Bandwidth Management in Wireless Mesh Networks

Y.Vijaya Kumar, A.Basi Reddy, B.Ramakantha Reddy, D.Abhishekh

Abstract— Wireless Mesh Networks plays an important role in the future internet and implemented using different type of technologies called 802.11, 802.16 and cellular technologies or the combinations of two or more technologies. These type of networks can be widely used in many applications, because of their faster configuration and less cost. For these networks, bandwidth management is always a challenging and research problem. To solve this problem, we propose a method which consists of Connection Admission Control (CAC) to estimate and reserve the bandwidth. Bandwidth reservation depends on the Average data rate calculated. The data packets can be distributed in the network, based on the calculation and decision we made ahead, that means based on the Avg. data rate & concerned path, we have to made some decision control. So in this way, we can manage the bandwidth efficiently.

Index Terms— Wireless mesh network, 802.11, 802.16, connection Admission control (CAC), AODV, Routing protocol, Bandwidth

1 INTRODUCTION

Wireless Mesh Network means that the nodes of the wireless networks communicated directly with the any other node within the mesh network. Each and every node within this mesh network not only act as a client or host and also acts as a router. These networks comprising of clients, routers and gateways. Laptops, cell phones and all other wireless devices come under the clients. Routers forward the data packets traffic to and from the gateways. The main difference between wireless mesh router and the conventional router is that it can achieve the same coverage but with low transmission power. Wireless mesh network may be treated as a special type of wireless ad-hoc networks. But the main difference between the ad-hoc networks and the mesh networks is that in mesh networks, we assume that almost all the nodes are immobile but this may not be the necessary condition. Whereas a mesh network is highly reliable and also redundancy is achieved. For example, when any one node within the network is not in working state, the remaining nodes continue their communication directly or through any of the intermediate nodes.

Wireless Mesh Network architecture can be classified into three categories

(i) Infrastructure mesh network
(ii) Client mesh network
(iii) Hybrid mesh network

In this infrastructure mesh networking, mesh routers form an infrastructure to the mesh clients and also these are connecting to the internet with the use of gateway functionality. These type of mesh networking routers uses the two types of radios. One is for backbone communication and other is for the client communication.

In client mesh networking, there is no need of the router and the data packets travelled throughout network with the help of neighboring nodes or clients. So it provides a peer-to-peer type of communication.

Where as in hybrid mesh networks both client to client communication and router to client communication is there, which means that it is combination of infrastructure and clients mesh networks. So this type of network is most common usage type of network.

There are two tiers present in this architecture.

(i) Back haul tier
(ii) Access tier

Mesh routers comes under the Back haul tier, whereas mesh clients comes under the access tier. In the recent years, some of the experiments conducted for the back haul tier with the 802.11 mesh networks. But with these type of mesh networks many problems came into existence. Some of them are hidden node problem, back off problem. For medium access, if the path is long to reach the packets from source to the destination then it will face more collision and data loss problems. To solve the above mentioned problems and some other problems which are not mentioned here, 802.16 mesh networks came into existence, which is mainly concentrating on the back haul tier of the mesh network

Some of the works relating to the bandwidth estimation and as well as reservation presented in the section II. Where as in the section III, we present the proposed System and in section IV detailed design for the proposed architecture was presented.

2 RELATED WORK

For these mesh networks QOS is a big issue. Because QOS involves many dimensions such as network bandwidth and delay etc.. Here we are mainly concentrating on the bandwidth property of the wireless mesh networks. In the 802.16 mesh networks, C.cicconetti, I.F. Akyildiz and L.Lenzini [1,2] pro-

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posed an algorithm called FEBA a distributed algorithm which is mainly concentrating on the unfairness of the different path length data flows and also differentiated services in terms of throughput, are provided to traffic flows with different priorities. To this aim, round-robin scheduling algorithm is used for the bandwidth reservation means the data packets are served in a round-robin manner and data flows are served appropriately weighted according to their flow priorities. Here the problem with this round-robin scheduling algorithm is that pure round-robin scheduling doesn't acknowledge priorities, and doesn't allow out-of- order processing. Real life systems typically use a mixture of algorithms that together allow for prioritized and out-of-order processing. While on the other hand trying to prevent starvation of lower priority items.

With presence of the hidden terminals, the available bandwidth estimation is very difficult. Based on this bandwidth estimation, they designed ACA to effectively address both the real-time& non real-time traffic flows. For the real-time flows, almost all the nodes makes ACA on a particular route of the network and for nonreal-time flows they adjust the sending rates of the data from the source by using a rate adaptation algorithm. This is done in order to prevent the network from the congestion

2.1 Problems of FEBA [1]:

In order to implement this algorithm, we must assume that the network topology is fixed.i.e, nodes are not added or removed from the network. But nodes on different links may change over time, links are considered to be stable. So in this case, all the links to the nodes are stable (or) static. If we want to change the links means in dynamic or in real-time environment this algorithm may not work properly.Bandwidth requests and grants were carried out in a Round-Robin fashion where the amount of service is proportional to the no. of traffic flows going to or coming out of the neighbor. Here the problem with this Round-Robin scheduling algorithm is that pure round robin scheduling doesn't acknowledge priorities, and does not allow out-of-order processing. Real-life systems typically use a mixture of algorithms that, together, allow for prioritized and out-of-order processing while, on the other hand, trying to prevent starvation of lower priority items.

2.2 Disadvantages of Round-Robin scheduling:

Round Robin Scheduling is preemptive (at the end of time-slice) therefore it is effective in time-sharing environments in which the system needs to guarantee reasonable response times for interactive users.The performance of the RR algorithm depends heavily on the size of the time quantum or time slice. If the time quantum is very large (infinite), the Round-Robin policy is the same as the FCFS policy. If the time quantum is very small (few msec), the RR approach is called processor sharing.Unlike Shortest Process Next and Shortest Remaining Time, round-robin does not exhibit live lock and it is impacted much by the halting problem (a process that never ends will not end, but other processes will still run).

The AODV routing protocol is used to find the different ways or paths from source to destination. The principle of operation of this particular routing protocol is that first source sends request message for the route. It circulates throughout the network until it reaches the destination. In addition to that, it creates a table for the node entries where it passes. After reaching the destination, the destination node sends the reply message to the source. After that reply message reaches the source node, after a particular time period, that node table entries will vanishes.

3 Proposed System

The proposed system provides an algorithm for wireless mesh networks. But here we are approaching a different method for bandwidth requesting and granting instead of using round-robin fashion. So, here we apply the AODV (Ad-hoc On-demand Distance Vector) routing protocol to find the multiple paths between source node and the destination nodes. i.e. how we will apply means, it is the mesh network so there is no central base station for the remaining nodes. Any node within this mesh network can act as client or router. So there is no central controlling of the network. Whenever a node wants to send the data packets to any other node within the network, it first broadcasts a route request message for the connection to destination node. Other nodes forward that message by creating temporary routing tables. If that message reaches the destination node, then the destination node sends a route reply message using the same route with which it gets request message. Whenever the link fails, then routing error is send back to the source node, so that process repeats. In the above way, we will find the no. of possible paths between source and destination nodes. After that we implement the Connection Admission Control (CAC) scheme for estimation & reservation of bandwidth.

Here we use CAC (Connection Admission Control) procedure to estimate and reserve the available bandwidth using fair queuing. The process of applying CAC is as follows. First of all we have to note down the no. of active data flows. After that we have to calculate the weights for all the active data flows. Finally we have to calculate the Avg. data rate, based on this we have to send the packets. After calculating Avg.data rate for every path, we will apply decision procedure that by considering which path& concerned Avg.data rate the job finishes first like SJF (Shortest Job First).

4 Detailed Design

4.1 Assumptions:

1. The links to the nodes are stable. Because 802.16 mesh nodes are used as clients as well as routers also.
2. Network topology is fixed. If at all any variations occur in the quality received by the nodes may change.
3. Single node has a single radio interface, so that some of the available channels to a single channel for a given point of time

4.2 Procedure/Algorithm

1. Applying AODV routing protocol to find the path between source node to destination node
i. Source node broadcasts a route request message for connection to destination node.

ii. Other nodes forward that message by creating temporary routing tables.

iii. If that message reaches the destination node, then the destination node sends a route reply message using the same route with which it gets request message.

In the above way, we will find the no. of possible paths between source and destination nodes. After that we will apply the below CAC procedure for each& every possible path.
NOTE: whenever the link fails, then routing error is send back to the source node, so that process repeats.
2. CAC is used to estimate and reserve the available bandwidth using fair queuing.
i. Note down the no. of active data flows.
ii. Calculate the weights for all the active data flows.
iii. Note down the link data rate.
iv. Calculate the Avg. data rate by using the below formula.

$$\text{Link data rate} * \left(\frac{\text{Scheduling weight for flow i}}{\text{Sum of weight of active flows}} \right)$$

Where

$$\text{Scheduling weight} = \left(1/\text{cost factor} \right)$$

Cost factor= time required to transmit the bits using modulation scheme.

v.After calculating Avg.data rate for every path, we will apply decision procedure that by considering which path& concerned Avg.data rate the job finishes first like SJF(Shortest Job First).
Note: Steps i to iv repeats for every possible path to the destination node identified by the above routing protocol.

3. Finally we will go for testing process, which is used for verifying that whether all the links are stable or hidden node problem and try for the solution to resolve the hidden node problem in the mesh mode by using re-granting procedure.

5 Results and Analysis

In this paper, we use the ns-2 simulator for the analysis of results for the proposed system. Here, we consider the dropping rate, flow rate and the successful transmission rate as the parameters for the analysis of results.

For the analysis purpose, we took some total number of packets at the sender node in the wireless mesh network and also we identify the total number of flows or paths to send those packets. We send the total packets through the identified flows or paths. After the successful transmission of all packets from the source node, we noted down the transmitted packets i.e., received packets at the receiver node and also we calculate the dropped packets. Dropped packets are calculated by subtracting the transmitted packets from the total number of packets. We tabulate the transmitted packets and dropped packets for different number of total packets as well as flows.

For example, if we send the 3736 packets through the 20 flows, we get 3709 packets as the receiver node, which will be treated as transmitted packets. After noted down the transmitted packets, we need to calculate the dropped packets in the same case. Here, we get 27 dropped packets which are subtraction result of transmitted packets from total packets.

The same scenario applicable for rest of the cases for different number of possible values, which are tabulated below.

TABLE-1
Data packet Results from execution

No.of flows	Total Packets	Transmitted packets	Dropped packets
20	3736	3709	27
40	7232	7165	67
60	12160	11941	219
l80	17370	16766	604
100	26540	25045	1495
120	25142	24346	796
140	25175	24193	982
160	26430	25350	1080
180	24501	23767	734
200	26551	25592	959
220	26946	26054	892
240	24808	24069	739

After we tabulating the results, some of the graphs were presented below which includes dropping rate and transmission rates for the total number of packets. Here we consider the dropping rate, flow rate and the successful transmission rate as the parameters for the analysis of results.

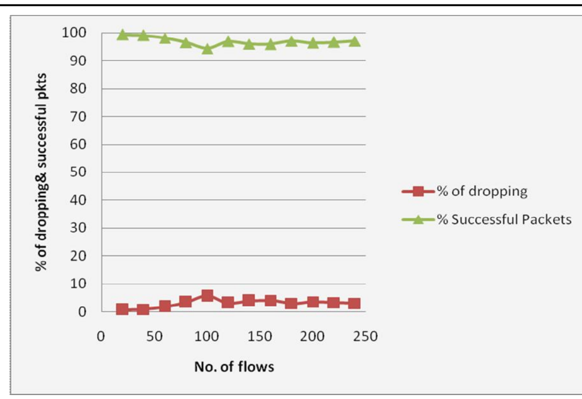

Fig. 1. No. of flows Vs % of dropping and successful packets

Here, in the above graph we showed clearly the successful rate and also the dropping rate of the packets for different number of flows by using the proposed system. By using, our proposed system we achieved the maximum successful rate of the packets which yields the minimum dropping rate of the packets

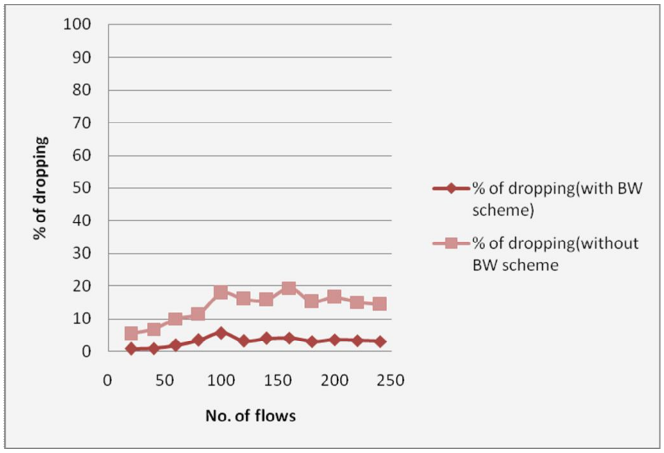

Fig. 2. No. of flows Vs % of dropping packets

Here, in the above graph we showed clearly the difference of the dropping rate of the packets for the existing scheme i.e., without Bandwidth management scheme and the dropping rate of the packets for the proposed scheme i.e., with Bandwidth management scheme. We plotted the graph for different number of flows and percentage of packets dropped. Here, we observed that the percentage of dropping will be less by using the Bandwidth management scheme which we proposed.

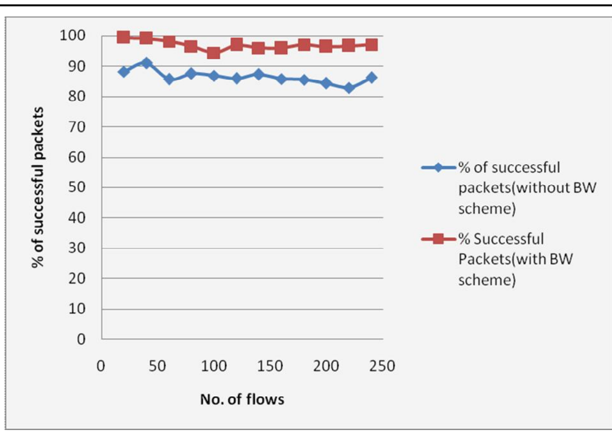

Fig. 3. No. of flows Vs % of Successful packets

Here, in the above graph we showed clearly the difference of the successful rate of the packets for the existing scheme i.e., without Bandwidth management scheme and the successful rate of the packets for the proposed scheme i.e., with Bandwidth management scheme. We plotted the graph for different number of flows and percentage of packets successful. Here, we observed that the percentage of successful will be high by using the Bandwidth management scheme which we proposed.

6 Conclusion

In this paper, the packets flow in a wireless mesh network is examined by using routing protocol for finding the path and also applying the CAC procedure. The routing protocol is used to find route between source and destination nodes. We also examined the way of flow of the packets in the wireless mesh mode. By this, we can say that we are reducing the bandwidth by applying above specified algorithm. By using this proposed system, how we are managing the bandwidth means, instead of using the whole bandwidth for sending the packets, we are using only some part of the bandwidth for sending the packets an also we exclude the in-active nodes. So that no need of assigning bandwidth for the inactive flows. In addition to the above, we also say that we utilized the assigned bandwidth efficiently by increasing the successful rate of the packets and also by reducing the dropping rate. But we can also say that bandwidth management is always going to be research problem. By applying new techniques, we may go for different approach for reducing the bandwidth utilization in an efficient manner. But here we went for one of the approach.

References

[1] C. C.cicconetti, I. F. Akyildiz, and L. Lenin, "FEBA: a bandwidth allocation algorithm for service differentiation in IEEE 802.16 wireless mesh networks," IEEE/ACM Trans. On Networking, vol.17, no.3, June 2009, pp. 884–897.

[2] C. C.cicconetti, I. F. Akyildiz, and L. Lenin, "Bandwidth balancing in multi-channel IEEE 802.16 wireless mesh networks," in Proc. IEEE INFOCOM, Anchorage, AK, May 2007, pp. 2108–2116.

[3] P. Venkata Krishna, N.Ch.S.N. Iyengar, and sudip Misra,"An efficient Hash Table-based node identification method for bandwidth reservation in hybrid cellular and ad-hoc networks", computer communications, 31 (2008) 722–733.

[4] Xun Yang, and Gang Feng, "Bandwidth reallocation for bandwidth asymmetry networks based on distributed multiservice admission control," IEEE Trans. on mobile computing, vol.7, no.11, Nov.2008, pp.1311-1324.

[5] Q.Shen, X.Fang, Pan Li, and Y.Fang, "Admission control based on available bandwidth estimation for wireless mesh networks," IEEE Trans. on vehicular technology, vol.58, no.5, June 2009, pp.2519-2528.

[6] Stefano Avallone and Ian F. Akyildiz," A channel assignment algorithm for multi-radio wireless mesh networks", Computer Communications 31 (2008) 1343–1353.

[7] Jorge Crichigno, Min-You Wu and Wei Shu," Protocols and architectures for channel assignment in wireless mesh networks", Ad Hoc Networks 6 (2008) 1051–1077.

[8] Jun Wang,Peng Du,Weijia Jia,Liusheng Huang and Huan Li," Joint bandwidth allocation, element assignment and scheduling for wireless mesh networks with MIMO links", Computer Communications 31 (2008) 1372–1384.

[9] A. Hamed Mohsenian Rad and Vincent W.S. Wong," Congestion-aware channel assignment for multi-channel wireless mesh networks", Computer Networks 53 (2009) 2502–2516.

[10] Xun Yang and Gang Feng, "optimizing admission control for multiservice wireless networks with bandwidth asymmetry between uplink and down-

link," IEEE Trans. On vehicular technology, vol.56, no.2, March.2007, pp.907 – 917

[11] Stefano Avallone, Ian F.Akyildiz and Giorgio ventre, "A channel and rate assignment algorithm and a layer-2.5 forwarding paradigm for multi-radio wireless mesh networks," IEEE Trans. On networking, vol.17, no.1, Feb.2009, pp.267-280.

[12] Dong wanly, Bi Kun and Zhang lei, "Distributed channel assignment algorithm for Multi-channel Wireless Mesh Networks," IEEE computer society ISECS International Colloquium on computing, communication, control and management, 2008, pp.444 – 448.

[13] I-Shyan Hwang, Bor-Jiunn Hwang, Ling-Feng Ku and Pen-Ming Chang,"Adaptive bandwidth management and reservation scheme I heterogeneous wireless networks," IEEE International conference on sensor networks, Ubiquitous and Trustworthy computing,2008, pp.338 – 342.

[14] Seungjae shin, Junbeom Hur, Hanjin Lee and Hyunsoo Yoon, "Bandwidth efficient key distribution for secure multicast in dynamic wireless mesh networks," Korea Advanced institute of Science and Technology and reviewed by IEEE communications society,2009.

[15] Ghalem Boudour, cedric Teyssie, and Zoubir mammeri, "Bandwidth reservation for Heterogeneous traffics in mobile wireless networks," IEEE computer society fifth international conference on Telecommunications,2009. pp.272 – 277.

[16] Lien-Wu Chen, Yu-Chee Tseng, You-Chiun Wang, Da-Wei Wang and Jan-Jan Wu,"Exploiting Spectral Reuse in Routing, Resource Allocation, and Scheduling for IEEE 802.16 Mesh Networks", IEEE Trans.on Vehicular Technology, vol.58, no.1, Jan.2009, pp.301-313.

[17] Emma Carlson, Christian Prehofer, Christian Bettstetter, Holger Karl and Adam Wolisz, "A daistributed end-to-end reservation protocol for IEEE 802.11 based WMNs," IEEE Journal on selected areas in communication, vol.24, no.11, Nov.2006, pp.2018-2027.

[18] Shie-Yuan Wang, Chih-Che Lin, Han-Wei Chu, Teng-Wei Hsu and Ku-Han Fang,"Improving the Performances of Distributed Coordinated Scheduling in IEEE 802.16 Mesh Networks",IEEE Trans.on Vehicular Technology, vol.57, no.4, July 2008, pp.2531-2547.

[19] A.Hamed Mohsenian Rad, Vincent w.s.wong, "Cross-layer fair bandwidth sharing for multi-channel wireless mesh networks," IEEE Trans. On wireless communications, vol.7, no.9, Sep.2008, pp.3436 – 3445.

[20] Tehuang Liu and Wanjiun Liao, "Location-dependent throughput and delay in wireless mesh networks," IEEE trans. on Vehicular technology, vol.57, no.2, Mar.2008, pp.1188 – 1198.

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