Performance Analysis and Development of an Efficient Routing Scheme for IEEE 802.16/WiMAX Mesh Networks

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*Abstract***— A collision-free centralized scheduling algorithm for IEEE 802.16 WiMAX provides a mechanism for creations multi-hop mesh and high-quality wireless multimedia services which can be developed as a high speed broad band wireless network. In centralized scheduling for IEEE 802.16 mesh networks, all packets should be transported through the BS (Base station).The links to or from the BS becomes the system's bottleneck and the throughput is heavily impacted by the interference. To solve this problem, we evaluated the proposed algorithm with five selection criteria of scheduling through extensive simulations and the experimental results are instrumental for improving the performance of IEEE 802.16 based WMNs in terms of link scheduling. We compared the effect of two routing and one scheduling algorithm on the scheduling length. The result shows that best algorithm has improved the system performance in the aspects of scheduling length, transmission range, and channel utilization ratio.**

Keywords- **IEEE 802.16, Mesh Network, WiMAX, Multi-hop Routing, Mesh mode.**

I. INTRODUCTION

The IEEE 802.16 standard, commonly known as WiMAX, was published to construct the last-mile wireless broadband access (WBA) in metropolitan area networks and provides better performance comparable to other traditional cable, DSL, or T1networks. In this paper, we consider the problem of routing and scheduling packets based on centralized scheme. In WiMAX mesh centralized routing and scheduling, the BS determines the routes of all SSs and also decides the transmission sequence in data subframes. The scheduling algorithm, along with the policy of routing tree construction decides the system performance. System performance is evaluated by the parameter scheduling length (where lower scheduling length indicates higher performance). So the problem is that how to reduce the scheduling length by designing efficient routing and scheduling protocol. In centralized operation we find no scope in scheduling. Therefore the problem is to develop an efficient routing algorithm for centralized mesh mode of operation. In our simulation we consider only uplink transmission and it can be easily converted to downlink transmission. In simulation we don't consider the condition of link failure; because our proposed algorithm is not aware of link failure. Moreover this routing algorithm is proposed only for fixed nodes. So there is scope to work on routing of centralized mesh network for mobile nodes with considering link failure.

II. BACKGROUND

Performances of wireless mesh networks can be improved by employing spatial reuse with concurrent transmission. A vast amount of research has been conducted in routing and scheduling in wireless networks. Jun wong, Weijia Jia, Liuseng Huamg et al [4] proposed an efficient centralized scheduling algorithm for IEEE 802.16 mesh radio networks. They used TDMA concept. In a time slot, those nodes will transmit which are not interfered by each others. They proposed four node selection criteria – nearest, farthest, minimum interference and random. In our paper, we mentioned this algorithm as R_A_1. According to this routing algorithm, when a new node joins to the network it will select a node of minimum node id from the neighbors of that node. But through this, more time slots may be needed to transmit/receive 1 packet to/from BS. To solve this problem, Hung-Yu, Samrat Ganguly and Rauf Izmailov Wei proposed maximum weighted nodeselection and minimum blocking metrics routing algorithm in their scheduling algorithm. We mentioned this routing algorithm as R_A_2 in this paper later. But, some problem remains still like ambiguity problem & Imperfect route selection. We have proposed our algorithm to solve this type of problems which is indicated as R_A_3.

III. PROPOSED ALGORITHM

We proposed a routing algorithm which removes the problems of R_A_2. The ambiguity problem is removed by two steps. If there are more than one neighbor nodes with minimum blocking metrics, then select a node among them which have minimum hops to/from BS & if there are also more than one node with minimum hops no from/to BS, then select the node of minimum node id among them. To remove imperfect node selection problem it is needed to update all previous node's route when a new node is inserted. When a new node joins in the networks, then all the nodes are arranged in a list in ascending order to their distance from BS and all nodes will be set as unselected/unrouted nodes. Each node will be scanned from list and their route (i.e. parent) will be selected according to blocking metric concept (as R_A_2). That means, the node will find the selected nodes from its neighbors and select one of them who has minimum blocking metric as its parent

R_A_3

1. Set BS as selected/routed node

Do step 2 to step 4 for each new node when it is inserted:

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2. Sorting all nodes in ascending order according to distance from BS.
3. Reset all nodes as unselected/unrouted node.
4. Scanning SSs in ascending order of distance from BS and find route of all SSs like below (do step 'a' to 'f' for each SS):

a. Find neighbors and then selected nodes from neighbors.

b. Find the node with minimum blocking metrics from selected nodes.

c. Select the node with minimum hop, if there is more than one node in step 'b'.

d. Select a node with minimum id, if there is more than one node in step 'c'.

e. Set the node in step'd' as parents of scanned SS.

f. Set the scanned SS as routed/selected node.

For R_A_2, route time for n no. of node is nt, where t is average route calculation time, when a new node is inserted. But, for R_A_3, Route calculation time of i-th node $= s + i \times t \cong i \times t$;

For n nodes, total route calculation time $=(s+t)+(s+2t)+(s+3t)+........+(s+(n-1)t)+(s+nt)$

$$= n \times s + \frac{n \times (n+1)}{2} \times t .$$

$$\therefore \frac{\text{Route time for n-th node (R\_A\_3)}}{\text{Route time for n-th node (R\_A\_2)}} = \frac{n \times t}{t} = n$$

$$\frac{\text{Total route time of n nodes (R\_A\_3)}}{\text{Total route time of n nodes (R\_A\_2)}} = \frac{n \times s + \frac{n \times (n+1)}{2} \times t}{n * t}$$

$$\cong \frac{n+1}{2}$$

Here route calculation time of n-th node using R_A_3 is n times than R_A_2. So it may be seemed that, calculation time is a problem for R_A_3, especially when node number (n) is very large. But interestingly notice that, total route calculation time of n nodes using R_A_3 is (n+1)/2 times than R_A_2. Therefore the ratio of calculation time has significantly decreased for total route calculation. Moreover routing algorithm does not run all times; rather it only runs when a new node joins or when changes occur in the network topology. So, more calculation time is not a major problem.

IV. PERFORMANCE EVALUATION

Our simulation is based on centralized scheduling and one directional transmission. The length of scheduling is the most important performance measure of a scheduling/routing algorithm and it is considered in most of the existing literatures. From our simulation first we find which scheduling criterion is best. We have developed a simulation model using C programming language. Using this model any routing or scheduling algorithm can be run on a network topology and gives the output in terms of scheduling metric, CUR, scheduling length. It gives the visualized output of the network. Finally we will show that how network performance vary (using R_A_3, R_A_2 & R_A_1) according to no. of nodes & transmission range between nodes. In fig-1, we have considered the transmission range of all nodes to 7 units & minimum separation between nodes 3 unit with variable node no whereas in fig-2, we have varied transmission range of the nodes in a particular area. From fig.1, it is clear that no. of scheduling length increases more for R_A_3 than R_A_1 & R_A_2 with the increment of the no. of nodes

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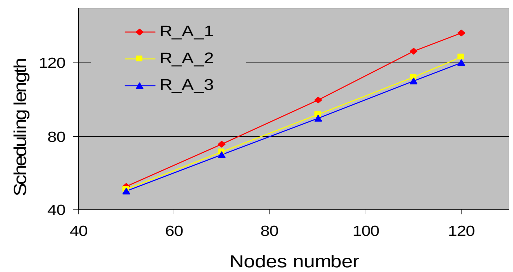

Fig. 1. Comparison among R_A_1, R_A_2 & R_A_3 in the Fig-1: . Comparison among R_A_1, R_A_2 & R_A_3 in the aspect of scheduling length varying node no

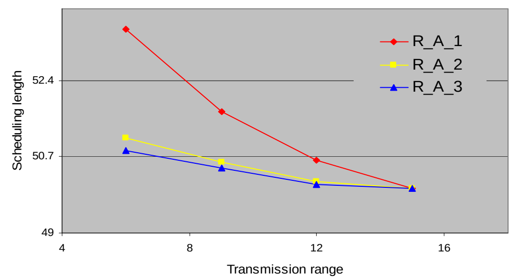

Fig. 2. Comparison among R_A_1, R_A_2 & R_A_3 in the aspect of scheduling length varying transmission range

From fig-2, it is clear that when transmission range increases then scheduling length for all routing algorithm becomes closer and for a large value of transmission range it becomes same. This is because when the transmission range is too large then all the nodes stay in the transmission range of BS and hence the network operates like PMP (point to multi point mode) mode. Then the scheduling length becomes equal to nodes number, because in PMP modes at each time slot only one node directly transmit to/from BS.

V. SUMMARY

We proposed a collision-free centralized scheduling algorithm for IEEE 802.16 based WMNs. This scheduling scheme takes fairness, channel utilization and transmission delay into consideration. In the proposed algorithm, the selection policy for scheduled links will impact the algorithm's performance. We use the length of scheduling, and transmission range to evaluate the performance of the proposed scheduling algorithm. Our future work will mainly focus on the problem of link failure and dynamic route construction.

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