Abstract—Wimax is a standard based wireless technology that provides high throughput broadband connection over long distance. It can offer low cost high speed and long range communications for applications. In wimax relay networks the relay stations are used to improve the transmission quality. Bandwidth allocation is the process of assigning bandwidth to users and applications. The comparative analysis of bandwidth allocation scheme is done for WiMAX relay network and its simulation results are tabulated comparatively.

Keywords— IEEE802.16j, DSS scheme, MSS scheme, ML-URA, Bandwidth allocation.

I. INTRODUCTION

A wimax network is composed of a Base Station (BS) and multiple Subscriber Stations (SSs). The BS manages the wimax network and serves as a gateway connecting the wimax network to external networks such as internet. Base Station is the node that logically connects wireless subscriber devices to operator networks. Subscriber Station is a stationary radio system that communicates with the base station, although it may also connected a relay station in multi-hop relay network operations. A BS and one or more SS can form a cell with point to point structure, BS acts as central entity to transfer all the data from mobile station. Compared with fixed SSs, MSs typically are battery operated and therefore employ enhanced power management. Relay Stations are SS configured to forward traffic to other RSs or SSs in a multi-hop security zone. The Relay Station may be in a fixed location or mobile.

The IEEE 802.16j task group has been formed to extend the scope of IEEE 802.16e to support Mobile Multihop Relay (MMR) networks by introducing Relay Stations to wimax networks. A WRN is composed of a Base station (BS), several Relay Stations (RSs) and many Subscriber Stations (SSs). A spanning tree rooted at the BS is formed for routing, in which all SSs are leaf nodes. If an SS is out of the transmission range of BS, it can use one or multiple RSs to communicate with the BS in a multihop manner. Compared to single hop wimax network in which each SS directly communicates with BS, a relay network can significantly extend the coverage range, reduce dead spots and improve network capacity.

The Bandwidth allocation in Wimax Relay networks are more challenging than wimax network. In wimax network the BS allocate bandwidth only to the SSs. But in wimax relay network the BS allocate bandwidth not only the SSs, but also RSs. Bandwidth allocation involves assigning priority to different classes of traffic based on how critical and delay-sensitive they are. This makes the best use of available bandwidth, and if the network becomes congested, lower priority traffic can be dropped.

The figure explain about the relation between BS, RS, SSs. Relay Station can be transferred between the BS with SS signals, enhancing the connection quality.

II. REVIEW OF LITERATURE

Wen-Hsing Kuo et al.[1] proposed the algorithm to solve the MRM (Multicast Recipient Maximization) problem by using auxiliary graph. MRM problem is the maximization problem which maximizes the total number of receivers. MRM try to maximize the recipients based on the downlink multicast program budget and the channel quality of the nodes. The algorithm designed to maximize the number of recipients by effectively conserving bandwidth consumption. This algorithm considers the diversities of bandwidth budgets and channel quality but does not consider the diversity of user device capabilities.

Cheng-Hsien Lin et al.[2] proposed the resource allocation which operates in Time Division Duplex mode. In this network, the (Multihop Relay- Base Station) MR-BS sent the broadcast data to the receivers. The sender needs to choose...
suitable scheme to ensure that all receivers can receive the data successfully. The resource utilization is efficient due to the relay traffic in the RSs. This makes the problem as the multi-level Broadcast Recipient Maximization problem. So propose a Multi-Level Utility-based Resource Allocation scheme to solve the maximization problem.

Wen-Hsing Kuo et al.[3] proposed a Multicast Subscriber Selection scheme to solve the multiclass problem. In wireless Relay Network, the number of receivers is maximized by determining the topology based on the resource budget and channel quality.

G.Li and H.Liu et al. [4], proposed the resource allocation for the OFDMA based two-hop relay network, which consists of a multiple source nodes, multiple relay nodes and a single destination node. It ensures fairness in orthogonal frequency division multiple access relay networks. Also define, the resource allocation for the OFDMA based two-hoop relay network which consists of a single base station, dedicated fixed relay stations and subscriber stations was studied. But these works focus on unicast transmission in relay networks.

M.K.Awad et al. [5], proposed multicast resource allocation over relay networks. The scheme considers two classes of nodes: relay nodes and receiving nodes. By finding the minimum spanning tree, the total energy required to conduct multicast can be minimized. Although the scheme is suitable for wireless relay networks, it only decides whether or not to activate a relay node during the multicast. The transmitting power of each relay node is assumed to be pre-determined and cannot be adjusted dynamically, thus limiting the system’s flexibility and performance. Moreover, instead of trying to maximize the number of recipients, the goal of this approach is to minimize the total energy requirement of the broadcast tree.

Ankit Gupta et al [6], proposed Efficient Bandwidth (EBM) algorithm for WiMAX network. In this scheme the bandwidth is allocated according to the priority of service class i.e the bandwidth is allocated first to highest priority class. The algorithm contains two parts: Call Admission Control (CAC) and Bandwidth Allocation. The Bandwidth is allocated based on the priority of the service class that is the bandwidth is allocated to the first priority class.

III. RESOURCE ALLOCATION SCHEME

A. Dynamic Station Selection (DSS):

In the dynamic Station Selection scheme, all utility functions are transferred into the envelope function. Using the envelope function allocate resource can achieve suboptimal allocation in polynomial-time complexity. DSS initialize the parameters by setting the residual resource \( r_{res} \) to \( r_{budget} \). DSS starts allocating resource by considering nodes in group 0 one by one. Once the relay stations are included and their members become available to be served, DSS compares the values of \( u^*_{m} \) among the unserved available nodes and chooses the node with the maximal one (i.e., \( m_{max}, n_{max} \)). Then, DSS includes one more node in this group and subtracts the required resource \( \Delta r_{m_{max}}(n_{m_{max}+1}) \) from the residual resource \( r_{res} \). This process is repeated until all nodes have been served or until the residual resource is sufficient to serve any more nodes.

Dynamic Station Selection Scheme:

Input: \( R= \{ R_0, R_1, \ldots, R_M \} \) \% Channel quality
\( I= \{ i_0, i_1, \ldots, i_M \} \% \) Resource Allocation
\( r_{budget} \% \) Budget
Output: \( A= \{ n_0, n_1, \ldots, n_M \} \% \) Resource Allocation

DSS ()
Set envelope \( U= \{ U_0, U_1, \ldots, U_M \} \); \% Utility
Function
For \( m=0 \) to \( m, n_m=0; \% \) number of nodes served in group \( m \)
End for;
\( r_{res} = r_{budget} \);
Do Loop;
\( u_{max}=0; \)
For \( m=0 \) to \( M, \% \) number of RSs
If \( (i_m=0), If (u_m(n_{m}+1)>u_{max}), u_{max} \leftarrow u_m(n_{m}+1); m_{max} \leftarrow m; \)
Endif;
Endfor;
Enddo;
Else
\( r_{res} \leftarrow r_{res} \Delta r_{m_{max}}(n_{m_{max}+1}); \% \) subtracts the requires resource from residual resource
\( n_{m_{max}} \leftarrow n_{m_{max}+1}; \)
Endif;
Enddo;
Return \( \{ [n_0, n_1, \ldots, n_M] \} \)

Given the channel quality \( R= \{ R_0, R_1, \ldots, R_M \} \). RS positions \( I= \{ i_0, i_1, \ldots, i_M \} \), and budget \( r_{budget} \). Multicast Recipient Maximization (MRM) finds a resource allocation \( f = [n_0, n_1, \ldots, n_M] \) that maximizes the total number of served SSs. The DSS behaviour can be illustrated in the auxiliary graph.

Auxiliary graph is a tree with weighted edges. Wireless Relay Network can be represented by an auxiliary graph as shown in figure[1]. All elements of group 0 (i.e., the RSs and SSs directly served by the BS) are placed in the main branch, and the elements of group \( m>0 \) are placed in a side branch.
connected to the main branch. With this placement, for each node, the total distance to the root is equal to the number of resource that it requires, i.e., \( r(m,n) \).

B. Multicast Subscriber Selection (MSS):

The Multicast Subscriber Selection allocates the resource to BS and RS based on the resource budget and channel quality of each link for maximizing the total number of SSs that receive the stream successfully. MSS searches for an allocation with an incrementally better performance to serve more recipients in each round.

![Resource allocation of the link](image)

In MSS scheme the wireless relay network can be represented by the above figure. From the figure, the Relay Stations (RS) are directly connected with the Base Station (BS). The resources are allocated to the stations \( (r_1, r_2, \ldots, r_y) \). The Subscriber Stations does not directly connected to the BS connected by using RSs. The resource is allocated to the SSs which are popped from the queue. The budget means its maximal usable resource, which is set by the system. This budget (that is number of time slots) is to be distributed among BS and RSs.

C. Multi-Level Utility based Resource Allocation [ML-URA] scheme:

First defines the utility function by using greedy algorithm then defines the ML-URA mechanism. In the utility function first we know the amount of additional resource that must be allocated to the RSs on the relay path. At that time, also count the number of additional MSs. Utility is defined as the number of additional MSs divided by additional resource that the network must allocate to the RSs on the relay path. If we compute the utility then find then find how the path between the MR-Bs and RS are constructed. The single shortest tree is constructed that is rooted at the MR-BS then connects each RS.

In ML-URA mechanism, it chooses the (MS, RS) pair with utility which represents the efficiency of resource allocated. On the chosen relay path find the additional MSs that can distribute by extra resource allocated to the RS.

The expression of utility of relay path is defined as,

\[
U_{i,y} = \frac{(F_{sp_{j,y}} + F_{RS_{j,y}} - F_{sp_{j,y}} F_{RS_{j,y}})W_{(j)}/C_{sp_{i,y}} + C_{RS_{i,y}}}{C_{RS_{i,y}}}
\]

In each round, it chooses the \((MS_i, RS_y)\) pair with the highest utility value \( u_{i,y} \) because the value represents the efficiency of the allocation, as defined in above equation. It then finds the extra MSs that can be served by allocating the additional resource to the RSs on the chosen relay path \( SP_y \). Finally, the algorithm checks if there is any wasted resource that could be recycled.

![Flowchart of ML-URA](image)

IV. RESULTS

The simulation results for DSS, MSS, ML-URA algorithms are studied and comparative table is formulated that table given the performance of the allocations of the two schemes under different resource budgets.
From the above table number of SSs are increased in the ML-URA scheme compared with DSS and MSS schemes at the different resource budget levels.

From the figure, number of served recipients is linearly proportional to the node number. This is because more SSs result in higher density. Given the same amount of allocated resource, more SSs would be served.

From the figure the number of served Subscriber Stations is linearly increased in the ML-URA scheme.
among RSs so that they have more opportunities to serve more MSs. By contrast, the increasing trend of the MSS is very limited.

V. CONCLUSION

In this paper, study about the different bandwidth allocation scheme. Compared the three schemes, in ML-URA scheme the number of SSs is increased from the given resource budget. Through simulation result, we show that MSS scheme can utilize RSs effectively and outperform both the ML-URA and the DSS Scheme. So the ML-URA scheme is flexible to allocate the resource.

REFERENCES

[10] Li-Ping Tung, Yeali S.Sun,and Meng Chang Chen ,”Dynamic Bandwidth Reservation Scheme in 802.11 and 802.16 Internetworking Networks” IEEE 2011.