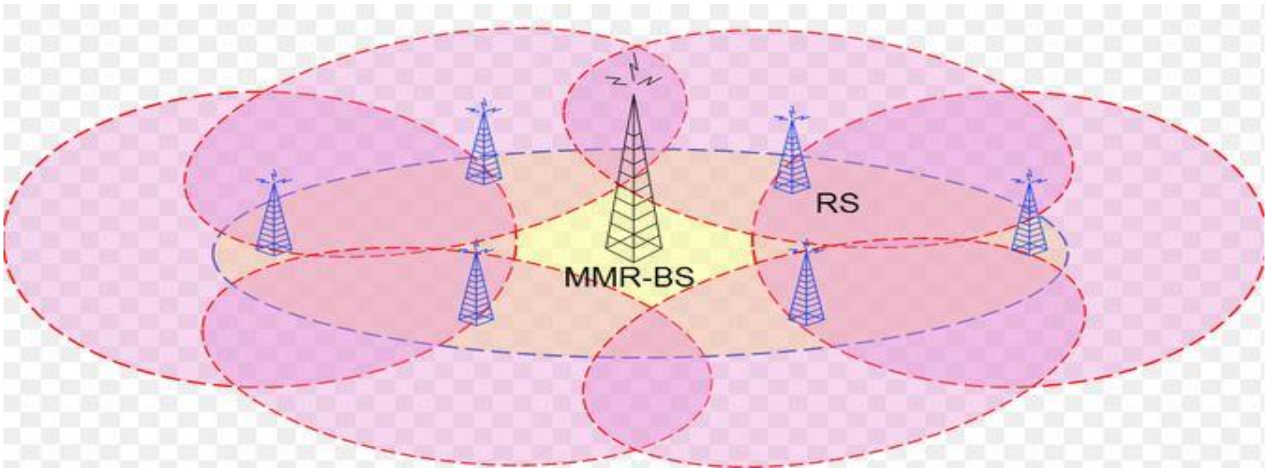

Figure 3: Non-Transparent Relay mode network

3. SIMULATION DESIGN

There are two simulation scenarios to be used here, the first will be a simple MMR network topology with a BS, two RSs and a MS, while the other will have a router connecting two different BSs and RSs and connecting to them with a single MS. The diagrams below show the different simulation scenarios. Simulation parameters are listed in Table 1.

Table 1: Simulation Parameters

Parameter	Value
Frequency	2.3 GHz
Propagation Model	COST_231_Hata
MS Velocity	10, 20, 50 m/s
Traffic Type	TCP
BS Transmission Power	43 dB
RS Transmission Power	43 dB
MS Transmission Power	35 dB
Modulation/Multiplexing	OFDMA
BS Antenna Height	30 m
RS Antenna Height	20 m
MS Antenna Height	1.5 m

3.1 Scenario with one BS, two RSs and one MS

This is a very simple transparent mode scenario, with a sending node, a single BS, two RSs and a MS. Figure 4 shows the simple network diagram or topology of this scenario.

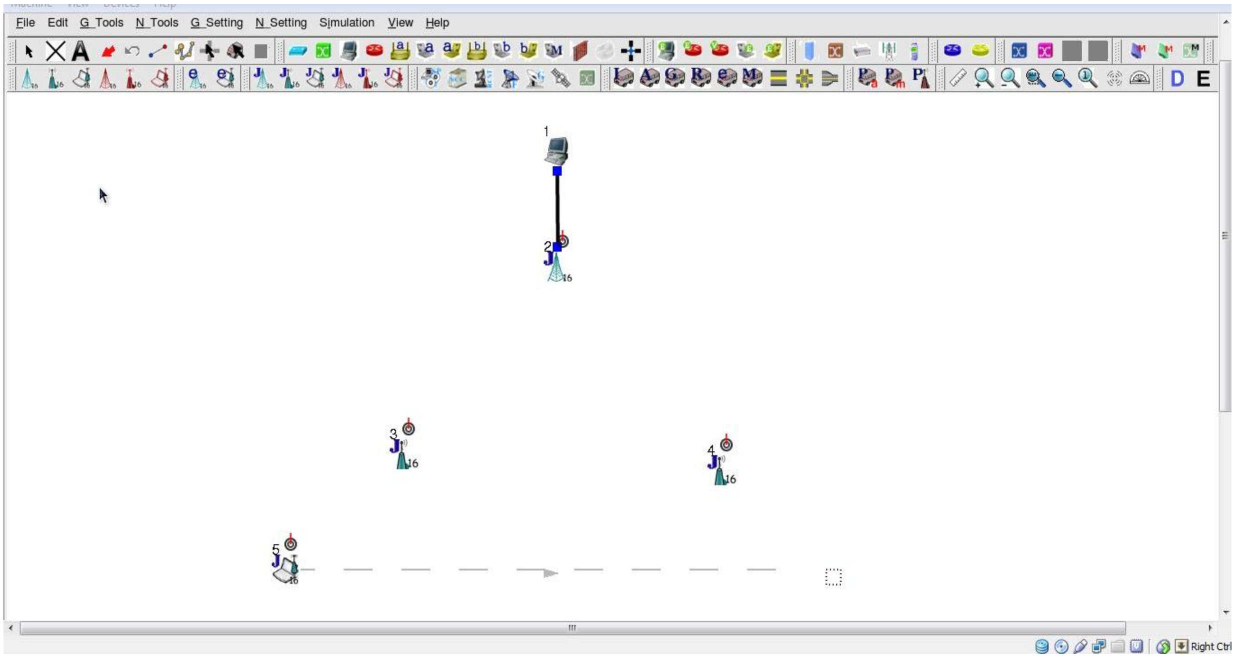

Figure 4: Topology of the first scenario with one BS, two RSs and one MS

3.2 Simulation Scenario with three Routers, two BSs, two RSs and one MS

This is a rather complex transparent mode scenario, with a sending node, 3 routers connecting the BSs, two BSs, two RSs and a MS. Figure 5 shows the simple network diagram or topology of this scenario.

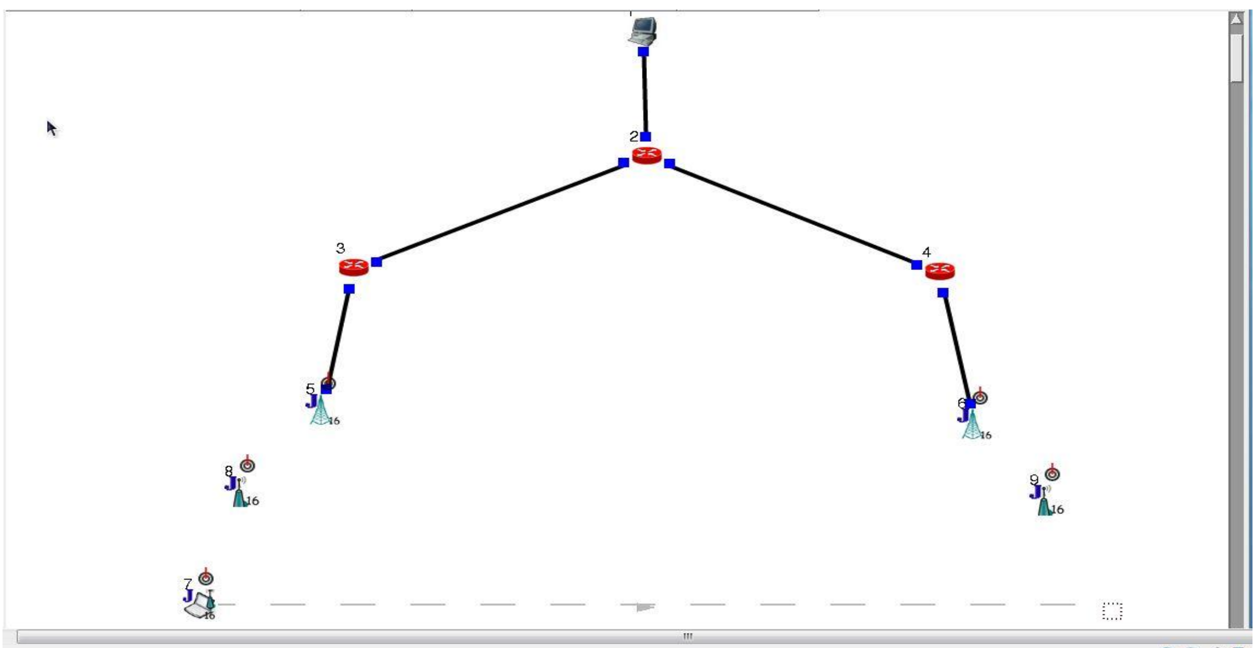

Figure 5: Topology of the second scenario

4. RESULTS AND DISCUSSION

Refer to first scenario in figure 4 the downlink traffic is the traffic from the BS to the MS. We tried to look at the throughput of this traffic when handover occurs using different velocities of the moving MS. Figure 6 shows the obtained result.

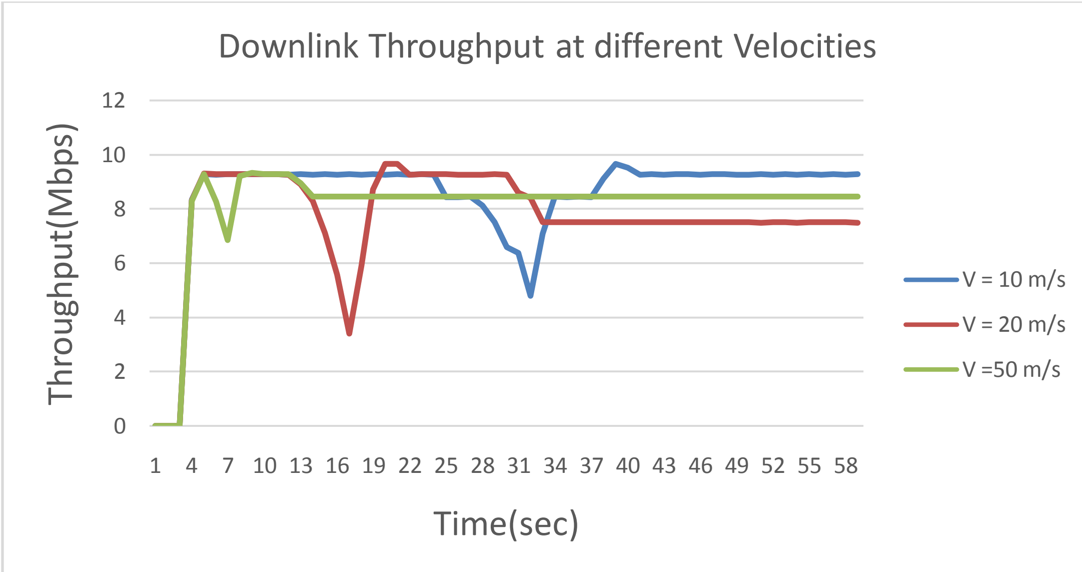

Figure 6: Downlink Throughput at different Velocities

Figure 6 shows a very sharp drop in the throughput at different velocities during handover. The handover behavior changes MS velocity increases, the faster the movement of the MS, the quicker the handover is likely to occur over the same distance. The drop in throughput for all the velocities used is not fixed dependent on some physical parameters during the time of handover such as doppler shift. Throughput can be reduced to about 50% depending on the moving velocity of the MS (when MS velocity = 10, 20 m/s).

Regarding to the uplink throughput is measured by providing an uplink sustain data rate from the MS to the BS, the throughput log file is then placed on the BS to determine how much throughput can be received by the BS with a moving MS at different velocities and different uplink sustain data rate. Figure 7 shows the throughput behavior during handover with different velocities of MS, while Figure 8 shows the average throughput as against different velocities, using the same uplink sustain data rate. It is important to mention that for velocity of 50m/s handover will not occur. This is because the velocity of the MS is very high; hence the MS will maintain a connection with the BSs – SBS to TBS without connecting through the RS.

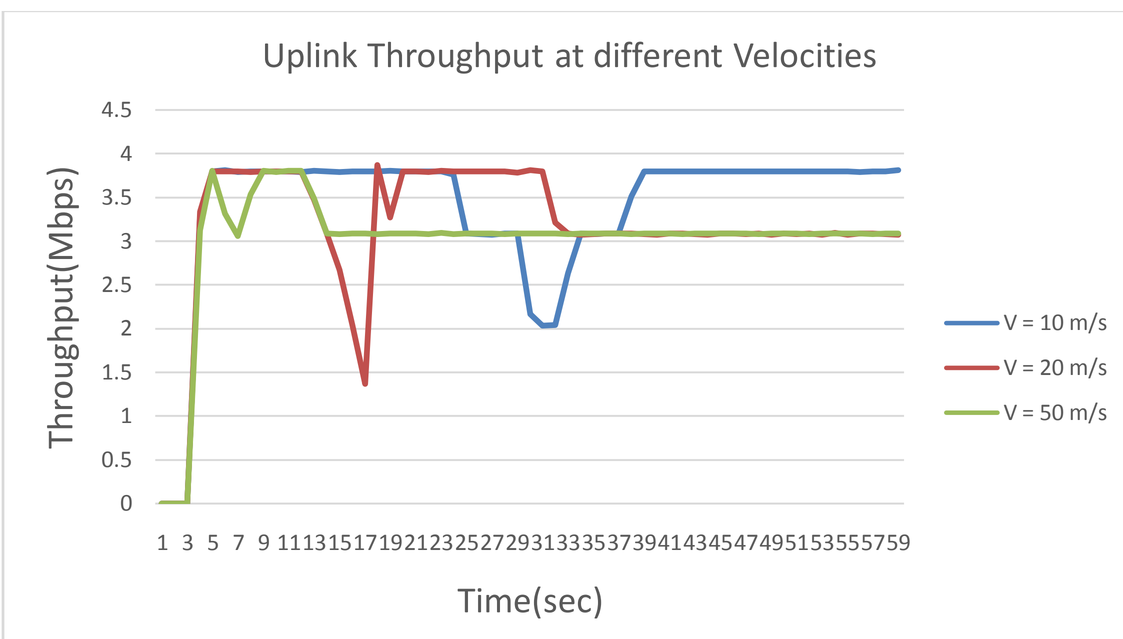

Figure 7: Uplink Throughput at different velocities

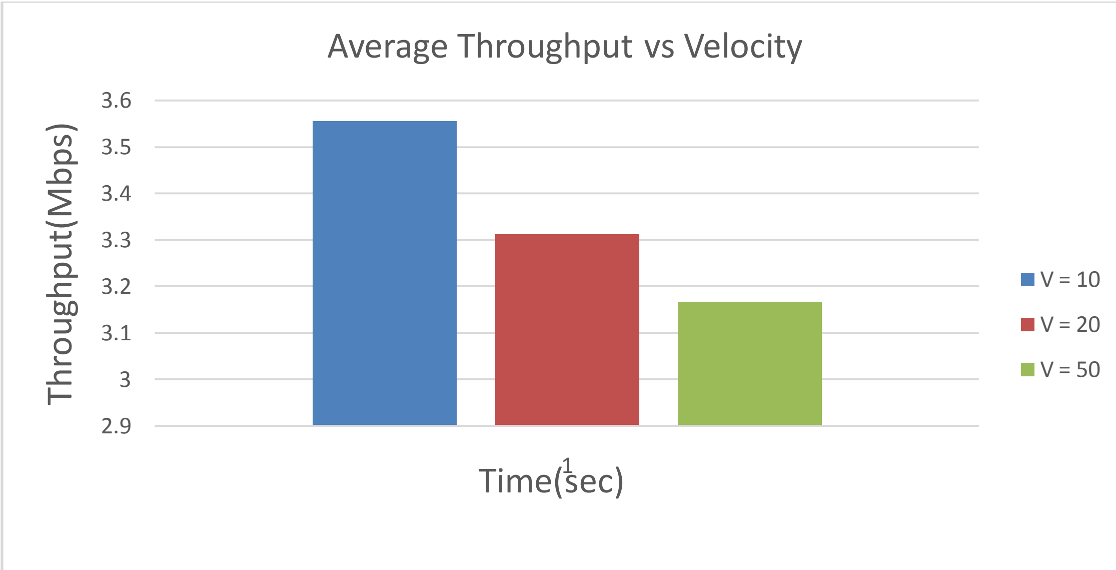

Figure 8: Average Throughput versus Velocity

From Figure 7, we see that there is a drop in the throughput at some point in each of the velocities used, that point is where the handover occurred. Like that of the downlink, the faster the velocity of the MS the quicker the handover is likely to occur over the same distance, however, there is not exact percentage that cuts across all the velocities used, as throughput also be influenced by other physical parameters during the time of handover. Notwithstanding, we see a general drop in the throughput to about 40% during the time of handover depending on the velocity of the MS.

Figure 8 at the other hand shows the average throughput against the velocities used. The result in this graph shows that with the increase in velocity of the MS, there is a likelihood that the overall throughput will drop over a certain distances. This means, the slower the MS moves, the better the throughput over a particular distance, bearing in mind that the same uplink sustain data rate was used in all the velocities.

As stated earlier, the second scenario in Figure 5 two separate BSs with RSs connected to them. This means the effect of handover should be more noticeable since the MS is moving from one RS to another RS belonging to another BS. Figure 9 shows the result of the simulation.

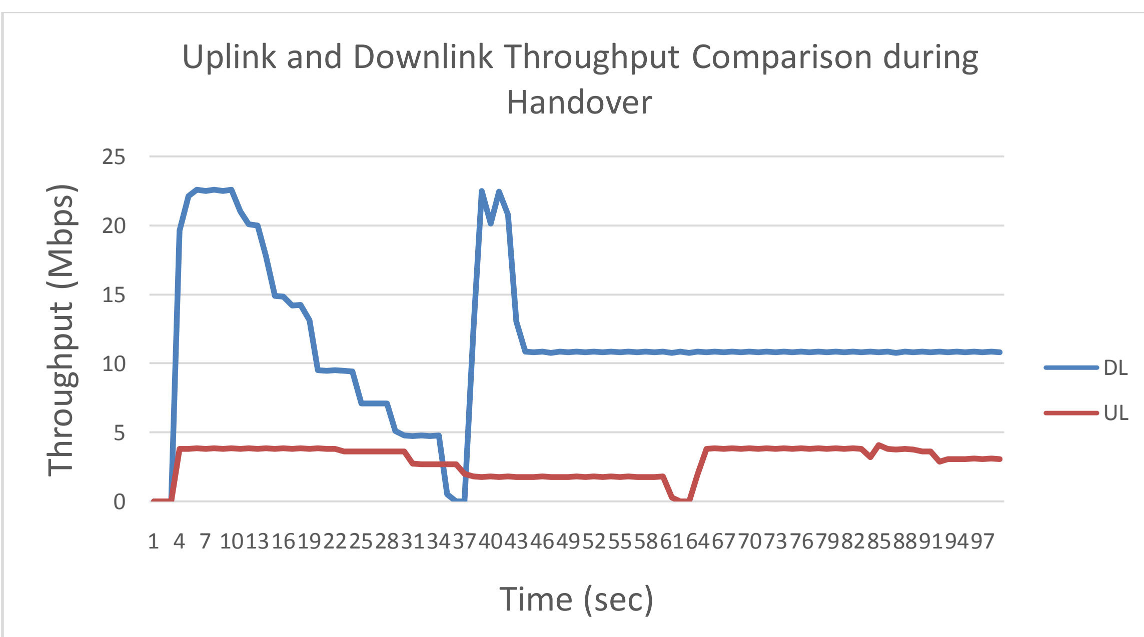

Figure 9: Uplink and Downlink throughput comparison during handover

Figure 9 shows us the ideal behavior of throughput during handover as we see a complete drop to 0 Mbps in both uplink and downlink scenarios. This is because the MS is actually moving from one BS to an entirely different BS and so during the time of handover, throughput is brought down to 0 Mbps. Not also forgetting the fact that in this second scenario, routers are also involved, which could affect the throughput as well. Also from the graph we notice that the throughput of downlink traffic is far higher than that of uplink traffic, this is normal because under normal circumstances, we should have more traffic from the BS to the MS than from the MS to the BS.

Packet delay in handover defines as the time difference between when packets are transmitted and received by the MS, since this is a MS controlled handover. We simulated using the both scenarios in Figure 4 and 5. Results are shown in Figure 10 and Figure 11.

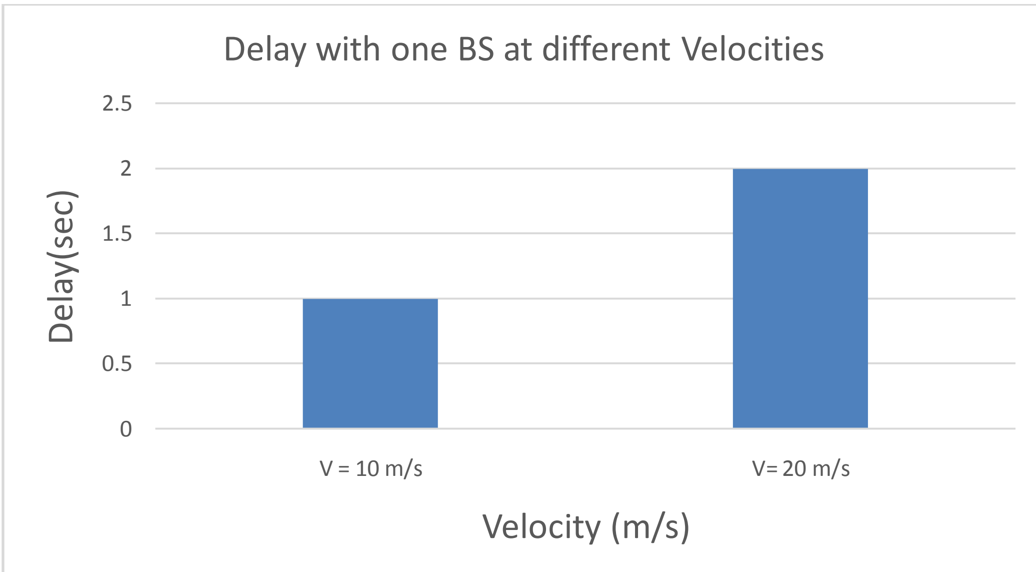

Figure 10: Delay with one BS at different velocities for the first scenario

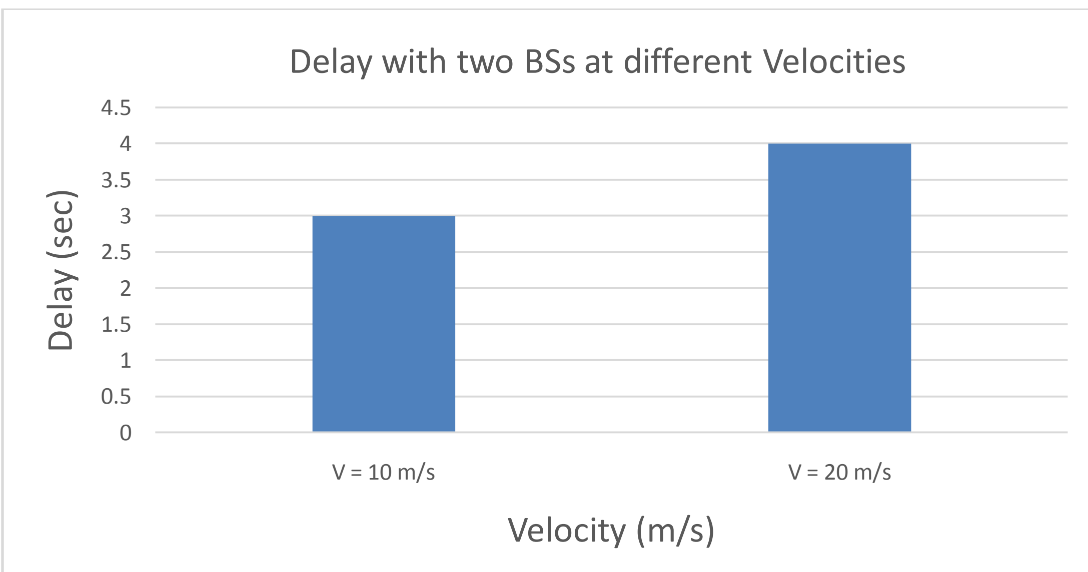

Figure 11: Delay with two BSs at different velocities the second scenario

Figure 10 shows the approximate time in seconds of the delay during handover from one RS to another connected to the same BS. At a higher velocity the delay seems to be a little bit higher, this could be because of the speed of the MS (the delay time as against the speed of the MS). The handover delay is between 1 to 2seconds between RSs of the same BS. The result showed only two different velocities used, this is because at a higher velocity of 50m/s and above, handover will not occur. The MMR system is designed to allow handover for up to 160km/h or about 40 m/s, anything more than this will not record a handover and simulation results showed that there was no handover when the velocity of MS was put at 50m/s.

Figure 11 showed the same behavior in delay the major difference being that the delay time is higher compared to that of figure 10. This is because there are more hop counts as the MS moves from its SBS and RS to its TBS and RS. Secondly, since the routers are involved, IP routing is in place, this means that layer 3 – Network Layer delay is also involved, amounting to the overall delay of the handover. The average handover delay in this scenario is between 3 to 4 seconds depending on the number of BSs and routers involved. This means we can conclude that there is more handover delay with multiple BSs involved than just one BS. It should however be noted that the result for delay are in their approximate values, this means that one can get less than those values, but the behavior of the delay in the different scenarios should still be the same.

CONCLUSION

This research was conducted to see the effect of handover on the performance of the MMR system, using throughput, packet drop and packet delay as evaluation parameters. We also tried to use some other parameters like velocity – or in most cases the uplink sustain rate of the MS to determine the effect handover has on throughput, packet drop and packet delay. From our results and analysis we have seen that handover reduces the throughput of the system to about 40% or more depending on the scenarios and how many RS are involved. In a scenario where we have more than one BS involved and layer 3 devices such as routers, the throughput of the system reduces completely to zero during the cause of handover and gradually picks up over the transmission time, this is because with layer 3 devices, IP routing is enabled. For packet delay, we saw that the average delay during the time of handover is about 1 to 2 seconds with a single BS but about 3 to 4 seconds with more than one BS and network layer devices like routers involved. This is because with layer 3 devices like routers, IP routing is enabled and therefore layer 3 delay is also introduced. For packet drop, we noticed that no packet drop is recorded during the handover time, this could be due to the connection oriented protocol used – TCP or due to the fact that the drop in packets is too small to be recorded by this simulation tool. We also applied our research findings on some applications that are supported by the QoS service classes we have in WiMAX, which shows how these day to day applications are affected by the handover process. This research was only based on the transparent mode relay (T_RS), more work can be done with the non-transparent relays which are meant to extend network coverage. With the transparent mode relays, the effect of handover may be seen more than the transparent relays. More work has to be done in other to reduce the handover time especially when connecting more than a single BS so as to reduce the delay and relays should be able to maintain a certain level of throughput even during the handover process.

REFERENCES

[1]. Mohammed Awadh Ben-Mubarak, BorhanuddinMohd Ali, Nor KamariahNoordin , Alyani Ismail and CheeKyun Ng "Mobile Station Movement Direction Prediction (MMDP)Based Handover Scanning for Mobile WiMAX System"SpringerScience+Business Media New York 2013

[2]. Manal Al-bzoor and KhaledElleithy. "WiMAX Basics from Phy layer to Scheduling and Multicasting Approaches". *International Journal of Computer Science & Engineering Survey, Vol. 2, No 1.* IJCSES, February 2011.

[3]. Kejie Lu, Yi Qian, Hsiao-Hwa Chen and Shengli Fu, "WiMAX Networks:From Access to Service Platform" IEEE, 2008

[4]. Steven W. Peters and Robert W. Heath, Jr., "The Future of WiMAX:Multihop Relaying with IEEE 802.16j", IEEE, 2009

[5]. RohaizaYusoff, MohdDani Baba and Muhammad Ibrahim. "Handover Mechanism for Mobile Multi-hop Relay WiMAX Networks".

[6]. Mohammed A. Ben-Mubarak, Borhanuddin Mohd. Ali, Nor Kamariah Noordin ,Alyani Ismail and CheeKyun Ng "Fuzzy Logic Based Self-Adaptive Handover Algorithm for Mobile WiMAX" Springer Science+Business Media New York 2012

[7]. VaskenGenc, Seán Murphy, John Murphy, "Performance Analysis of Transparent Relays in802.16j MMR Networks" UCD School of Computer Science and Informatics University College Dublin, Belfield, Dublin 4, Ireland

[8]. RohaizaYusoff, MohdDani Baba, RuhaniAbdRahman, Muhammad Ibrahim and Naimah Mat Isa "Performance Analysis of Transparent and Non-transparent Relays in MMR WiMAX Networks", IEEE, 2011

[9]. Pavel Mach and Robert Bestak, "Analysis and Performance Evaluation of IEEE 802.16Enhanced with Decentrally Controlled Relays" IEEE, 2009

[10]. VaskenGenc, Seán Murphy and "John Murphy Performance Analysis of Transparent Relays in802.16j MMR Networks" UCD School of Computer Science and Informatics

[11]. VaskenGenc, Seán Murphy and John Murphy "Analysis of Transparent Mode IEEE 802.16j System Performance with varying Numbers of Relays and Associated Transmit Power" IEEE, 2009

[12]. http://www.cisco.com/cisco/web/solutions/small_business/resources_center

[13]. Wan NurulIzza Wan Darman, Mohd Dani Baba and D. Mohd Ali "Performance Study on Relay Station Usage in IEEE 802.16j Mobile Multi-hop Relay Network", IEEE 2012

[14]. Yu Chen and Izzat Darwazeh. "End-to-End Delay Performance Analysis in IEEE 802.16j Mobile Multi-hop Relay (MMR) Networks". IEEE, 2011

[15]. Wan NurulIzza Wan Darman, Mohd Dani Baba, D. Mohd Ali, and AzitaLailyYusof "Performance Comparison of Non-Relay and Relay Scenario in IEEE 802.16j Network" IEEE, 2012

[16]. D.Satish Kumar and N. Nagarajan. "Simulation of Hard Handover (HHO) Mechanism in IEEE 802.16j Transparent Mode Networks. *International Journal of Computer Applications, Vol. 14, No.2.* Janauary, 2011
[17]. D. Satish Kumar, and N. Nagarajan "NCTUns Simulation model for IEEE 802.16j Mobile multi hopRelay (MMR) WIMAX networks" Innovative Systems Design and Engineering ISSN 2222-1727 Vol 2, No 5, 2011
[18]. Kin K. Leung, Sayandev Mukherjeeand George E. Rittenhouse "Mobility Support for IEEE 802.16d Wireless Networks" Bell Labs, Lucent Technologies.
[19]. David Soldani and Sudhir Dixit. "Wireless Relays for Broadband Access". IEEE, 2008
[20]. Kyungmin Lee and Juwook Jang, "Reduction of Relay Overhead in IEEE 802.16j Mobile Multi-hop Relay (MMR) Networks" IEEE, 2009
[21]. Woon Yong Jo, Ju and Wook Jang, "Reduction of Latency in Mobile Multi-hop Relay(MMR) Networks" IEEE, 2009
[22]. Shun-Ren Yang, Chien-Chi Kao, Wai-Chi Kan, and Tzung-Chin Shih. "Handoff Minimization through a Relay Station Grouping Algorithm With Efficient Radio-Resource Scheduling Policies for IEEE 802.16j Multihop Relay Networks" IEEE, 2010
[23]. Zhifeng Tao, Anfei Li, Koon Hoo Teo *and* Jinyun Zhang "Frame Structure Design for IEEE 802.16j Mobile Multihop Relay (MMR) Networks" IEEE, 2007
[24]. David Soldani, "Multi-hop Relay Networks", Huawei Technologies, European Research Centre, Germany. www. Intechopen.com
[25]. Fernando Gordejuela-Sanchez, David Lopez-Perez, Jie Zhang and Liqiang Zhao Efficient "Mobile WiMAX Capacity Estimations in a Multihop Environment" IEEE, 2008
[26]. Bin Lin, Pin-Han Ho, Liang-Liang Xie1, and Xuemin (Sherman) Shen "Relay Station Placement in IEEE 802.16j Dual-Relay MMR Networks" IEEE 2008
[27]. Chutima Prommak, and Chitapong Wechtaison, "WiMAX Network Design and Optimization Using Multi-hop Relay Stations", *New Aspectsof Applied Informatics, Biomedical Electronics & Informatics and Communications*, ISBN: 978-960-474-216-5
[28]. Sojeong Ann, Kyung Geun Lee and HyungSeok Kim, "A Path Selection Method in IEEE 802.16j Mobile Multi-hop Relay Networks" *The Second International Conference on Sensor Technologies and Applications* IEEE, 2008
[29]. Yang Yu, Seán Murphy and Liam Murphy, "Planning Base Station and Relay Station Locationsin IEEE 802.16j Multi-hop Relay Networks". IEEE, 2007
[30]. Vasken Genc, Sean Murphy, Yang Yu, and John Murphy," IEEE 802.16J Relay-based Wireless Access Networks: An Overview". IEEE, 2008