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COST MINIMIZATION FOR WIRELESS NETWORKS USING E-CDS ALGORITHM

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Abstract : **IEEE 802.16 Broadband Wireless technology offers a high speed internet access for both the nomadic and mobile users. To satisfy the needs of the interactive users with low latency and greater throughput, an efficient and robust resource allocation scheme is required. The Medium Access Control (MAC) layer supports both centralized and decentralized scheduling. In distributed, each node arranges them in an ad hoc manner and participates in apportionment of channels, data transfer without the support of BS. In our project, distributed scheduling is taken into account for relaying the packets which are independent of the centralized BS and tightly coupled interworking architecture is addressed for the interworking of Mobile Wi-MAX and WLAN networks. Maintain Handoff History Information in order to reduce unnecessary handoffs and call dropping. The coordinated distributed scheduling incorporates the election algorithm to determine the competing node's transmission slots and hold off time algorithm to compute the node's contention slots. We propose an Enhanced Coordinated Distributed Scheduling (E-CDS) algorithm which prioritizes the transmission opportunities for the conflicting nodes and decides the hold off time of a node using the number of active neighbors. Vertical Handoff (VHO) algorithm is used for the interworking of Wi-MAX and WLAN networks. An ovel approach helps in calculating the conflicts between the nodes based on the routing tree. The proposed scheme strives to achieve broader utilization of transmission slots and minimal time for establishing the data scheduling. Our simulation result proves that E-CDS algorithm provides greater network utilization compared to the existing approaches. The hand-off execution helps in various functions such as available bandwidth, delay, data rate, and cost and so on.**

INTRODUCTION - Wi-MAX

Wi-MAX technology is an improved and efficient version of the Wi-Fi technology, as it can route data to Wi-Fi connected devices as well, which in turn can take advantage of the available Wi-MAX connection. Unlike Wi-Fi connectivity, there is no need for a line of sight connection between subscriber terminals in Wi-MAX. Also the number of devices that can be connected to a single base station in a Wi-MAX network can range between hundreds to thousands of subscriber terminals [7]. The Wi-MAX network is also an IEEE standard as in 802.16 and is capable of supporting real time, low latency applications such as voice, video and internet access simultaneously.

Wi-MAX (802.16) technology is also known by other names such as "Mobile Wi-MAX, 802.16d" and "Fixed Wi-MAX, 802.16e". Even though the current authentication and authorization mechanisms provide fruitful solutions, the improvements to the wireless technology leads a space to vulnerable attacks in numerous ways.

OBJECTIVES OF Wi-MAX

Flexible Architecture: Wi-MAX supports several system architectures, including ubiquitous, Point-to-Point, Point-to-Multipoint, and coverage. The Media Access Control (MAC) of Wi-MAX supports Point-to-Multipoint and ubiquitous service by scheduling a time slot for each Subscriber Station (SS).

High Security: Wi-MAX supports AES (Advanced Encryption Standard) and 3DES (Triple DES, where DES is the (Data Encryption Standard). By encrypting the links between the BS and the SS, Wi-MAX provides subscribers with privacy (against eavesdropping) and security across the broadband wireless interface. Security also provides operators with strong protection against theft of service.

Quick Deployment: Compared with the deployment of wired solutions, Wi-MAX requires little or no external plant construction. For example, excavation to support the trenching of cables is not required.

Once the antenna and equipment are installed and powered, Wi-MAX is ready for service. In most cases, deployment of Wi-MAX can be completed in a matter of hours, compared with months for other solutions.

Multi-Level Service: The manner in which QoS is delivered is generally based on the Service Level Agreement (SLA) between the service provider and the end-user. Further, one service provider can offer different SLA s to different subscribers, or even to different users on the same SS [6].

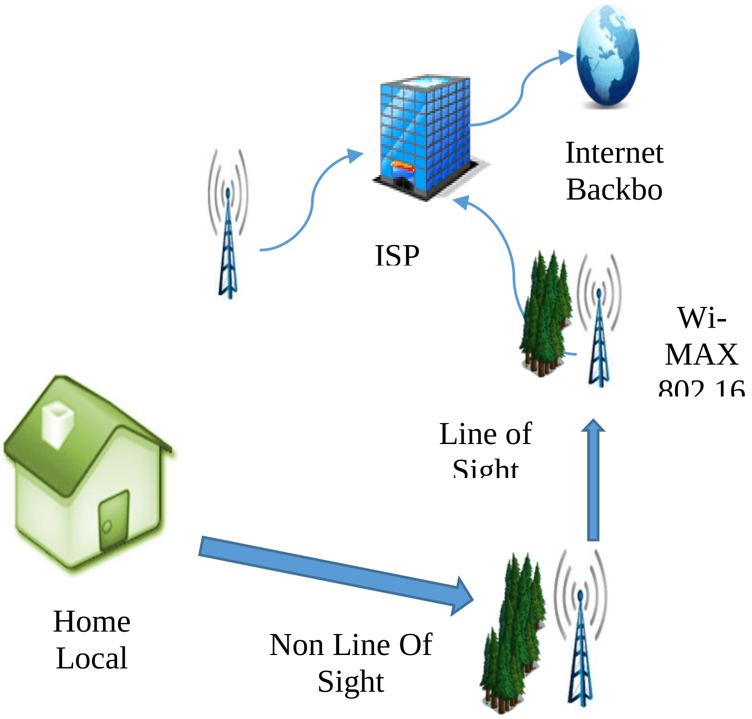
Interoperability: Wi-MAX is based on international, vendor-neutral standards, which make it easier for end-users to transport and use their SS at different locations, or with different service providers. Interoperability protects the early investment of an operator since it can select equipment from different equipment vendors, and it will continue to drive the costs of equipment down as a result of mass adoption.

Portability: As with current cellular systems, once the Wi-MAX SS is powered up, it identifies itself, determines the characteristics of the link with the BS, as long as the SS is registered in the system database, and then negotiates its transmission characteristics accordingly.

MOBILE Wi-MAX : Definition of Mobile Wi-MAX

The Mobile Wi-MAX Air Interface adopts Orthogonal Frequency Division Multiple Access (OFDMA) for improved multi-path performance in non-line-of-sight environments. Scalable OFDMA (SOFDMA) is introduced in the IEEE 802. The Mobile Technical Group (MTG) in the Wi-MAX Forum is developing the Mobile Wi-MAX system profiles that will define the mandatory and optional features of the IEEE standard.

Figure : Simple Wi-Max Architecture



PROBLEM DEFINITION

Existing System is ineffective under overlaid heterogeneous network environments. The performance of the application and the network conditions are considered in the handoff process. But ping pong effects due to variations of multi-attribute handoff are not considered. The decision criterion for hand-off execution is a function of multiple system variables such as available bandwidth, delay, data rate, and cost and so on.

BROADCAST SCHEDULING PROBLEM IN WI-MAX

This paper discuss about, The Wi-MAX standard IEEE 802.16d also called as Wi-MAX Mesh network can operate in multi-hop mode, in which the subscriber stations can communicate with the base station without having direct link between them. In such type of networks, the allocation of channel for the Subscriber Stations is an open issue. This paper deals with providing an efficient algorithm for spatial reuse. First, a dynamic programming (DP) algorithm to find the conflict-free set of nodes that can be activated to achieve optimality in throughput is proposed.

Next, a genetic algorithm is provided, which is more scalable than the DP approach, but does not guarantee optimality. Mutation is mainly used to prevent the population from being dominated by the same kind of chromosomes. Thus, after some time, the population might get dominated by only those kinds of chromosomes, which might sometimes turn out to be a suboptimal solution. To prevent this situation, the children chromosomes are ‘‘mutated”. The probability of an individual to be mutated *dbmp* is very small and is predefined. The probability Pm is also called mutation probability.

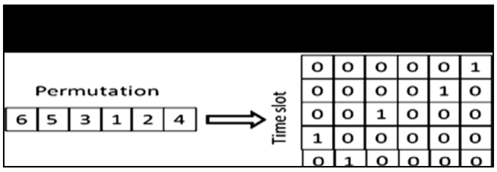


Figure ; Mutation Example

REVIEW OF NETWORK ROUTING IN WI-MAX

Routing in Wireless Mesh Network (WMN) is challenging because of the unpredictable variations of the wireless environment. There are various challenges for the routing in Wi-MAX mesh such as delay, long transmission scheduling and increasingly stringent Quality of Service (QoS) support and load balance and fairness limitations. The goal of this paper is to review some routing algorithms proposed by various authors for IEEE 802.16 mesh networks. This paper discusses the problem of routing for providing QoS, for minimizing interference, robustness and fairness. The shortest path routing always produce a lot of congestion in the network because all the nodes will try to choose the same shorter route and results in unbalanced network.

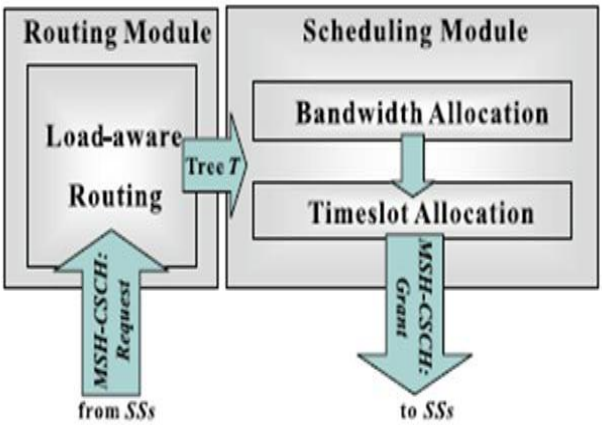


Figure : The System Model at BS

A fixed routing algorithm which may work well for both real as well as data traffic, due to fixed path, reservation of resources is possible and hence QoS guarantees can easily be provided. Thus, if the link failure occurs or route degrades considerably, which is reasonably high in wireless medium, the routing will fail. Authors do not mention any mechanism to handle such link failure. However, recounting the routing tree may solve this issue.

SCHEDULING USING GRAPH COLORING ALGORITHM

This paper deals with a conflict-free scheduling in multi hop packet radio networks. A method for establishing communication channels between the given set of pairs of nodes is proposed.

The delays for all channels are constant and requested network resources minimized. For each channel a virtual path is determined and optimal scheduling found using DSATUR graph coloring algorithm. The paper combines the MAC and routing layer in a single algorithm. Such an approach applied to wireless networks, leads to communication time shorter than the one described in the literature. Different techniques of access to radio bandwidth are exploited to avoid conflicts. In the TDMA mode, stations send and receive messages of constant duration, called packets. A packet traverses between adjacent stations in a fixed length timeslot. Two stations cannot be assigned to the same timeslot if it causes a conflict. As the TDMA cycle shows a repeatable pattern of assigning timeslots to links or stations of a network. In FDMA or CDMA modes timeslots are replaced by frequencies or codes, respectively, to obtain a conflict-free scheduling. From the optimization methodology point of view, there is no significant difference between these schemes and the task is to obtain the shortest TDMA cycle, the smallest number of frequencies, or codes.

BANDWIDTH BALANCING IN MULTI-CHANNEL WI-MAX

In wireless mesh networks, the end-to-end throughput of traffic flows depends on the path length, i.e. the higher the number of hops, the lower becomes the throughput. Here, a Fair End-to-end Bandwidth Allocation (FEBA) algorithm is introduced to solve this problem. FEBA is implemented at the Medium Access Control (MAC) layer of single-radio, multiple channels IEEE 802.16 mesh nodes, operated in a distributed coordinated scheduling mode. FEBA negotiates bandwidth among neighbors to assign a fair share to each end-to-end traffic flow. This is carried out in two steps. First, bandwidth is requested and granted in a round-robin fashion where heavily loaded links are provided with a proportionally higher amount of service than the lightly loaded links at each round. Second, at each output link, packets from different traffic flows are buffered in separate queues which are served by the Deficit Round Robin (DRR) scheduling algorithm. If multiple channels are available, all of them are shared evenly in order to increase the network capacity due to frequency reuse. The performance of FEBA is evaluated by extensive simulations and is shown to provide fairness by balancing the bandwidth among traffic flows.
The WMN architecture, in general, consists of two tiers [1]: *backhaul* and *access* tiers where the *backhaul* tier consists of *wireless mesh routers* which create a multi-hop ad hoc network and provide Internet or intra-WMN connections to *wireless mesh clients* in the *access* tier. Wireless mesh routers are fixed device with unlimited energy, high computational and communication capabilities.

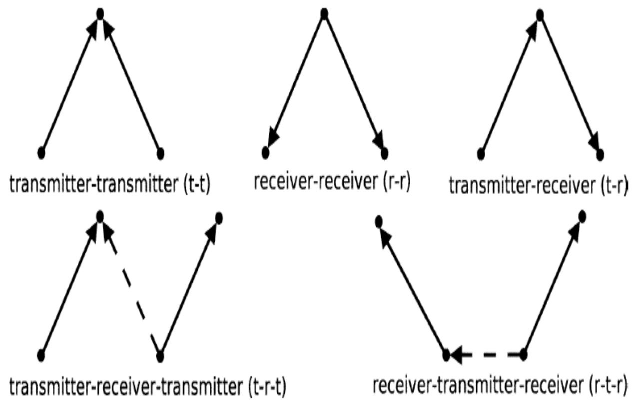


Figure : Conflicts in TDMA Wireless Networks

Symbolic Name of Service Type	Meaning	Scheduling Service
UGS	Unsolicited Grant	UGS
RT-VR	Real-Time Variable Rate Service	RtPS
NRT-VR	Non-Real-Time Variable Rate Service	NrtPS
EERT-VR	Extended Real-Time Variable Rate Service	ErtPS
BEE	Best Efforts Service	BE

The conflicts are based on the distance model interference, which assumes that two links interference with each other at a receiver, if the receiver cannot decode packets from either link. We show five types of transmission conflicts between isolated airs of links in figure .

The first three types of conflicts are between the links that share a neighbor—*primary conflicts*. In the case of the transmitter-transmitter (t-t) conflict, the parallel transmissions garble each other at the common receiver. In the case of the receiver-receiver (r-r) conflict, a single transmitter cannot separate packets intended for two different receivers.

The transmitter-receiver (t-r) conflict happens because the nodes cannot transmit and receive at the same time. A node has primary conflicts with its neighboring nodes.

In addition to the three direct neighbor conflicts, TDMA networks also have a restriction on their second hop neighbor links – secondary conflicts. We show this as the transmitter-receiver-transmitter (t-r-t) conflict. In the t-r-t conflict, the two conflicting links are shown with a solid line. They cannot transmit at the same time because the two transmitters share a neighbor, which hears both transmissions, shown with the dashed line for the overheard transmission.Only the first four conflicts need to be considered in TDMA networks [11]. However r-t-r (receiver-transmitter-receiver) conflict, the conflicting links cannot transmit at the same time because the two transmitters cannot overhear each other. This is not a problem, since a sender can transmit while other transmissions are ongoing.

The conflict matrix B = (b_{ij}) is an N * N matrix which gives details about the compatibility of nodes. Formally, the conflict matrix can be defined as,

$$b_{ij} = \begin{cases} 1, if\ v_i\ and\ v_j\ are\ atmost\ 2\ hops\ away \\ 0, otherwise \end{cases}$$

Thus, nodes vi and vj can transmit simultaneously only if bij equal to 0. This is the conventional way of finding the conflict matrix from the network topology. Thus the conflicts could be efficiently calculated from the routing tree which defines the recipients of each node's transmission.

Conflict matrix is defined as,

$$b_{ij} = \begin{cases} 1, if\ v_i\ and\ v_j\ are\ neighbours \\ 1, if\ v_i's\ predecessor\ in\ routing\ tree\ and\ v_j\ are\ neighbours \\ 0, otherwise \end{cases}$$

Thus the conflicts between the nodes can be minimized by constructing an interference aware routing tree, which can be constructed by algorithms [12] by considering the blocking metric. Consider a sample network topology represented as a graph as shown in Figure .

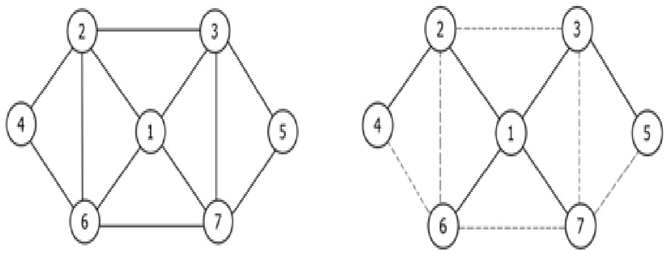


Figure :Sample Topology and Routing Tree

The conflict matrix calculated using Figure is shown below,

$$B = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 0 & 1 & 0 \\ 1 & 1 & 1 & 0 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 & 0 & 1 & 1 \\ 1 & 1 & 1 & 0 & 1 & 1 & 1 \end{bmatrix}$$

Figure : Conflict Matrix for Above Network

The conflict free matrix specifies the conflicts that arise when both the nodes transmit or receive packets from the same node that is common between them. For example, in the Figure 3.4, the nodes 4 and 7 are in two hop conflict with each other only if node 4 or 7 transmits packets to 6.

But node 4 transmits its packet to node 2 and node 7 transmit packet to node 1 in the network, i.e. it may have other nodes as its intermediate node for sending data which is determined by the routing tree.

SYSTEM ARCHITECTURE

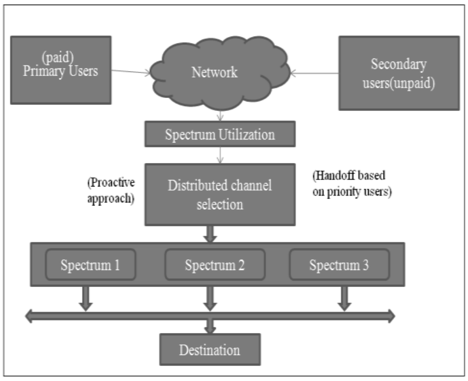


Figure :System Architecture

SCHEDULING

The transmissions will follow the same TDMA frame repeated over time. The frame for a network of N nodes and schedule length of M is represented by means of T matrix containing M*N elements, where

$$t_{ij} = \begin{cases} 1, if\ v_i\ transmits\ in\ time\,slot\ \ j \\ 0, otherwise \end{cases}$$

We consider scheduling of nodes in a Wi-MAX mesh network in which nodes in the network transmit packet to the BS. So only uplink scheduling is considered. The downlink schedule can be calculated similarly as for uplink scheduling. The number of packets to be transmitted by a node i to transmit its data is denoted as an integer as demand(i); demand is a single dimensional vector of size n denoting the time-slots needed to transmit data by each node in the network. When a node transmits data from node i to node j for a single time-slot, the demand (i) is decremented by 1 and demand (j) is incremented by 1.

The objective is to find the optimal TDMA frame, such that the following constraints are satisfied:

- Node's outbound link must be scheduled only after its inbound link is scheduled. i.e., scheduling delay must be minimized.
- No node can receive and transmit data at the same time, i.e., the primary constraint should be satisfied.
- No node can receive data from 2 other nodes at the same time, i.e., the secondary constraint must be satisfied.

Based on the above constraints, we propose a scheduling algorithm, Progressive Concurrent Scheduling (PCS) which addresses the problem of scheduling delay and also allows concurrent transmissions by the subscriber stations (SSs) thus minimizing the schedule length.

1) Calculating the states optimally In this algorithm, we construct collision free set, considering each of the nodes, allotting the slot for the nodes in the collision free set and scheduling the remaining node recursively and choose the one with the minimum scheduling length.The recurrence for calculating the Minimum length Schedule (MS) for a demand may be stated as

$$MS(demand) = \begin{cases} 1 + MS(demand_{updated}) \\ \\ 0, demand(i)\ for\,all\,nodes\,i\,is\,0 \end{cases} \quad (3.5)$$

When we find the transmission schedule recursively, we may be solving the same problem more than once, thereby increasing the complexity of the algorithm. To avoid solving same problem more than once, we use dynamic programming to memorize the already solved slots, storing their answer and then using the saved answer instead of calculating again.

The Progressive Concurrent Scheduling Algorithm may be formulated as

```
function Progressive Scheduling Algorithm
Input: demand, consisting of no of packets to be sent by each node to base station
Output: Transmission schedule for nodes satisfying the demand.
begin
if MS[demand] is already calculated then
 return MS[demand]
Set T={}
for all node i other than root
 add i to T if demand[i]!=0
schedule MinLenSchedule=sum of demand[i]
for every node n in T
 S=CFS(n) in T;
 schedule s
 allocate the first time slot of s to all nodes in S
 update demand from nodes in S to its predecessors
 schedule opt=PCS(demand);
 add schedule opt to end of schedule s
 if (length(MinLengthSchedule) < length(s) ) then
                              MinLengthSchedule = s
 MS[demand]=MinLengthSchedule
 return MS[demand]
end
```

For the sample graph presented in Figure if we apply progressive concurrent scheduling algorithm we will get a schedule as represented in Figure

Slot	1	2	3	4	5	6
Schedule(Nodes)	2,5	3,4	2	3	6	7

Figure :PCS TDMA Schedule

PERFORMANCE ANALYSIS

The performance of the proposed scheduling algorithm is compared with the graph based scheduling algorithm with the help of a simulation model implemented in C++. The GCS and PCS algorithms were tested by 100 randomly generated graphs of different number of nodes, each representing a Wi-MAX network topology. Since Wi-MAX nodes have a larger range, the average degree of a node was set as 3.

The graphs were generated as follows.

According to graph theory,

$$\sum_{i=1}^{N} d_i = 2 \times e$$

Where ‘e’ is the number of edges in the graph and ‘d_i’ s the degree of the node v_i. Dividing both sides by n, we get,

$$\frac{\sum_{i=1}^{N} d_i}{N} = \frac{2e}{N}$$

Average node degree = $\frac{\sum_{i=1}^{N} d_i}{N}$ = 3 (in our case)

Thus we have,

$$\frac{2e}{N} = 3 \Rightarrow e = \frac{3N}{2} = 1.5n$$

Also, since 1.5n > (n-1), it is guaranteed that a graph with 1.5n nodes will contain only a single component.

The graph is thus generated randomly, generating 2 numbers in the range [1,n] and drawing an edge between them. $\lfloor 1.5N \rfloor$ Such edges are added, (where $\lfloor \ \rfloor$ is the floor function) so that the node degree becomes approximately 3.

The TDMA schedule length generated for the gcs and pcs algorithms are tabulated below in figure.

	TDMA schedule length	
No of nodes	Gcs	Pcs
10	13	12
20	25	22
30	34	30
40	67	63
50	85	82
60	107	102
70	132	127
80	168	160
90	196	188
100	228	218

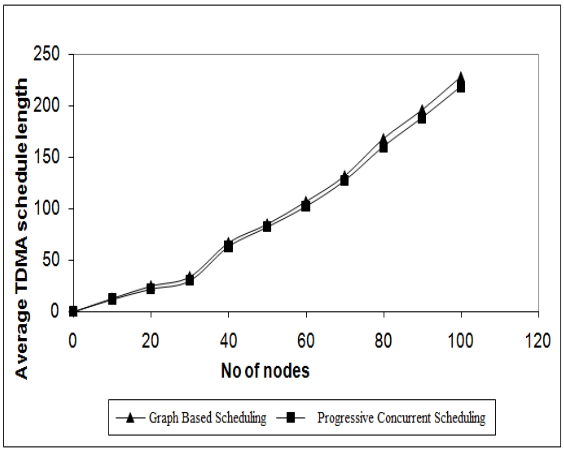
Figure :TDMA Schedule Lengths for PCS and GCS

Figure ,shows the test cases in ns-3 modules and figure 4.3 shows the test case units in ns-3 modules. MAC layer testing in Wi-MAX is shown in figure 4.4. Figure 4.5 depicts the trace delay between SS. Figure4.6 depicts the trace of packet size and address. Figure 4.7 shows the uplink allocation and the down link allocation. Figure 4.8 shows the packet transfer between the Net devices. Figure 4.9 shows the passing command line arguments to increase the numbers.

Simulation and Results

The results and inferences of the proposed algorithms are presented. First, a comparison between BFCFS and DPCFS is made. Thus the different approaches to solve the problem were presented and could be modified to improve the efficiency by eliminating repeated states, and hence reducing the complexity of the algorithm. DPCFS always produced the maximal CFS of nodes, but suffered from high memory requirements.

Thus Genetic algorithm reduces it.



Comparative Analysis of PCS and GCS

The comparative analysis of the TDMA schedule length of the two algorithms is shown in figure 4.10. The difference in the schedule length corresponds to the scheduling delay caused when the outbound link is scheduled before the inbound link gets scheduled in the case of graph based scheduling algorithm GCS.

CONCLUSION

The need for efficient routing and scheduling algorithms in Wi-MAX networks is evident for the deployment of new applications such as VoIP. A novel approach for calculating the conflicts between the nodes based on the routing tree has proposed. The scheduling delay in graph coloring based scheduling algorithm has been discussed and an efficient algorithm for eliminating scheduling delay has been proposed in this paper. The performance of the proposed scheduling algorithm has been evaluated through simulation.

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