IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 6, No 1, November 2012
ISSN (Online): 1694-0814
www.IJCSI.org

Delay-aware Load Balanced Routing Protocol for IEEE 802.16 Wireless Mesh Networks

Sanjeev Jain[1], Vijay Shanker Tripathi[2] and Sudarshan Tiwari[3]

[1] **Department of Electronics & Communication Engineering, MNNIT, Allahabad-211004, India**

[2] **Department of Electronics & Communication Engineering, MNNIT, Allahabad-211004, India**

[3] **Department of Electronics & Communication Engineering, NIT, Raipur-492010,India**

Abstract

In IEEE 802.16 Wireless Mesh Networks (WMN) routing, delay aware load balancing can be achieved by selecting the shortest path with low latency and network load. But network load and latency together are not considered in most of the existing routing metrics. Here, we propose a delay aware load balanced routing protocol for wireless mesh networks by designing a combined route metric. Initially, we calculate the metric of traffic interference (TIM) which considers the traffic load of interfering neighbors. Next, we calculate the metric for end to end service delay (EDM) by using the expected time spent in transmitting all packets waiting for transmission through a link. This metric can be used to select the path with the lowest end-to-end service delay in terms of current network load. Using these two metrics we define a combined route metric for efficient route selection. A route discovery mechanism is proposed which broadcasts request packets along with expected link delay and load value. The suitable path is selected based upon the least routing metric value. A route maintenance mechanism is also proposed to maintain the stability of the network. Using this, frequent changes in the path can be avoided and transmission efficiency is increased. By simulation results, we show that the proposed protocol reduces the delay and overhead there by increasing the overall packet delivery ratio, when compared with existing protocols.

Keywords: wireless mess network; routing; IEEE 802.16; load balancing, delay;

1. Introduction

1.1 Wireless Mesh Networks

The nodes in the wireless mesh networks establish ad hoc networks automatically and can maintain mesh connectivity. Mesh networks are self-organized and self – configured. Mesh routers and mesh clients are the two types of nodes in the WMNs. From the wireless network point of view, the protocol design of existing wireless networks, especially of IEEE 802.11 networks, ad hoc networks, and wireless sensor networks are under research. The new specifications for WMNs are activated in the industrial standards groups, such as IEEE 802.11, IEEE 802.15, and IEEE 802.16. [1]

Few applications of the wireless mesh network are given here

- Broadband Internet Access: The cable or digital subscriber lines are mostly used in the internet broadband connections.
- Indoor WLAN Coverage: The multiple access points are required to provide coverage of any but smallest buildings. This has become one of the most repulsive aspects of the technology though IEEE 802.11 has become popular in WLANs.
- Mobile User Access: Comparatively high speed connections are offered by the third generation of cellular systems (3G). For stationary users speed is about 2Mbps and for mobile users in macro cells 144 kbps is offered.
- Connectivity: At times, awkward, exclusive, prolonged or unattractive network connectivity is been provided. WMN are specifically constructed by the firetide for providing connectivity. [2]

1.2 IEEE 802.16 Wireless Mesh Networks

Backhaul connectivity of the mesh networks is provided by the mesh base station in the IEEE 802.16 and controlling of one or more subscriber stations is also provided. Collection of bandwidth request from subscriber station and management of resource allocation are the responsibilities of the mesh BS when a centralized scheduling scheme is used. In order to synchronize the new nodes and make them join the mesh network, advertisement of the mesh networks has to be done using Configuration (MSH-NCFG) and Mesh Network Entry (MSH-NENT) messages. The basic network configuration information including BS ID number and the base channel currently used are sketched out using the active nodes within the mesh. This periodically advertises MSHNCFG messages with network descriptor. [3]

In addition to the increased range and higher bandwidth the 802.16 based WiMax mesh provides various advantages when compared to the IEEE 802.11 a/b/g based mesh network. In WiMax based multi-hop relay system, the granularity radio resource control is better in TDMA based scheduling of channel access when compared with RTS/CTS based 802.11 a/b/g systems. Efficient resource allocation is provided by the TDMA based scheduling mechanism by allowing centralized slot allocation and this is suitable for fixes wireless backhaul network. [4]

There are two drawbacks in the IEEE 802.16a mesh mode. Only fixed broadband application is the objective of the mesh mode and it is not attuned with the present PMP mode. “Mobile Multihop Relay (MMR)” was established by a study group in order to address these limitations. The PMP mode needs to be extended for an SS outside the coverage of a BS and these possibilities are calculated in this study. The multihop relaying techniques with relay stations (RSs) are used for supporting the mobile stations. Information from SS/MS and a BS or between other RSs or between an RS and BS are relayed using RS. [5]

1.3 Routing in Wireless mesh networks

Centralized scheduling and distributed scheduling are the specific scheduling mechanisms in mesh mode to schedule the traffic among the links. On classifying distributed scheduling, we get coordinated distributed and uncoordinated distributed scheduling. The transmissions in the two hop neighborhood are coordinated in the coordinated distributed scheduling and there are no collisions in it. In order to setup temporary bursts between a pair of neighboring nodes, uncoordinated distributed scheduling is used and it behaves in an ad hoc manner. On the other hand, the transmission scheduling for SSs relies on BS in the centralized scheduling. A routing tree is developed by the BS for an easy management. In this routing tree, BS is the root, SSs are the other nodes and transmissions occur along the links of the routing tree. In the routing tree, the flow assignments over the links are determined when the SS sends a report of its bandwidth requests to the BS regularly. The topology of the routing tree has a direct impact on the throughput due to the difference in degree of interference and density of traffic load caused by different routing tree topologies. [6]

Wireless mesh network routing is subjected to few fundamental challenges. Attacks such as wide spectrum of soft and hard failures, links with intermediate loss rates, several channel disconnections, denial of service attacks and node failures are caused in the wireless routing. Wireless routing needs to guarantee robustness against these attacks. In addition to the addressing of the attacks, routing should be scalable enough for handling large node population. The major disadvantage of wireless communication factor is the multiple access interference. The network capacity and the scalability are the most significant factors in the interference of wireless systems. An efficient multi- hop routing and scheduling scheme are developed due to the interference aware routing and thus parallel transmission gets maximized. High throughput and scalability are also provided. [7]

1.4 Load Balancing Issues in Wireless Mesh Networks

Frequent changes happen in the quality of the paths. There is a decrease in transmission efficiency of the original optimal path when the load of the nodes on the path increases. Lack of bandwidth, packet loss or channel interference are responsible for the increase in the load. Network becomes unstable due to frequent changes in the path. Load balancing of WMN can be done by using the routing metric which selects the best path for nodes and distributes the flow. This optimizes the transmissions. [8]

The quality and the efficiency of the path cannot be guaranteed in WMNs since the nodes choose the shortest path for transmissions. In order to choose a path with high quality and efficiency, a routing metric is required. The load balance of the network can be assured using a routing metric, by maintaining an optimal path during the net flow changes. [8]

Compared to the MANETs, it is predicted that the WMNs serve a large community of users. The fair load balancing at the IGW are not focused by the existing mesh routing networks. [9]

In WMN traffic is routed either towards the internet gateways (IGWs) or from the IGWs to clients, since access of the internet or other commercial servers is the primary interest for WMN users. The traffic load on certain paths and mesh routers increases when a best path is selected by multiple edge mesh routers towards a gateway. Hence the overall performance of the network decreases significantly. The routes between each traffic access point are determined by the routing algorithm in such a way that the load on the entire mesh network is balanced. [12]

Rapid gateway overloading, centre overloading, or channel overloading are caused due to unbalanced load in WMNs. Load imbalance is caused at certain gateways since more traffic is indented towards the gateway and this leads to gateway overloading. [13].

1.5 Problem Identification and Proposed Solution

In order to balance the load in IEEE 802.16 Wireless Mesh Networks (WMN) routing, we have to select the shortest path with low latency and network load. But existing routing metrics rarely consider the network load and latency together. This will lead to uneven distribution of the cost and congestion may occur.

Here, we propose a load balanced routing protocol for wireless mesh networks by designing a combined route metric. Initially, we calculate the metric of traffic interference (TIM) which considers the traffic load of interfering neighbors. The average load of the neighbors that may interfere with the transmission between two nodes over a channel is calculated.

Next, we calculate the metric for End to end service delay (EDM) by using the expected time spent in transmitting all packets waiting for transmission through a link. This metric can be used to select the path with the lowest end-to-end service delay in terms of current network load.

Finally we define a combined route metric which includes both TIM and EDM metrics for efficient route selection.

During route discovery, the source node broadcast a route request (RREQ) packet to all nodes which consists of expected link delay and load value of the neighboring nodes. On receiving the RREQ packet, each node estimates the combined route metric and forwards it towards next node. When the route metric of the received RREQ packet is less, the current RREQ at the intermediate node is updated. Once the first RREQ message reaches the destination, route reply packet is generated and it gets forwarded towards the source node along with the route metric. As the RREP packets are propagated, the intermediate nodes built a forward route to the destination. Thus, an efficient route is established with least delay and minimum load.

2. Related Work

Guan-Lun Liao1 et al [8] have proposed an Adaptive Situation-Aware (ASA) routing metric. They have three major contributions in this work: 1) they classify the existing load balance routing metric and load balance scheme; 2) in order to achieve the load balance in MWMNs, they proposed an adaptive routing metric under the consideration of transmission efficiency and interference; 3) finally, they proposed a novel scheme based on their adaptive routing metric and Max-flow min-cut theory for improving the load balance in MWMNs.

Deepti Nandiraju et al [9] have proposed a novel technique that elegantly balances the load among the different IGWs in a WMN. They switch the point of attachment of an active source serviced gateway depending on the average queue length at the IGW. The proposed load balancing scheme includes: an initial gateway discovery module, which determines a primary gateway for a mesh router and a load balancing module that rebalances the load among the gateways.

Devu Manikantan Shila et al [10] have presented a new routing metric for multihop wireless mesh networks. This metric is based on the load on interfering neighbors and link transmission rates. They integrated this metric in the well known AODV routing protocol and compared to existing routing metrics for Wireless Mesh Networks.

Hervé Aïache et al [11] have proposed a load aware isotonic routing scheme that uses weighted shortest path routing to balance the load across the network. The critical component of the scheme is a weight metric, called LAETT that captures both traffic load and link quality.

Liang Ma et al [12] have proposed a routing metric and a traffic splitting algorithm to provide load balancing in WMNs. The proposed routing metric known as Weighted Cumulative Expected Transmission Time with Load Balancing (WCETT-LB) is based on the WCETT routing metric. WCETT-LB introduces load balancing feature at the mesh routers and supports global load-aware routing. The integration of a load-balancing metric to WCETT and the global congestion aware routing scheme can provide performance improvement in the entire network.

Anh-ngoc et al [13] have proposed a new load aware routing metric called LARM, which captures the differences in the transmission rates, packet loss ratio, intra / inter flow interference and traffic load in multi radio mesh network. It is incorporated into proposed load balancing routing called LBM, to provide load balancing for multi radio mesh networks.

Yigal Bejerano et al [14] have presented simple and effective management architecture for WMNs, termed configurable access network (CAN). Under this architecture, the control function is separated from the switching function, so that the former is performed by a network operation center (NOC) which is located in the wired infrastructure. The NOC monitors the network topology and user performance requirements, from which it computes a path between each wireless router and a gateway, and allocates fair bandwidth for carrying the associated traffic along the selected route. By performing such functions in the NOC, they offload the network management overhead from wireless routers, and enable the deployment of simple/low-cost wireless routers.

Karnik, A et al [15] have developed and investigated a novel optimization framework to determine the optimal throughput and configuration, i.e., flow routes, link activation schedules and physical layer parameters. Determining the optimal throughput is a computationally hard problem, in general. However, using a smart enumerative technique they obtained numerical results for several different scenarios of interest. They obtained several important insights into the structure of the optimal routes, schedules and physical layer parameters. Besides determining the achievable throughput, they believe that their optimization-based framework can also be used as a tool, for configuring scheduled wireless networks, such as those based on IEEE 802.16.

Lien-Wu Chen et al [16] have proposed spectral reuse framework covers bandwidth allocation at the application layer, RTC (Routing Tree Construction) and resource sharing at the medium access control (MAC) layer, and channel reuse at the physical layer.

Zhang, S et al [17] have proposed a joint admission control and routing scheme for multiple service classes with the objective to maximize the overall revenue from all carried connections. QoS constraints such as handoff dropping probability can be guaranteed. Multiple service classes can be prioritized by imposing different reward rates. They formulate the problem as a decision process, and apply optimization techniques to obtain the optimal admission control policies. They showed that the proposed joint admission control and routing scheme can produce maximum revenue obtainable by the system under QoS constraints. They also showed that the optimal joint admission control policy is a randomized policy, i.e., connections are admitted to the system with some probabilities when the system is in some states.

3. Proposed Work

3.1 Calculation of Traffic Interference Metric (TIM)

We consider the traffic load in the interfering neighbors as the metric of traffic interference. Here both inter flow and intra flow interference is caused. When the neighboring nodes transmit on the same channel, they compete with each other for channel bandwidth. The number of interfering nodes is not considered for degree of interference instead, the load generated by the interfering node is taken into account. This metric considers the traffic of interfering nodes to capture the interflow interference.

The TIM metric is defined as follows:

$$TIM = ETTab(D) \times L_{avg}(D), \quad \eta_l(D) \neq 0$$
$$TIM = ETTab(D), \quad \eta_l(D) = 0 \quad \ldots\ldots (1)$$

where $Lavg_{ab}$ is the average load of the neighbors that may interfere with the transmission between nodes a and b over channel D.

Lavg(D) is Average Interfering Load, is given as

$$Lavg(D) = \Sigma\eta_l \, Lint(D)/\eta_l(D) \quad \ldots\ldots\ldots (2)$$

$$\eta_l(D) = \eta_a(D) U \eta_b(D) \quad \ldots\ldots\ldots (3)$$

Lint (D) interfering load, is the load of the interfering neighbor. η_l (D) is the set of interfering neighbors of nodes a and node b. ETTab captures the difference in transmission rate and loss ratio of links. $Lavg_{ab}$ is the neighboring activity of the nodes.

When there is no interfering neighbor, TIM metric selects the path with high transmission rate and low loss ratio. In the presence of interfering neighbors, TIM metric selects the path with minimum traffic load and minimum interference.

3.2 Calculation of End to End Service Delay Metric (EDM)

The Expected End-to-end Service Delay Metric (EDM), is proposed to allow any shortest path based routing protocol to select a route with lowest end-to-end latency.

The EDM is defined as “network load-aware and radio-aware service delay” which is the end-to-end latency spent in transmitting a packet from source to destination. In order to estimate the EDM value, the Expected Link Transmission Time (ELT^2) is used initially, for successfully transmitting a packet on each link and then multiplying ELT^2 by the mean number of backlogged packet in output queue at each relay node. ELT^2 is similar to the medium time metric (MTM).

The MTM assigns a weight to each link, equal to the expected amount of medium time it would take, by successfully sending a packet of fixed size S on each link in the network. The value depends on the link bandwidth and its reliability which is related to the link loss rate. The difference between the MTM and ELT^2 is the scheme estimating each parameter and the inclusion of contention delay in link metric.

It is assumed that each node is serviced with a first-in-first-out (FIFO) interface queue.

Let Te be the expected time spent in transmitting all packets waiting for transmission through a link at node k, called per-hop service delay.

Te should take into account the expected service delay of any node such as queue delay, contention delay and transmission time of link *a* between node k and any neighbor node in the transmission range.

With a given *Te*, the EDM of path, l, with h-hops, between source and destination, is estimated as follows:

$$EDM(l)= \sum_{j=1}^{h} Te \quad \text{............} (4)$$

Estimation of Te

In order to estimate Te, M neighbor nodes in transmission range of node n, the mean number of backlogged packets is assumed, Let $\eta_{k,a}$ be the mean number of packets waiting for transmission on link i at node n to successfully transmit through link a. Te is estimated as follows:

$$Te= \Sigma(\eta_{k,a}\times(dc_{k,w}+ELT^2(k,a)))+ELT^2(k,a) \quad \text{.............}(5)$$

where the ELT^2 *(k,a)* is the ELT^2 of link a at node k and $dc_{k,w}$ is the mean contention delay at node k.

As a result, route selection using the EDM finds the path with the lowest end-to-end service delay in terms of current network load. In addition, a routing protocol using this metric can simultaneously perform traffic load balancing.

Estimation of ELT^2

ELT^2 (k,a) is first defined as the link transmission time spent by sending a packet over link *a* at node k. This measure is approximated and designed for ease in implementation and interoperability.

The ELT^2 for each link is calculated as:

$$ELT^2(k) = [Hcnt + Fs / t] \times 1/ (1- Fe) \quad \text{............} (6)$$

where Hcnt is the control overhead , $dc_{k,w}$ is the mean contention delay, and the input parameters t and Fe are the bit rate in Mbs and the frame error rate of link a for frame size Fs respectively. The rate *r* is dependent on local implementation of rate adaptation and represents the rate at which the node would transmit a frame of standard size (Fs) based on current conditions. Fe estimation is a local implementation and is intended to estimate the Fe for transmissions of standard size frames (Fe) at the current transmit bit rate used to transmit frames of size (*t*).

3.3 Route Discovery

A combined route metric (RM) is proposed which includes both TIM and EDM metrics for efficient route selection.

$$RM = C1 * TIM + C2 * EDM$$

Here C1 and C2 are the normalizing factors for TIM and EDM whose values range from 0 to 1.

Initially, when a source node has a packet to transmit to the destination which has no entry in the routing table, it will initialize the values of TIM and EDM to 0 and generates an RREQ packet with this value. This RREQ packet is broadcast to its neighboring nodes in order to discover the routes. Apart from the RM value, each RREQ has a unique identifier that is a combination of the MAC address for the interface to which it is sent and a sequence number that is incremented for each RREQ packet generated.

When an intermediate node receives the RREQ packet, it creates a reverse route entry to the source node. If the node has already seen the RREQ packet, and yet it receives a new RREQ packet with a better path which has smaller RM metric, it updates the reverse path accordingly. Then that node forwards the RREQ to the next hop. An intermediate node is not allowed to reply to an RREQ packet though it has a route to destination, in order to maintain up to date information of interference and delay.

The reverse route is built during the RREQ flooding. When the first RREQ message reaches the destination, RREP packet is generated and unicast towards the source node along the reverse route.

When the RM metric of the received RREQ packet is less, the current RREQ at the intermediate node is updated. A forward route is built from the intermediate nodes to the destination when the RREP propagates.

When a duplicate RREQ is arrived at the destination node, the RM is compared with the former one. When a smaller value is found, a new RREP packet is sent back to the source and this brings changes in the route accordingly. On receiving the RREP packets, the source node forwards the data packets to the destination.

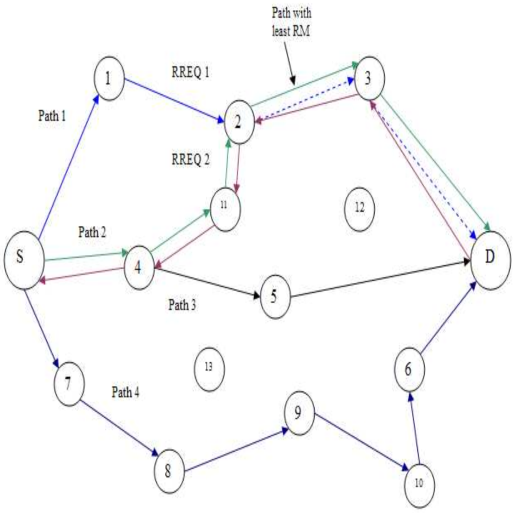


Figure 1 – Best path selection

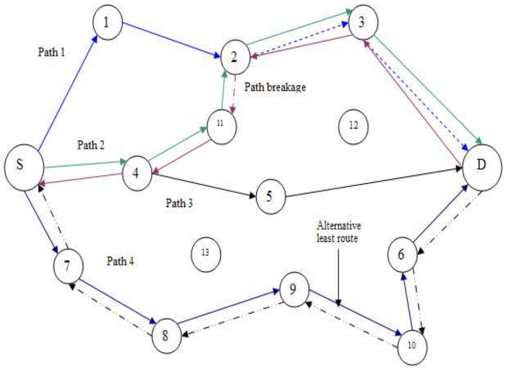
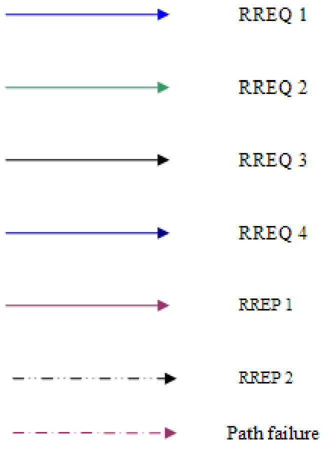


Figure 2 – Alternate path selection during path failure



In figure 1, four paths are assigned from the source to the destination. Initially, RREQ is sent through path 1 to the destination. A duplicate RREQ 2 is sent through the path 2 and the node 2 compares the RM value of the two paths. The path 2 has the least RM value and hence this path is taken as the best path. The RREP is sent through the paths D-3-2-11-4-S.

In figure 2, breakage occurs in path 2, and the path with the next least RM value is taken as the best path. Here path 4 has next least RM value and thus the path D-6-10-9-8-7-S.

We consider a timer to associate with the route to maintain the routing table. This timer gets updated by each node when the data flow from the source to destination. The validity of the route can be checked using the timer. In order to maintain the validity, the route should be used in a particular period of time P. If it is not used within P, the node removes the route from its routing table.

A route error packet (RRER) helps in detecting the link failure, (i.e) when an active route is broken. An alternate least route is found by the source node, to its destination using a route recovery mechanism explained in section 3.4.

3.4 Route Maintenance

Due to the change in the path quality, load of the nodes on the path increases fatally and thus there is a decrease in the transmission efficiency of the original optimal path. The network becomes unstable due to frequent changes in the path. Here we design a load balance scheme to update the metric cost of the nodes.

Initially, for periodical update we set the time threshold as Th. When the time of the last update is above Th, the RM value of each path gets updated.

Algorithm

Let link a=1, Tc is the current time, Ts be the start time, S is the source node, Th is the threshold value. Pc be the current path and Po be the other neighboring path.

```
1. If      Tc of S >  [Ts of (S+Th*a)]

           1.1 S updates RM of each possible path
           1.2 a = a+1
   Else
           1.3 RM value remains the same.
   End if

2. If   RM of Pc ≤   RM of Po, then
           2.1Load remains same at current path
   Else if RM of Pc >> RM of Po

           2.2 The path is changed to the path having
   minimum RM value.

   End if
```

When the current time of source node is greater than the start time of (S+Th*a), RM value gets updated. The current path is considered as a load balanced path until the path has a minimum metric value. During the next periodical update, the current path is replaced with other path when the cost of the other path is lesser than the current path.

We use this scheme to maintain the path on the optimal path and avoid the situation that changes the path too frequently.

4. Simulation Results

4.1 Simulation Model and Parameters

We use NS2 [18] to simulate our proposed protocol. We use the IEEE802.16e simulator [19] 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, mobile nodes are arranged in a ring topology of size 500 meter x 500 meter region. We keep the number of nodes as 25. All nodes have the same transmission range of 250 meters. A total of 4 traffic flows (one VoIP and three VoD) are used.

Our simulation settings and parameters are summarized in table 1.

Table I. Simulation Settings

No. of Nodes	25
Area Size	500 X 500
Mac	802.16e
Radio Range	250m
Simulation Time	100 sec
Traffic Source	VoIP and VoD
VoD Packet Size	1000 to 3000 bytes
VoD Rate	100Kb
VoIP Codec	GSM.AMR
No. of VoIP frames per packet	2
No.of Traffic Flows	1,2,3,4 and 5
Topology Type	Ring
OFDM Bandwidth	10 MHz

4.2 Performance Metrics

We compare our Delay aware Load Balanced Routing (DLBR) protocol with the Load Balancing Metric [13] protocol**.** We evaluate mainly the performance according to the following metrics, by varying the simulation time and the number of channels.

- **Average end-to-end delay:** The end-to-end-delay is averaged over all surviving data packets from the sources to the destinations.
- **Average Packet Delivery Ratio:** It is the ratio of the number of packets received successfully and the total number of packets sent
- **Overhead:** It is the control overhead measured in packets

A. Based on Traffic Flows

Initially we vary the number of traffic flows as 1,2,3,4 and 5 with packet size as 1000 bytes.

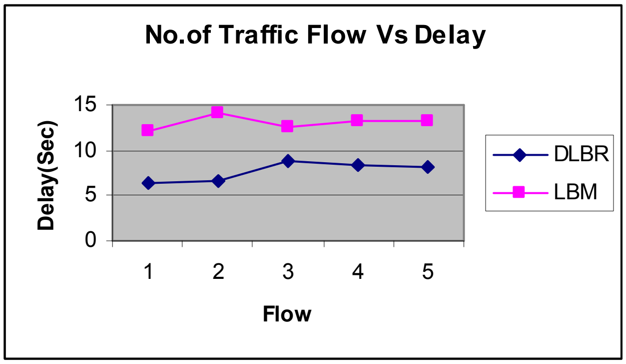


Fig 3: Flow Vs Delay

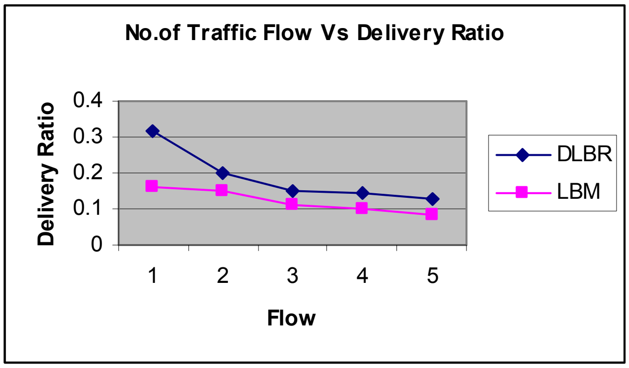


Fig 4: Flow Vs Delivery Ratio

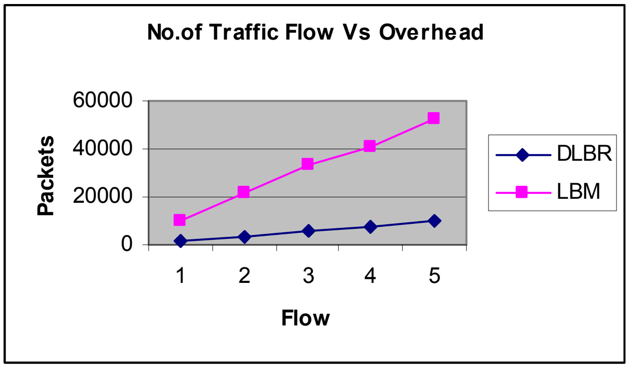


Fig 5: Flow Vs Overhead

From Figure 3, when the number of traffic flow increases, the average end-to-end delay also increases. We can see that the average end-to-end delay of the proposed DLBR protocol is less when compared to the LBM protocol.

Figure 4 presents the packet delivery ratio of both the protocols. When the number of traffic flow increases the packet delivery ratio decreases. We can observe that DLBR achieves good delivery ratio, when compared to LBM.

Figure 5 gives the overhead of both the protocols when the number of traffic flow is increased. As we can see from the figure, the overhead is more in the case of LBM than DLBR.

B. Based on Packet Size

In our second experiment we vary the packet size as 1000,1500,2000,2500 and 3000 bytes with 2 flows.

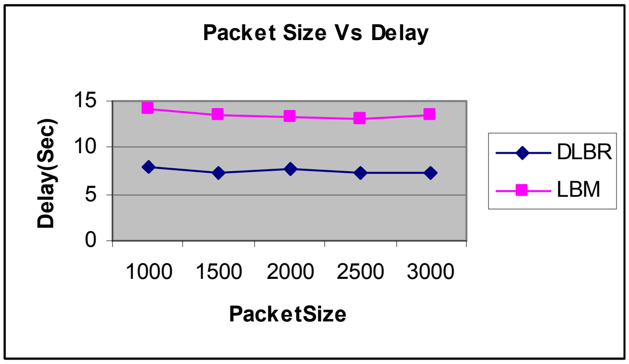


Fig 6: Packet Size Vs Delay

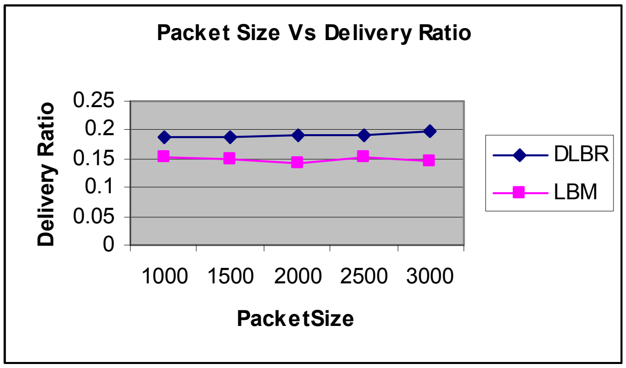


Fig 7: Packet Size Vs Delivery Ratio

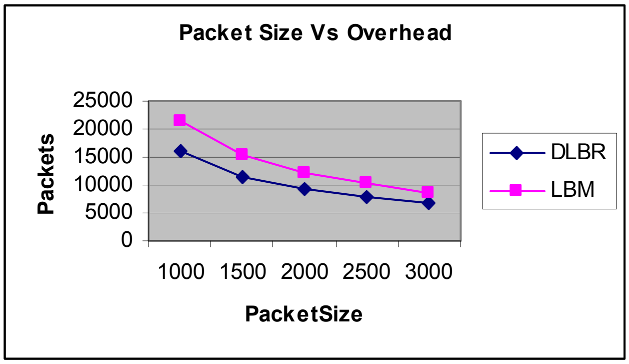


Fig 8: Packet Size Vs Overhead

From Figure 6, when the Packet Size increases, the average end-to-end delay also increases. We can see that the average end-to-end delay of the proposed DLBR protocol is less when compared to the LBM protocol.

Figure 7 presents the packet delivery ratio of both the protocols. When the Packet Size increases the packet delivery ratio decreases. We can observe that DLBR achieves good delivery ratio, when compared to LBM.

Figure 8 gives the overhead of both the protocols when the Packet Size is increased. When the Packet Size increases the overhead decreases. As we can see from the figure, the overhead is more in the case of LBM than DLBR.

5. Conclusion

In this paper, we have proposed a load balanced routing protocol for wireless mesh networks by designing a combined route metric. Initially, we calculate the metric of traffic interference (TIM) which considers the traffic load of interfering neighbors. The average load of the neighbors that may interfere with the transmission between two nodes over a channel is calculated. Next, we calculate the metric for End to end service delay (EDM) by using the expected time spent in transmitting all packets waiting for transmission through a link. This metric can be used to select the path with the lowest end-to-end service delay in terms of current network load. This metric can be used to select the path with the lowest end-to-end service delay in terms of current network load. Using these two metrics we define a combined route metric for efficient route selection. A route discovery mechanism is proposed which broadcasts request packets along with expected link delay and load value. The suitable path is selected based upon the least routing metric value. When a failure occurs in the path, the alternate path is the path with the next least routing metric value. Route maintenance is also proposed to maintain stability of the network. The frequent changes in the path can be avoided and thus increasing transmission efficiency. Thus an efficient route is established with least delay and minimum load. By simulation results, we have shown that the proposed protocol reduces the delay and overhead there by increasing the overall packet delivery ratio, when compared with existing protocols.

References

[1]. Ian F. Akyildiz, and Xudong Wang, "A Survey on Wireless Mesh Networks" IEEE Radio Communications, Vol. 43, No. 9,2005, pp. S23-S30.

[2]. Mihail L. Sichitiu "Wireless Mesh Networks: Opportunities And Challenges" World Wireless Congress, 2005

[3]. Konark kelaiya "Routing & Scheduling Algorithm of IEEE 802.16 Mesh Backhaul Network for Radio Recourse Management (RRM)" Mobile and Pervasive Computing, CoMPC,2008, pp.175-179.

[4]. Hung-Yu Wei, Samrat Ganguly, Rauf Izmailov and Zygmunt J. Haas "Interference-Aware IEEE 802.16 WiMax Mesh Networks" IEEE Vehicular Technology Conference ,VTC 2005 Spring,2005,pp.3102-3106.

[5]. Myung J. Lee, Jianliang Zheng, Young-Bae Ko and Deepesh Man Shrestha "Emerging Standards For Wireless Mesh Technology" IEEE Wireless Communications, Vol. 13, No. 2,2006, pp. 56-63.

[6]. Yanbin Lu¤y and Guoqing Zhang "Maintaining Routing Tree in IEEE 802.16 Centralized Scheduling Mesh Networks" ICCCN, 2007, pp. 240-245.

[7]. Shou-Chih Lo and Lyu-Chen Ou "Efficient Routing and Centralized Scheduling Algorithms for IEEE 802.16 Mesh Networks" IEEE International Conference on Scalable Computing and Communications (Scalcom), 2009, pp. 212-217.

[8]. Guan-Lun Liao "Adaptive Situation-Aware Load Balance Scheme for Mobile Wireless Mesh Networks" 3rd IEEE International Workshop on Mobility Management in the Networks of the Future World (MobiWorld 2011), 2011, pp.391-396.

[9]. Deepti Nandiraju "Achieving Load Balancing in Wireless Mesh Networks Through Multiple Gateways" Mobile Adhoc and Sensor Systems (MASS), 2006, pp. 807-812.

[10]. Devu Manikantan Shila "Load aware traffic engineering for mesh networks" International Conference on In Computer Communications and Networks, (ICCCN), 2007, pp.1040-1045.

[11]. Herve Aïache "A load dependent metric for balancing Internet traffic in Wireless Mesh Networks" IEEE MASS, Mesh-Tech, 2008, pp. 629–634.

[12]. Liang Ma "A Routing Metric for Load-Balancing in Wireless Mesh Networks" Proceedings of the 21st International Conference on Advanced Information Networking and Applications Workshops – Vol. 02 ,2007, pp.409-414.

[13]. Anh-Ngoc LE,Dong-Won KUM,You-Ze CHO and Chai-Keong "Routing with Load-Balancing in Multi-Radio Wireless Mesh Networks", IEICE Transactions Commu, Vol. E92-B,No.3,2009, pp.700-708.

[14]. Yigal Bejerano a, Seung-Jae Han and Amit Kumar "Efficient load-balancing routing for wireless mesh networks", Science Direct, Computer Networks 51, 2007, pp. 2450–2466.

[15]. Karnik, A.; Iyer, A.; Rosenberg, C "Throughput-Optimal Configuration of Fixed Wireless Networks", Networking, IEEE/ACM Transactions,Vol.16, No.5,2008,pp.1161-1174.

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

[17]. Zhang, S.; Yu, F.R.; Leung, V.C.M "Joint connection admission control and routing in IEEE 802.16-based mesh networks", Wireless Communications, IEEE Transactions, Vol. 9 , No.4,2010 , pp.1370-1379.

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

[19]. Cicconettti, C., Akyildiz, I. F. And Lenzini, L.'WiMsH: a simple and efficient tool for simulating IEEE 802.16 wireless mesh networks in ns-2', Proceedings of the 2nd International Conference on Simulation Tools and Techniques, 2009, http://dl.acm.org/citation.cfm?id=1537624

Sanjeev Jain: Received the Bachelor's Degree in Electronics and Communication Engineering from M.B.M Engineering College, Jodhpur, India subsequently M.E. from Malviaya National Institute of Technology, Jaipur, India. Currently pursuing Ph.D., From M.N.N.I.T, Allahabad, India. Simultaneously he is holding the post of Associate Professor at Government Engineering College Bikaner affiliated to Rajasthan Technical University, Kota, India. His research interests include Communication Engineering and Networking, Wireless Mesh Networks, Wireless Sensor Networks.

Dr. V.S. Tripathi received his Bachelor Degree in engineering from J.K Institute of applied physics and Technology University of Allahabad, Allahabad, the M. Tech. & Ph.D. from Motilal Nehru National Institute of Technology, Allahabad. His fields of interest are Wireless communication and Antenna He is author of more than 25 Journal/ conference papers.

Dr. Sudarshan Tiwari received Ph.D degree in Electronics and Computer Engg. from IIT Roorkee in 1994 and currently working as Director, NIT, Raipur before this he was professor of Electronics and communication Engineering. Department of MNNIT Allahabad, India. He is the author or co-author of more than 125 technical publications including journal and proceeding papers. His research interests include Communication Engineering & Networking, Wireless communication and networks, Wireless sensor networks, Network Coding and WDM optical Networks.