BANDWIDTH RESERVATION TECHNIQUE BASED ON TRAFFIC PRIORITY FOR WIRELESS MESH NETWORKS

Valarmathi K.[1] Malmurugan N.[2]

[1]Research Scholar, Sathyabama University Chennai, India valarmathiphd@gmail.com
[2]Principal, Oxford Engineering College Trichy, India

ABSTRACT

Multimedia applications in wireless mesh networks need proper resource allocation strategy, since the crucial factors for Quality of Service (QoS) in real time multimedia applications are the Bandwidth allocation and delay factors.In this paper, a bandwidth reservation technique based on traffic priority is proposed for wireless mesh networks. Using the bandwidth request and bandwidth reply messages, the destination node reserves the bandwidth along the reply path, based on the priority of traffic classes. By simulation results, It has bee shown that the proposed technique achieves high bandwidth utilization and throughput with reduced delay.

Keywords: Wireless Mesh Networks (WMN), Quality of service (QoS), Bandwidth Reservation, Bandwidth Request (BREQ), Bandwidth Reply (BREP).

I. INTRODUCTION

A. Wireless Mesh Networks

Wireless mesh networks (WMN's) contains several stationary wireless routers which are interlinked by the wireless links. Wireless routers acts as the access points (APs) for wireless mobile devices. Through the high speed wired links, some wireless routers act as a gateway for internet. Wireless mobile devices transfer data to the corresponding wireless router and further these data's are transferred in a multi-hop manner to the internet via intermediate wireless routers. The popularity of WMN's is due to their low cost and auto-organizing features [1].

Multi-channel wireless mesh network architecture requires topology discovery, traffic profiling, channel assignment and routing. This includes static aggregation nodes similar to the wireless LAN access points. For the construction of multi-channel wireless mesh networks MCWMN, 802.11b interface hardware is used because it can handle the bandwidth problem. Every node in a multi-channel wireless mesh networks MCWMN includes multiple 802.11 complaint NIC's and it is tuned to a particular radio channel for long duration such as hours or days [2].

B. Bandwidth Allocation in WMN

Bandwidth allocation refers to various methods used in the communication industry to design and assign frequency channels to various wireless applications. It can be defined as a process which allocates resources to various connections so that minimum rate requirements of every connection are satisfied.

In other words, it is a method of fairly allocating traffic bandwidth in shared telecommunication medium and between different users of that particular bandwidth on demand. This is referred to as bandwidth management where sharing of link adapts in some way to the instantaneous traffic demands of the nodes connected to the link.

In case of high speed digital audio and videos, multimedia application requires the source of inflexible Quality of Service (QoS), when compared with traditional application. The purpose of proper Bandwidth allocation is essential for these conditions. The crucial factors for QoS in real time multimedia applications are the Bandwidth allocation and delay factors [3].

The challenges faced in wireless media for Bandwidth allocation on multimedia application includes [4]

- Harmful effects such as Fading and co-channel interferences (CCI) causes distortion in channels.
- The resources such as Bandwidth and power are limited.
- The data rates in multimedia application are irregular.

- System efficiency and fairness are the service factors which are given more importance among individuals.

The few Bandwidth Allocation techniques are:

IntServ and DiffServ [5]

QUOTA [6]

SWAN [7]

INSIGNIA [8]

In our previous paper [13], we have proposed a congestion control routing protocol along with multi-channel assignment. We have used a traffic aware metric in that protocol to provide quality of service. The proposed protocol can improve the throughput and channel utilization to very high extent because it provides solution for multi-channel assignment and congestion control. The proposed algorithm assigns the channels in a way that, congestion is avoided and co-channel interference levels among links with same channel are reduced.

As a continuation of our previous work, in this paper, we propose to develop a Bandwidth Reservation Technique based on traffic Priority (BRTP) for wireless mesh networks. Our protocol consists of two phases namely Bandwidth Request phase and Bandwidth Reply phase. In the former Phase, a Bandwidth Request (BREQ) message is forwarded from the node that requests the admission of a new traffic flow to its destination. In the later Phase, a Bandwidth Reply (BREP) message proceeds backwards, hop-by-hop, from the destination node to the node that originated the request along the path laid down by the corresponding (BREQ) message. The destination node precedes the reply according to the priority of traffic classes and reserves the bandwidth on the reply path.

II. RELATED WORK

Bo Wang et al [6] have focused on the problem of providing QoS support for real-time flows, while allocating bandwidth to elastic flows fairly. They have proposed QUOTA (quality-of-service aware fair rate allocation), a framework that combines QoS support and fair rate allocation. Their proposedframework QUOTA provides higher priority to real- time flows than elastic flows by reserving the necessary bandwidth for the former and fairly allocating the left-over bandwidth to the latter.

Claudio Cicconetti et al [9] have introduced a Fair End-to-end Bandwidth Allocation (FEBA) algorithm. Their FEBA algorithm 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 proportional to a specified weight to each end-to-end traffic flow. Thus the traffic flows are served in a differentiated manner, with higher priority traffic flows being allocated more bandwidth on the average than the lower priority traffic flows.

Ho Ting Cheng et al [10] have proposed a low-complexity intracluster resource allocation algorithm by considering the power allocation, sub-carrier allocation, and packet scheduling. The time complexity of their proposed scheme is on the order of $O(LMN)$, where L is the number of time slots in a frame, M is the number of active links, and N is the number of sub-carriers.

Ho Ting Cheng et al [11] have proposed an efficient intra-cluster packet-level resource allocation approach. Their approach considers power allocation, sub-carrier allocation, packet scheduling, and QoS support. Their proposed approach combines the merits of a Karush-Kuhn-Tucker (KKT)-driven approach and a genetic algorithm (GA)-based approach. Their proposed approach achieves a desired balance between time complexity and system performance.

Andre Herms et al [12] have addressed the problems of the reservation on a single hop. They have discussed the reasons for the inconsistencies in the existing approaches which lead to admission failures and present a protocol for preventing them. This allows for increasing the reliability of established communication links in WMNs. They have focused only on the local admission control and not the various searching strategies for finding a suitable path.

III. BANDWIDTH RESERVATION TECHNIQUE

A. Overview

Basically, our proposed technique consists of two phases namely Bandwidth Request phase and Bandwidth Reply phase. In the Bandwidth Request Phase, a Bandwidth Request (BREQ) message is forwarded from the node that requests the admission of a new traffic flow to its destination. During this phase bandwidths are not reserved. The BREQ message consists of traffic flow specifications and the requested bandwidth.

Next in the Bandwidth Reply Phase, a Bandwidth Reply (BREP) message proceeds backwards, hop-by-hop, from the destination node to the node that originated the request along the path laid down by the corresponding (BREQ) message. The destination node precedes the reply according to the priority of traffic classes and reserves the bandwidth on the reply path.

B. Determining Priority of Traffic Classes

The traffic flow specifications consists of traffic classes such as UGS, ertPS, rtPS, nrtPS, BE and the priority for the each traffic is given in the same order.

The equation for the priority for the traffic classes is given by;

$$PTC = RBW + SC \quad (1)$$

Where RBW is the requested bandwidth and is calculated by

$$RBW = 1 - \frac{BWreq}{BWmax} \quad (2)$$

BWreq is the node's requested bandwidth.

BWmax is the maximum bandwidth.

Where SC is the value assigned to each traffic service types as 1, 0.80, 0.60, 0.40 and 0.20 in order as per the priority of the traffic classes.

In case of a buffer overflow, the traffic classes and transmitted according to their priority by utilizing other channels having low priority traffic. In case of same priority value, there will be traffic congestion. So the proposed method makes use of earliest deadline technique to schedule the traffic using a Deadline Factor (DF). It is given by using the request's residual time R_t and request's execution time E_t. Thus the equation for DF is given by;

$$DF = \frac{1}{1 + e^{R_t - E_t}} \quad (3)$$

Thus our equation of earliest deadline technique takes into account both PTC and DF (eq 1 and 3) to allocate traffic for similar priority data.

$$PTC = PTC + DF \quad (4)$$

Algorithm for Earliest Deadline Technique

In incoming traffic flow

At $T = 1$

1. If $Ch < C_{th}$, then

    1.1 Channel is marked as good channel,

    1.2 Assign priority using (1)

    1.3 Schedule the traffic

2. Else if $Ch > C_{th}$, then

    2.1 Mark the channel as bad.

    2.2 Put each traffic in separate queues q_1, q_2, L, q_m

    2.3. If $Q_1(i) > Q_{\max}$, where $i = 1, 2, L, k$ then

        2.3.1 Schedule the traffic using

3. End if

4. $T = T + 1$,

5. Repeat from 1.0

C. Bandwidth Request Phase

The node that originates the traffic flow conveys the admission request to the final destination node through BREQ message, which is relayed by the intermediate nodes alont the path. In addtion to the requested banwidth (RBW) and the traffic classes (RC) such as UGS, ertPS, rtPS, nrtPS, a BREBREQ message includes:

- Source and Destination node IDs (SID and DID)
- Intermediate node IDs
- TSPEC
- Traffic flow identifier (TFID)

In the Bandwidth Request Phase the bandwidths are not reserved and only the necessary request's residual time $R_t$and request's execution messages are transmitted to the destination. The source is required to select the TFID of any new flow in such a way that the source, destination, TFID uniquely identifies the traffic flow in the network.

Let N1, N2, N3 are the intermediate nodes between the source *S* and the destination D. Then the bandwidth request process is illustrated as below:

S —BREQ: [SID, DID, RBW, TC, TSPEC, TFID]→ N_1

N_1 —BREQ: [SID, DID, RBW, TC, TSPEC, TFID, (N1)]→ N_2

N_2 —BREQ: [SID, DID, RBW, TC, TSPEC, TFID, (N1, N2)]→ N_3

N_3 —BREQ: [SID, DID, RBW, TC, TSPEC, TFID, (N1, N2, N3)]→ D

D. Bandwidth Reply Phase

In this phase, the destination sends back to the source a BREP message and it is routed through the same path that has been enclosed by the BREQ message. This is obtained by using the list of intermediate node IDs included in the BREQ message. On receiving the BREP message, each node reserves the bandwidths according to the priority of the traffic. The traffic priority is determined as in 3.2.

If the nodes do not receive packets until the traffic flow is dropped for a particular amount of time TS, then the bandwidth remains allocated. Thesource generates probe packets to guarantee an established traffic flow state on each node in the path to prevent premature termination of the traffic flow. Probe packets are the messages which include the information about their traffic and these packets are discarded by the receivers in the MAC layer. The generation interval of the probe packets must be smaller than the TS. Generally, by transmitting the probe packets it consumes the bandwidth which is already reserved for the traffic flow in the data sub- frame.

The bandwidth reply process is illustrated as below:

D —BREP: [SID, DID, RBW, TC, TSPEC, TFID]→ N_3

N_3 —BREP: [SID, DID, RBW, TC, TSPEC, TFID, BA(N3)]→ N_2

N_2 —BREP: [SID, DID, RBW, TC, TSPEC, TFID, BA(N3), BA (N2)]→ N_1

N_1 —BREP: [SID, DID, RBW, TC, TSPEC, TFID, BA(N3), BA (N2), BA(N1)]→ S

IV. SIMULATION RESULTS

A. Simulation Model and Parameters

We use NS2 [14] to simulate the proposed technique. We use the IEEE802.16 e simulator [15] patch for NS2 version 2.33 to simulate a WiMax Mesh Network. It has the facility to include multiple channels and radios. It supports different types of topologies such as chain, ring, multi ring, grid, binary tree, star, hexagon and triangular. The supported traffic types are CBR, VoIP, Video-on-Demand (VoD) and FTP. In our simulation, 20 mobile nodes are arranged in a topology of size 500 meter $\times$ 500 meter region. All nodes have the same transmission range of 250 meters. In our simulation, the speed isset as 5m/s. A total of 3 traffic flows (two VoIP and one VoD) are used.

Our simulation settings and parameters are summarized in table 1.

Table 1. Stimulation Settings

0	20
Area Size	500×500
Mac	802.16 e
Radio Range	250 m
Simulation Time	100 sec
Traffic Source	VoIP and VoD
VoD Packet Size	65536
VoD Rate	150 Kb
VoIP Codec	GSM.AMR
No. of VoIP frames per packet	2
Topology Type	Ring
OFDM Bandwidth	10 MHz

B. Performance Metrics

The proposed BRTP technique is compared with the FEBA [9] algorithm. The performance is evaluated mainly, according to the following metrics.

- Average End-to-End delay: The end-to-end-delay is averaged over all surviving data packets from the sources to the 1.2
- Aggregated Throughput: We measure aggregated throughput in terms of no. of packets received.
- Bandwidth Utilization: It is the ratio of bandwidth received into total available bandwidth for a traffic flow.

RESULTS

Effect of Varying Rate

In the first experiment, the transmission rate is varied as 0.5, 1.0, 1.5 and 2 Mb and the above metrics are measured.

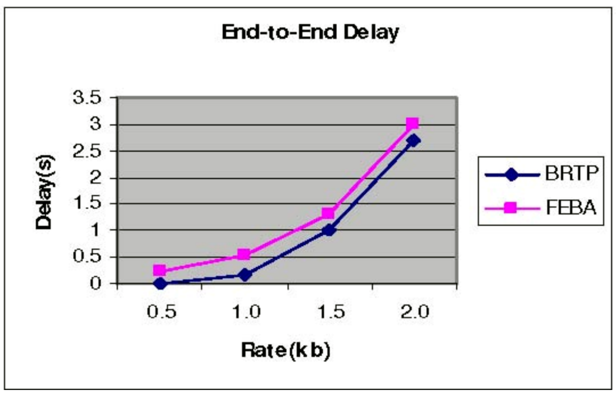

Fig. 1. Rate Vs Delay

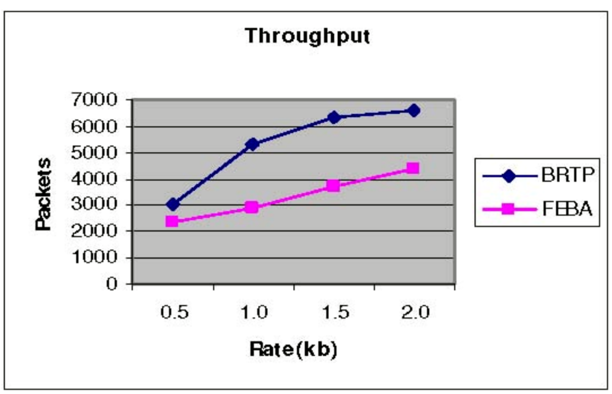

Fig. 2. Rate Vs Throughput

Fig.1 shows the end-to-end delay values when the number of rate is increased. It is clear that BRTP has less delay when compared to FEBA algorithm.

Fig.2 shows the throughput values when the number rate is increased. From the figures, it can be seen that the throughput is more in the case of BRTP and outperforms the FEBA algorithm.

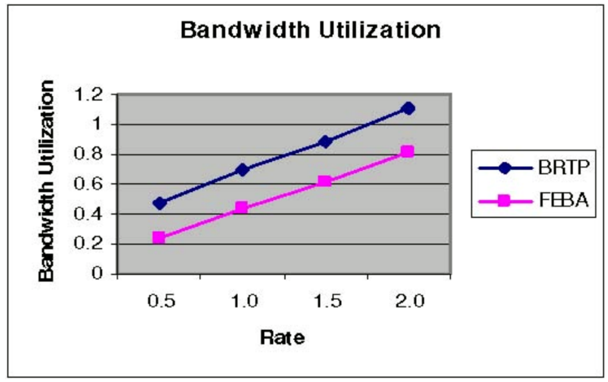

Fig. 3. Rate Vs Bandwidth Utilization

Fig.3 shows the bandwidth utilization obtained, when the number of rate is increased. It shows that BRTP utilizes more bandwidth than the FEBA algorithm.

Effect of Varying Flows

In the second experiment, we vary the number of data flows as 2, 4, 6, 8 and 10.

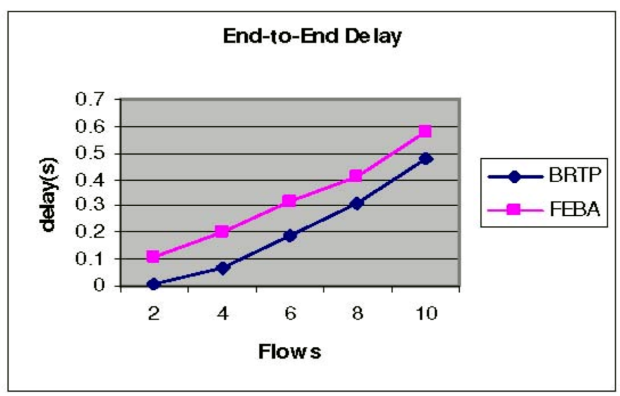

Fig. 4. Flow Vs Delay

Fig. 4 shows the end-to-end delay values when the number of flow is increased. It is clear that BRTP has less delay when compared to FEBA algorithm.

Fig. 5 shows the throughput values when the number flows are increased. From the figures, it can be seen that the throughput is more in the case of BRTP and outperforms the FEBA algorithm.

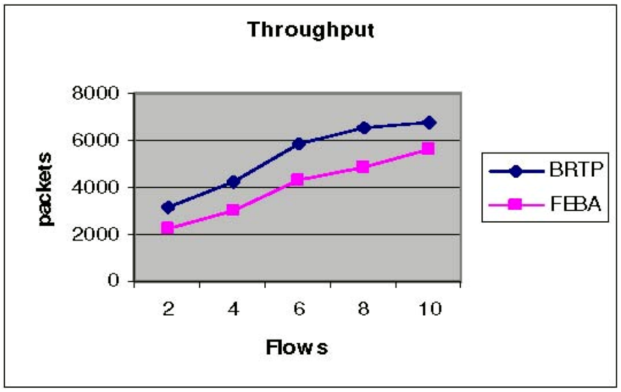

Fig. 5. Flow Vs Throughput

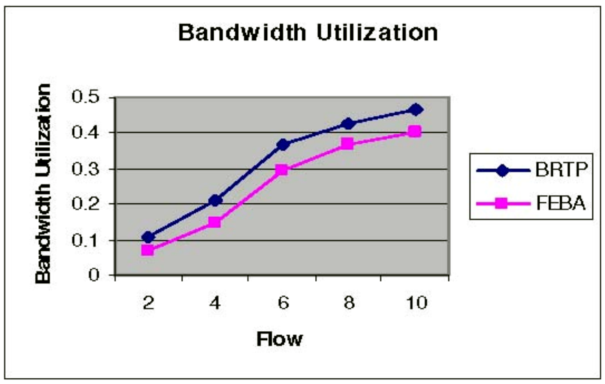

Fig. 6. Flow Vs Bandwidth Utilization

Figure.6 shows the bandwidth utilization obtained, when the number of flows are increased. It shows that BRTP utilizes more bandwidth than the FEBA algorithm.

V. CONCLUSION

In this paper, we have proposed a Bandwidth Reservation Technique based on traffic Priority (BRTP) for wireless mesh networks. It consists of two phases namely Bandwidth Request phase and Bandwidth Reply phase. In the former Phase, a Bandwidth Request (BREQ) message is forwarded from the node that requests the admission of a new traffic flow to its destination. In the later Phase, a Bandwidth Reply (BREP) message proceeds backwards, hop-by-hop, from the destination node to the node that orginated the request along the path laid down by the corresponding (BREQ) message. The destination node precedes the reply according to the priority of traffic classes and reserves the bandwidth on the reply path. In addition to this, to prevent premature termination of the traffic clow a, the source generates probe packets to guarantee a constant refresh of the established traffic flow state on each node in the path. By simulation results, we have show that our proposed technique achieves high bandwidh utilization and throughput with reduced delay.

REFERENCE

[1] Demesster "A cluster driven channel networks", th IEEE Internationa conference

[2] Raniwala, Gopalan, and Chiueh, "Centralized Channel Assignment and Routing Algorithms for Multi-Channel Wireless Mesh Networks", in Mobile Computing and Communications Review, Vol. 8, April 2004.

[3] Kaan Bur and Cem Ersoy, "Ad hoc quality of service multicast routing", Computer Communications, Volume 29 , Issue 1, 2005.

[4] Zhu Han and K. J. Ray Liu, "Resource allocation for wireless networks: basics, techniques, and applications", Cambridge university press, 2008, ISBN – 978 0 521 87385 7.

[5] Bosheng Zhou, Alan Marshall and Tsung-Han Lee, "A Cross-Layer Architecture for DiffServ in Mobile Ad-hoc Networks", International Conference on Wireless Networks, Communications and Mobile Computing, WIRELESSCOM 2005

[6] Bo Wang and Matt Mutka, "QoS-aware fair rate allocation in wireless mesh networks", Elsevier, Computer Communications 31, 2008

[7] Gahng-Seop Ahn, Andrew T. Campbell, Andras Veres and Li-Hsiang Sun, "SWAN: Service Differentiation in Stateless Wireless Ad Hoc Networks", In the Proceedings of the 21st Annual Joint Conference of the IEEE Computer and Communications Societies, INFOCOM 2002.

[8] Seoung-Bum Lee, Gahng-Seop Ahn, Xiaowei Zhang, and Andrew T. Campbell, "NSIGNIA: An IP-Based Quality of Service Framework for Mobile ad Hoc Networks", Journal of Parallel and Distributed Computing, 2000.

[9] Claudio Cicconetti, Ian F. Akyildiz and Luciano Lenzini, "FEBA: A Bandwidth Allocation Algorithm for Service Differentiation in IEEE 802.16 Mesh Networks", IEEE/ACM Transactions on Networking (TON), Volume 17, Issue3, June 2009.

[10] Ho Ting Cheng and Weihua Zhuang, "Joint Power-Frequency-Time Resource Allocation in Clustered Wireless Mesh Networks", IEEE Network, vol. 22, no. 1, pp. 45-51, Jan/Feb 2008.

[11] Ho Ting Cheng and Weihua Zhuang, "Novel Packet-Level Resource Allocation with Effective QoS

Provisioning for Wireless Mesh Networks", IEEE Transactions on Wireless Communications, Vol. 8, No. 2, February 2009

[12] Andre Herms and Georg Lukas, "Preventing Admission Failures of Bandwidth Reservation in Wireless Mesh Networks", IEEE/ACS International Conference on Computer Systems and Applications, 2008

[13] K. Valarmathi and N. Malmurugan, "Joint Design of Congestion Control Routing With Distributed Multi Channel Assignment in Wireless Mesh Networks", Networking and Internet Architecture, IJCSIS, Vol. 7 No. 3, March 2010.

[14] Network Simulator http://www.isi.edu/nsnam/ns

[15] "WiMsh: a simple and efficient tool for simulating IEEE 802.16 wireless mesh networks in ns-2", Proceedings of the 2ndInternational Conference on Simulation Tools sand Techniques, 2009