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Impact of Group Mobility on QoS of Mobile WiMAX (IEEE 802.16e) Network with CBR Application

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Abstract: IEEE 802.16e is a wireless broadband network standard aimed at providing robust, high data rate mobile communication. With a modified IEEE 802.16e standard, it becomes possible to provide robust group mobility in battle zone or emergency operations that require centralized control. In these situations, the group mobility issues are very important to support the military and emergency applications, in which multiple mobile stations (MSs) could move in the same direction with short separations as a group. In this paper we designed a system to analyze the performance of mobile WiMAX network (IEEE 802.16e) based on QoS parameters (Throughput, Average jitter and Average end-to-end delay) in group mobility environment having different group size, while CBR application is going on.

Keywords: - Group mobility, CBR, IEEE 802.16e, Group size, QoS

I. INTRODUCTION

Broadband wireless standard IEEE 802.16 technology is specified to provide a robust last mile broadband access [1]. The WiMAX network is suitable to be employed as a communication platform for the military usage and emergency operations. In these situations, the group mobility issues are very important to support the military and emergency applications, in which multiple mobile stations (MSs) have to move in the same direction with short separations as a group. In real military systems, node mobility is not always independent. Mobility correlation among nodes is quite common [2]. In recent years, group mobility, where mobile nodes are organized into groups to coordinate their movement, has emerged from the demand of applications where a team of users with mobile devices work together [3]. In each group, all the group members stay closely and move together in accordance with the same mobility pattern. Since a group of nodes always move as a whole and have the similar location tracks, group mobility can be further exploited to improve the efficiency of location management. Even though the vehicles of a group are likely to have similar movement tracks, the individual vehicles in a group tend to have relative mobility.

The mobility vector of a node can be considered as the sum of the group mobility vector, shared by the members of a group and the internal mobility vector, relative mobility of an individual node in a group. The mobility of a node is decided by the vector sum of the two mobility vectors and the group boundary. The mobile devices and the mobility are supported with the specific handover process. The handoff process is defined as the set of procedures and decisions that enable an MS to migrate from the air interface of one BS (Base station) to the air interface of another. MS handover is performed under two conditions; when the signal quality of the serving BS is too low or when the QoS capability of the serving BS cannot fulfill requirements.

Both MS and BS can initiate the handover. When group size is larger, the handover latency becomes much more significant and it affects transmissions adversely. In this paper we develop a system that works under group mobility environment having different group size and mobility patterns.

The paper is organized as follows: Section II briefly outlines the related work. Section III describes the system under consideration. Section IV show results and discussion and then it is concluded in section V

II. RELATED WORK

Researchers have done a lot of work in the field of WiMAX (IEEE802.16), Mobile WiMAX (IEEE802.16e) and Group Mobility. IEEE 802.16e is a standard that specifies the air interface of fixed broadband wireless access (BWA) systems supporting multimedia services. The medium access control layer (MAC) supports a primarily point-to-multipoint architecture. In [1] authors provided enhancements to IEEE Std 802.16 2004 to support subscriber stations moving at vehicular speeds and thereby specified a system for combined fixed and mobile broadband wireless access . A comparison with contemporary cellular alternatives based on the WiMAX Forum Release-2 system profiles was provided in [2]. A proposal of new group mobility modeling-the diamond group mobility (DGM) and comparison of its performance with that of the reference point group mobility (RPGM) was given in [3]. An adaptive scheduling algorithm to suit group mobility systems in the mobile WiMAX network was proposed in [4]. They explored group mobility issues with QoS support under the mobility framework supported by the IEEE 802.16e and also devised an adaptive strategy to provide better QoS to real-time traffic flows in the mobile WiMAX networks.

A group-based location service (GrLS) for mobile ad hoc networks (MANETs) was also proposed [5]. The novelty of GrLS was in its exploitation of group mobility to improve the protocol efficiency. GrLS was the first group-based location service protocol. A fast handoff scheme using mobility patterns for WiMAX networks to shorten the handoff latency was proposed in [6]. A group handover scheme to design an efficient and effective handover process with low latency for the group mobility systems in the mobile WiMAX networks was proposed in [7]. The bridge MS was introduced to integrate several handover processes for the group of MSs into only one, which could eliminate the collision of the ranging requests and shorten the latency incurred. A novel group mobility model, namely the reference region group mobility model that could be used to mimic group operations in MANETs, i.e. group partitions and mergers was proposed in [8]. So the models and schemes in above discussion motivate us to analyze the performance of mobile WiMAX network in terms of QoS under group mobility environment, while CBR application is in process. In next section, we described a system under consideration.

III. SYSTEM DESCRIPTION

We develop a system for analyzing the performance of WiMAX network under group mobility environment with CBR (constant bit rate) application. CBR is data traffic that keeps the bit rate same from source to destination throughout the process. Figure 1 represents the general view of system of mobile WiMAX network under group mobility environment.

```
    --------------I-10---------------10 (MS, SNTer3)
    --------------I-10---------------9  (MS, SNTer2)
    --------------I-10---------------8  (MS, SNTer1)
    --------------I-10---------------5  (MS, SNTer)
 ||||    3(BS)      2(BS)        1(BS)
 ||||
 ||||                                              Group 0
 ||||
I-405          6 (switch center)
 ||||
 |||| 4(BS)
 ||||
 |||| 7(SS, SNT headquarter)
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Figure 1: General view of system with group mobility environment in Mobile WiMAX network

In this system we consider four WiMAX subnets (192.0.0.0, 192.0.1.0, 192.0.2.0 and 192.0.3.0) having BS1, BS2, BS3 and BS4 respectively. These base stations are operating on different wireless channels. The base stations are connected to the switch center (node 6) by wired links. System to analyze performance of mobile WiMAX network in group mobility environment is shown in figure 2.

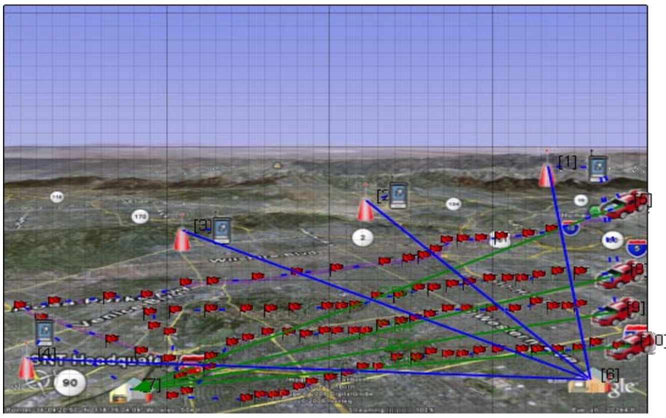

Figure 2: System to analyze performance of mobile WiMAX network in group mobility Environment

Nodes 5, 8, 9 and 10 are mobile stations in group 0 that communicate with destination node i.e. node 7. Group 0 is initially connected to BS1, when it moves from source to destination it communicates with node 7 and communication takes place through BS1, BS2, BS3 and BS4. In this system group mobility model is considered and mobility pattern is specified for every mobile node in a group 0. System parameters for above discussed system are given in table 1

Table 1: System parameters of mobile WiMAX network

Nodes	**Node ID**	**Node Name**	
	1,2,3,4	Base station	
	5,8,9,10	SNTer (Mobile station)	
	6	Switch center	
	7	SNT headquarter	
Groups	**Group name**	**Group members**	
	Group0	5,8,9,10	
Networks	**Network address**	**Type**	**Nodes**
	192.0.0.0	Wireless subnet	1,5,8,9,10
	192.0.1.0	Wireless subnet	2
	192.0.3.0	Wireless subnet	3
	192.0.4.0	Wireless subnet	4,7

The impact of group mobility on QoS of mobile WiMAX (IEEE 802.16e) network with CBR application is discussed in the next section.

IV. RESULTS AND DISCUSSIONS

We analyzed the performance of mobile WiMAX network by simulating scenarios having different group size of mobile devices/nodes. For performance evaluation of mobile WiMAX network, we are considering Throughput, Average Jitter, Average end to end delay as QoS parameters. Throughput refers to how much data can be transferred from one location to another in a given amount of time. It is measured in bps (bit per second). The throughput is calculated as follows:

$$Throughput = N[(total\ bytes\ sent * 8) / (time\ last\ packet\ received - time\ first\ packet\ received)] \quad \textbf{(1)}$$

Where, Time is in seconds, N is number of Nodes.

Average Jitter is a variation or dislocation in the pulses of a digital transmission; it may be in the form of irregular pulses. Average jitter can be calculated as:-

$$Average\ jitter = total\ packet\ jitter\ for\ all\ received\ pakets / (number\ of\ packets\ received - 1) \quad (2)$$

Where, Packet jitter is the difference between transmission delay of the current packet and transmission delay of the previous packet.

Average End-to-end delay refers to the time taken for a packet to be transmitted across a network from source to destination.

$$Average\ end-to-end\ delay = \frac{total\ of\ transmission\ delays\ of\ all\ received\ packets}{number\ of\ packets\ received} \quad \textbf{(3)}$$

Where, transmission delay of a packet is the difference between time at which packet received by the server and packet transmitted by the client, and the time is in seconds. In general average end-to-end delay is:

$$d_{end-end} = N[\, d_{trans} + d_{prop} + d_{proc}] \quad (4)$$

Where, $d_{end-end}$ is end-to-end delay, d_{trans} is transmission delay, d_{prop} is propagation delay, d_{proc} is processing delay and N is number of nodes.

To analyze the performance with different group size in mobile WiMAX environment we are considering two mobility patterns such as mobility pattern 1,which considers 24 path indicators & mobility pattern 2, considers 4 path indicators to specify a path of group and six system scenarios with following specifications:-

Scenario 1:- Considering group size 1 (one mobile station in a group) and mobility pattern 1. Each of the mobile station in a group takes 85 seconds to reach at the destination.

***Scenario 2*:-** Considering Group size is same as that of Scenario 1 but mobility pattern is 2 and time taken by each mobile station to reach at the destination is 16 seconds.

***Scenario 3*:-** Considering group size 2, Mobility pattern and time taken by each mobile station to reach at the destination is same as that of Scenario 1.

Scenario 4:- Considering group size 2, Mobility pattern and time taken by each mobile station to reach at the destination is same as that of Scenario 2.

***Scenario 5*:-** Considering group size 4, Mobility pattern and time taken by each mobile station to reach at the destination is same as that of Scenario 1.

Scenario 6:- Considering group size 4, Mobility pattern and time taken by each mobile station to reach at the destination is same as that of Scenario 2.

Depending upon the above described Scenarios and mobility patterns; we analyzed impact of group size and mobility patterns on the QoS parameters of mobile WiMAX network. A comparative statement with respect to different group size and mobility patterns are given in Table 2:-

Table 2: Comparison of QoS parameters of Scenarios with different group size

CBR server	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**
Throughput (bits/s)	443554	403432	929351	405478	2129420	1394600
Average Jitter (s)	0.0122	0.0132	0.0254	0.0237	0.0566	0.0421
Average End-to-End Delay(s)	0.1069	0.1452	0.3119	0.3386	1.0271	0.5883

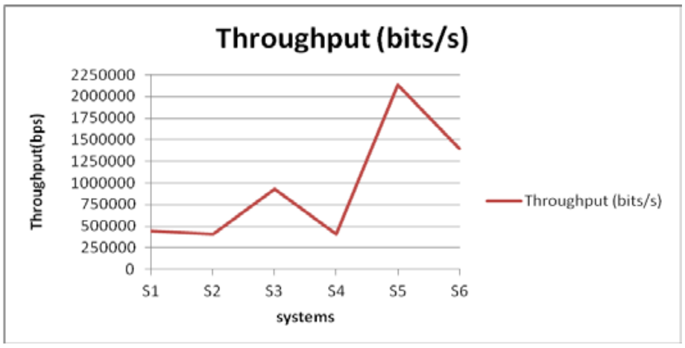

Figure 3: Comparison of Throughput having different group sizes and mobility patterns

CBR client is sending 51200 bytes through each of the mobile stations in a group. But number of bytes received at the destination node is different. According to figure 3, when we consider Scenario 1, number of bytes received by CBR server are 51200 and throughput is 443554 bps. But in Scenario 2, server will receive 45544 bytes and throughput falls down to 403432bps. Similarly in Scenario 3 and 4, numbers of bytes received are 102400 and 68096 respectively and corresponding to it throughput is 929351bps and 405478bps. When we increased the group size to 4 in Scenario 5 and 6, throughput is 2129420bps and 1394600 bps respectively. Throughput is increasing as we are increasing group size but throughput depends not only on group size but also on mobility patterns. If number of path indicators are more in a mobility pattern then speed of mobile station is slow and loss of bytes are negligible and vice versa. When we have compared scenarios of mobility patterns 1 and 2 individually, throughput is increased. But when we compared scenarios having mobility pattern 1 with scenario having mobility pattern 2 then throughput of scenarios having mobility pattern 1 is high.

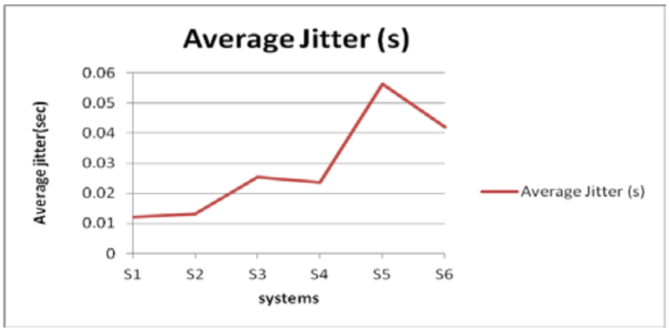

Figure 4: Comparison of Jitter Scenarios having different group sizes and mobility patterns

During digital transmission jitter should be required minimum. The reason behind it is that data is split up into manageable 'packets' with headers and footers that indicate the correct order of the data packets or whole signal is broken down into chunks of data which is transmitted to a receiving unit for reassembly. If jitter occurs, synchronization became a problem and the receiving unit finds it difficult to correctly assemble the incoming data stream**.** In figure 4, it is clear that average jitter increased with the increase in group size for the same mobility pattern. In Scenarios 1, 3 and 5 having mobility pattern 1 the average jitter was 0.0122273s, 0.0254324s and 0.0564616s respectively. Whereas for mobility pattern 2, Scenarios 2, 4 and 6 the average jitter was found to be 0.013238s, 0.0237295 and 0.0421306 respectively. But when we compared scenarios on the basis of different mobility patterns, then average jitter of mobility pattern 2 was less as compared to mobility pattern 1. In particular, distortion due to Jitter and packet loss will have an important impact on QoS w.r.t different group sizes.

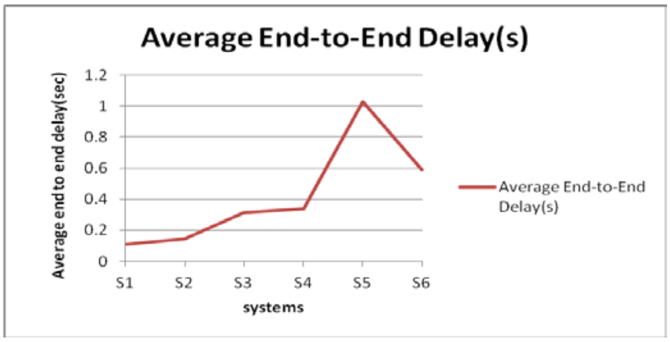

Figure 5: Comparison of average end-to-end delay having different group sizes and mobility patterns

Average end to end delay depended upon transmission delay, processing delay, propogation delay and number of mobile stations. Speed is inversely proportional to time therefore if speed was more then average end to end delay came out to be less. As shown in figure 5, average end to end delay of scenarios having same mobility pattern 1 increased with the increase in group size. In scenarios 1, 3 and 5 having mobility pattern 1 the average end to end delay was 0.106987s, 0.311941s and 1.02719s respectively. Whereas for mobility pattern 2, scenarios 2, 4 and 6 the average end to end delay was found to be 0.145261s, 0.338699s and 0.588309s respectively. But when we compared scenarios on the basis of different mobility patterns, then average end to end delay of mobility pattern 2 was less as compared to mobility pattern 1. Average end-to-end delay depends upon the group size and mobility pattern.

V. CONCLUSION

In conclusion we compared different scenarios on the basis of different group sizes and mobility patterns to analyze the performance of WiMAX network based on QoS parameters. As the group size increases, throughput, average jitter and average end-to-end delay increased. But impact of mobility patterns on QoS parameters is also identified, as mobility patterns decide the speed of the group. In case of mobility pattern with more number of path indicators and large group size, throughput is enhanced but it also increased average jitter and average end to end delay which is inadmissible.

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