International Journal of Computer Engineering & Technology (IJCET)
Volume 10, Issue 1, January-February 2019, pp. 1-10, Article ID: IJCET_10_01_001
Available online at
http://www.iaeme.com/ijcet/issues.asp?JType=IJCET&VType=10&IType=1
Journal Impact Factor (2016): 9.3590 (Calculated by GISI) www.jifactor.com
ISSN Print: 0976-6367 and ISSN Online: 0976–6375

BUFFER BASED ROUTING MECHANISM FOR LOAD BALANCING IN WIRELESS MESH NETWORKS

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ABSTRACT

In recent years it is witnessed that the Wireless Mesh Networks (WMNs) are becoming the most promising technology as they offer low cost broadband wireless connectivity, larger coverage area, high flexibility and easy deployment. WMNs are an extension of existing wireless networks. WMN is an emerging technology; however, there are certain challenges that still exist in the network such as scalability, load balancing, mobility, power management etc. Here we have proposed a novel routing protocol which considers buffer occupancy of intermediate nodes for route selection. Simulation results convey that the proposed protocol outstandingly enhances the performance of the network by balancing the traffic load among less congested nodes compared to the standard protocol.

Keywords: Buffer, Load balancing, WMN.

Cite this Article: Keerthi D S, Shobha Rani A and T G Basavaraju, Buffer Based Routing Mechanism for Load Balancing in Wireless Mesh Networks. International Journal of Computer Engineering and Technology (IJCET), 10(1), 2019, pp. 1-10.
http://www.iaeme.com/IJCET/issues.asp?JType=IJCET&VType=10&IType=1

1. INTRODUCTION

WMNs are one of the most favorable wireless technologies which find several applications, e.g., broadband home networking, enterprise networking, community and neighborhood networks, building automation etc. They are an extension of wireless ad-hoc networks and they aim at delivering a cost effective and robust, high bandwidth network over a particular coverage area. WMNs [1] are dynamically self-healing, self-organized and self-configured as the nodes in the network automatically establish and maintain mesh connectivity among themselves which in turn provide benefits such as effortless network maintenance, low up-front costs and dynamic and reliable service coverage. A more sophisticated routing protocol along with an efficient routing metric can be used to enhance the performance of the WMNs. WMNs employ a number of routing protocols where every protocol maintains its own routing strategy [2, 3]. These protocols are categorized as proactive, reactive and hybrid based on the strategies adopted by them.

Load Balancing is a method of evenly distributing the traffic across two or more nodes for effectively mediating communication and achieving redundancy even if there is any link failure. Load balancing can be achieved by increased throughput, minimal overheads and optimal utilization of resources. Whenever the routes are exploited repeatedly over a longer duration, the packet concentration elevates in intermediate nodes. This creates bottlenecks and thereby degrades the network performance due to congestion and also results in longer delays. The caching technique used in most of the on-demand routing protocols causes additional mass of load on certain nodes. In WMN, congestion is the major cause for the uneven distribution of traffic that causes underperformance of the network. Congestion is a condition where multiple packets are present in network exceeding existing resource available and thereby deteriorating the performance of the network. These packets completely fill up the buffer space and possibly overflow, manifesting in excess end to end delay, packet drop and low network throughput and degraded bandwidth.

The organization of the paper is as follows. The related work is discussed in Section 2. The proposed routing scheme BBL-AODV is completely described in section 3. The simulation results, performance comparison and analysis are presented in section 4. The inference of the paper is in section 5.

2. RELATED WORK

Many protocols exist for load balancing in wireless networks. Most of them have considered parameters like link occupancy, queue size, delay etc. as a metric for route selection. In [4], the authors have proposed a buffer aware routing protocol which takes buffer space of neighbouring nodes into account while taking routing decision. Even though the protocol performs well it introduces more delay while performing route discovery.

In [5], the authors present a congestion control approach by advertising the buffer space to the surrounding neighbour nodes. This approach is independent of the routing protocol but it needs additional mechanisms when inappropriate traffic is generated in the network. Congestion avoidance mechanism [6] deals with high load and fast mobility, which selects the best path based on minimum value of buffer queue occupancy instead of minimum hop count as in standard AODV.

Kruti N Kapadia et al. [7] have put forth an airtime congestion aware metric for a multi-radio WMN. It uses airtime link metric for estimating RTT for delay calculation and channel utilization. With the combination of both parameters, load is uniformly distributed over less congested nodes. Raffaele Bruno et al. [8] have developed an algorithm based on queuing model for detection of congested paths in heterogeneous mesh networks.

The algorithm is implemented at the nodes with the objective of forwarding traffic to less congested gateways based on their queue occupancy.

Dhurandher et al [9] have presented a novel protocol for distributed admission control and interference aware admission control for WMN with the aim of providing QoS guarantee for multimedia applications. The protocol calculates suitable admission control ratio that ensures loss rate within the tolerable limit. In addition to this it also computes end to end delay to exercise flow request. ECARP [10] is proposed for heavy traffic loads in MANETs and this protocol considers the number of packets in node buffer to regulate congestion among nodes. CARM [11] prefers less congested, high throughput links for traffic by employing weighted delay, retransmission count, and queuing delay in buffer.

In our work we have proposed a modified AODV protocol called Buffer Based Load Balancing Adhoc on Demand Protocol (BBL-AODV), which considers node buffer occupancy as well as average buffer occupancy of all neighbouring nodes as a routing metric during route discovery.

3. BUFFER BASED LOAD BALANCING AODV PROTOCOL

Buffer Based Load Balancing AODV Protocol (BBL-AODV) is an enhancement over the standard AODV protocol. It uses a path metric which allows source node to select the best path to the destination based on buffer occupancy of intermediate nodes. The standard AODV protocol discovers the route by broadcasting/flooding RREQ message and establishes a path when RREP message is received. The path selection is based on minimum hop count and sequence number irrespective of packet handling capacity. In Buffer Based Load Balancing (BBL) Protocol, each node maintains information about its node buffer occupancy in its routing table. Each node calculates its average buffer occupancy *avg_buff_occ* based on node buffer occupancy *node_buff_occ* of all neighboring nodes and itself. The node is assigned with a threshold value *thr* for optimum buffer utilization.This threshold value defines buffer space that a node requires to forward received packets. Whenever a node receives RREQ packet, it compares its current node buffer occupancy with threshold *thr*. If the current buffer occupancy is less than threshold *(node_buff_occ< thr)*, the node broadcasts RREQ packets or else it discards. Therefore, load is distributed along the less congested path and this enhances the performance of the wireless mesh network.

The average buffer occupancy is calculated as follows:

$$\text{avg\_buff\_occ} = \frac{\text{node\_buff\_occ} + \sum_{j=1}^{n} \text{node\_buff\_occ}}{n+1} \tag{1}$$

where ‘n’ represents total neighboring nodes.

The node_buff_occ represents the buffer occupancy of the node which is given by the following equation.

$$node\_buff\_occ = \frac{\sum_{i=1}^{b} buff_{\,i}\_pkt}{b} \tag{2}$$

where, buff $_i$ _ pkt represent total number of packets in every buffer present.

‘b’ refers to the number of buffers in each node.

The BBL-AODV Algorithm for Route Selection is described as follows.

Step 1: Node has data to send

Step 2: Check the active nodes for transmission // active refers to a node already participating in data transfer

Step 3: If (node= =active)
then go to step 4
else go to step 7
end if
Step 4: Calculate *node_buff_occ* of each intermediate node.
Step 5: If node_buff_occ<thr,
then forward the packet
else rebroadcast RREQ
end if
Step 6: Broadcast RREQ and wait for RREP
Step 7: Receive RREP go to step 4

4. PERFORMANCE EVALUATION

This section discusses parameters and performance metrics chosen for simulation of the proposed BBL-AODV protocol with standard AODV protocol. The performance of the proposed routing mechanism is evaluated by carrying out simulations using the licensed network simulator Qualnet v6.1.

4.1. Simulation Parameters

We have done substantial number of simulations for studying the performance and effectiveness of the suggested BBL-AODV against the standard AODV protocol in a wireless mesh network. The simulation is run for 300 seconds on a grid topology of simulation area 1500 x 1500 m^2at lower and higher data rates for different Node densities. The nodes are placed in the simulation area in a uniform fashion with 150 m as inter-node distance. The traffic source selected is Constant Bit Rate traffic with each packet size being set to 512 bytes. The Table 1 below describes the simulation parameters employed for performance analysis.

Table 1 Simulation Parameters

Parameter	Value
Protocols	AODV, BBL-AODV
No. of Nodes	25, 36, 49, 64, 81,121
Radio type	802.11b Radio
MAC Protocol	802.11s
Antenna Model	Omni-directional
Path Loss Model	Two ray propagation
Traffic Type	CBR
No. of CBR	3

4.2. Performance Metrics

The effectiveness of the proposed and the standard protocol is compared using the performance metrics like throughput, total number of packets received, end to end delay and jitter.

- *Throughput:* The rate at which message is delivered successfully over a communication channel and is measured in bits per second.
- *Total number of packets received:* It is the number of packets received at the destination.
- *End-to-end delay:* It is the time taken by a packet to traverse from source to destination.
- *Jitter:* It is measuring time difference in packet inter-arrival time.

4.3. Simulation Results

In this paper, the results are presented for different node densities at low and high data rates for both BBL-AODV and standard AODV protocol.

4.3.1. Low Data rate

In this scenario packets are forwarded through three CBR connections. Each source generates a low traffic of 1 packet/sec and is routed to the destination for a period of 300 sec. The above procedure is repeated for 36, 49, 64, 81 and 121 node densities respectively. After each simulation, the performance metrics such as throughput, delay, jitter and total messages received are recorded.

Figure.1-4 shows throughput, total packets received, end-to-end delay and jitter with varying node densities for BBL-AODV and AODV. It is observed that throughput remains almost same for BBL-AODV and standard AODV protocol. This is because the traffic generated in the network is within the buffer threshold limit for each node. So, both protocols use default routing strategy for path selection in the network. This is true even for total packets received, end-to-end delay and jitter respectively.

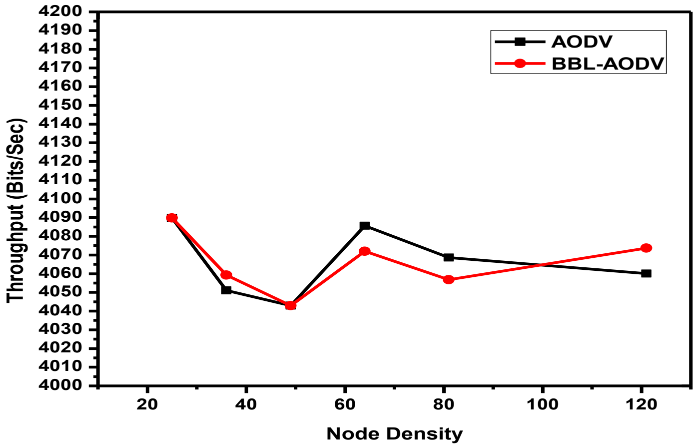

Figure 1 Variation of throughput v/s node densities

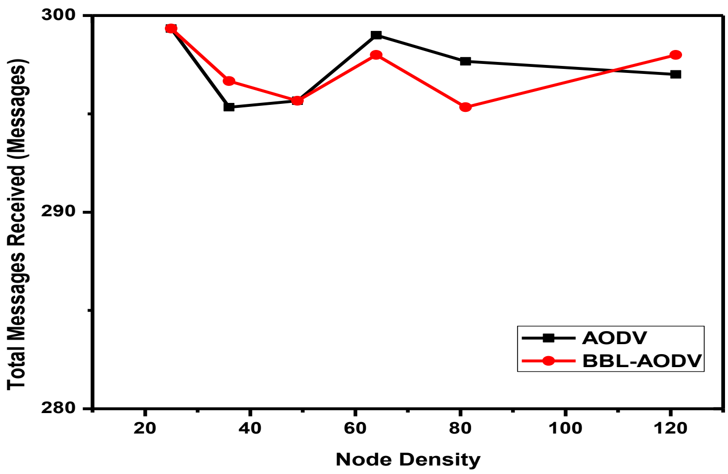

Figure 2 Variation of total messages received v/s node densities

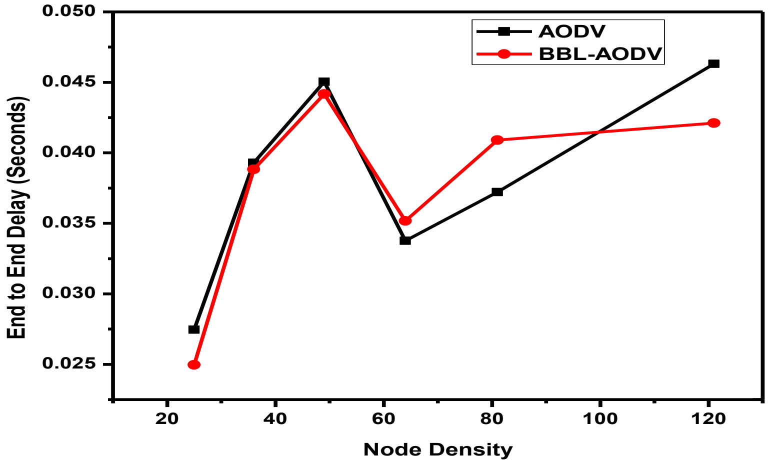

Figure 3 Variation of End to End Delay v/s node densities

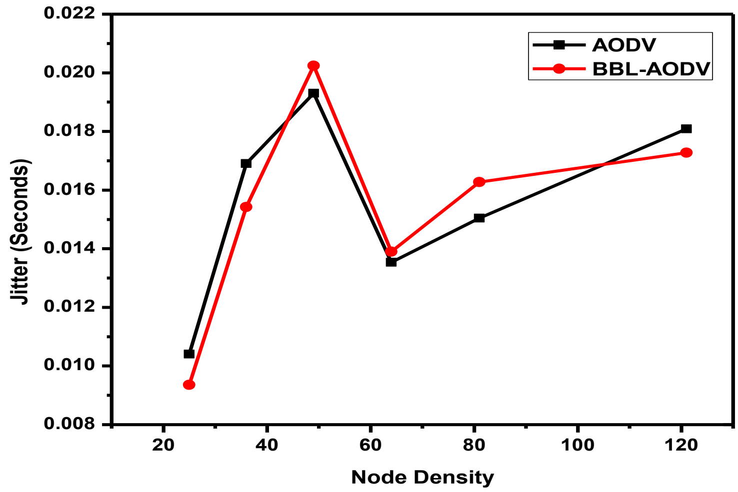

Figure 4 Variation of Jitter v/s node densities

4.3.2. High Data rate

In this section, the proposed protocol is compared with AODV protocol for a high data rate. The packets are forwarded through three CBR connections. Each source generates high traffic that is 100 packet/ sec and is routed to the destination for a period of 300 sec. The above procedure is repeated for 36, 49, 64, 81 and 121 node densities respectively. After each simulation the performance metrics such as throughput, delay, jitter and total messages received are recorded.

Figure 5 shows the variation of throughput with respect to the node densities for BBL-AODV and AODV protocol. It is observed that throughput for our proposed protocol is greater than AODV. This is due to the fact that when the load is very high, AODV failed to handle congestion thus resulting in degradation of the performance of the network. But the performance of the BBL-AODV is good since it uses the knowledge of buffer availability of each node during route discovery and avoids packet forwarding through the highly congested nodes.

Figure 6 depicts the total message received v/s node density. It is evident that the number of packets received at the destination is more in BBL-AODV as compared to AODV. This is due to the fact that the packet drop ratio is less in BBL-AODV as it avoids nodes having buffer occupancy greater than threshold which in turn increases the packet reception at the destination.

In Figure 7 it can be observed that the end-to-end delay in case of BBL-AODV is less than that of AODV. As traffic flow increases, AODV will experience higher delay due to congestion. Therefore, data packets take more time to reach the destination. BBL-AODV captures the link quality by monitoring buffer utilization. It minimizes congestion along the path by computing buffer occupancy based on the proposed metric a*vg_buff_occ* and *node_buff_occ* thus nodes are not over flooded. This results in optimum utilization of all network resources thereby allowing data packets to take less time to reach destination. Hence end to end delay of BBL-AODV is lower than that of AODV. Since delay variation in BBL-AODV is less than AODV, it is suitable for real time applications. Hence BBL-AODV performs better than AODV protocol.

Figure 8 shows the jitter variation for BBL-AODV and AODV. It is observed that BBL_AODV experiences lesser jitter for increase in the node density and traffic rate when compared to AODV. Hence the proposed protocol outperforms the AODV protocol in terms of throughput, total number of packets received, end to end delay and jitter.

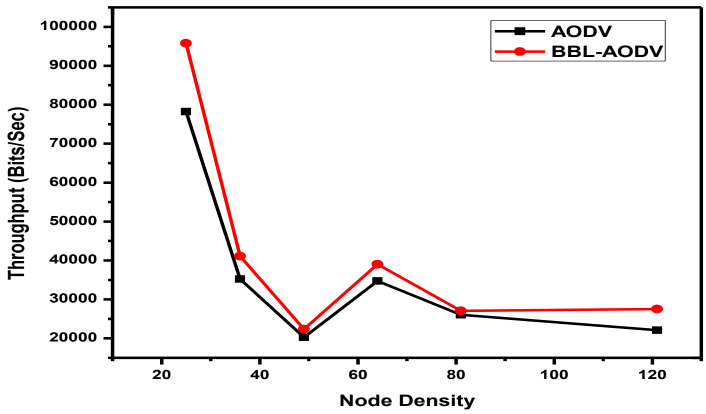

Figure 5 Variation of throughput v/s node densities

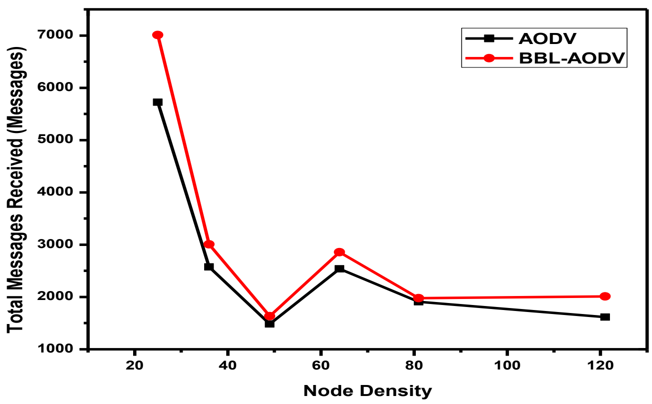

Figure.6. Variation of total messages received v/s node densities

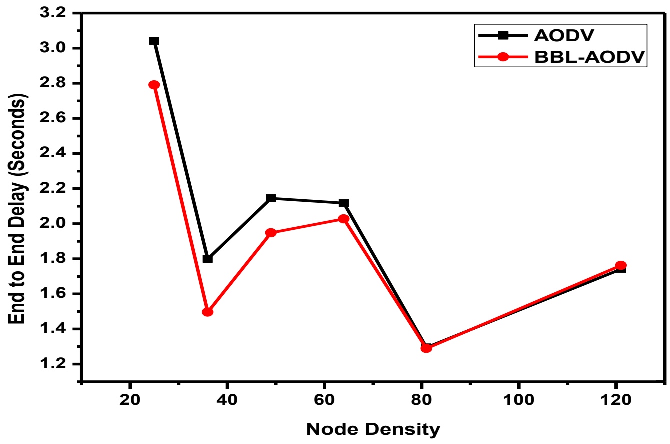

Figure 7 Variation of End to End Delay v/s node densities

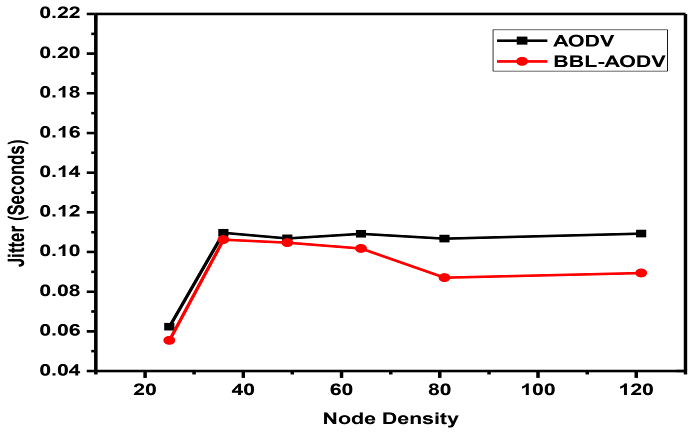

Figure 8 Variation of Jitter v/s node densities

5. CONCLUSION

In this work, we have proposed BBL-AODV; an effective buffer-based routing protocol for wireless mesh network. It captures link quality by monitoring buffer utilization. It minimizes congestion along the path by computing buffer occupancy based on the proposed routing metric. Simulations are done to analyze the proposed protocol's performance for different node densities with varying data rate. The metrics used to estimate the performance of the proposed protocol and standard protocol are throughput, delay, jitter and total messages received. From the results, it is evident that the proposed protocol outperforms the standard AODV protocol scheme with reference to the predefined performance metrics and hence results in optimum utilization of all network resources and increases the overall performance of the wireless mesh network.

ACKNOWLEDGEMENT

This work is supported by the Technical Education Quality Improvement Program Phase II with the World Bank assistance. The authors would like to thank State Project Facilitation Unit, Directorate of Technical Education, Government of Karnataka, National Project Implementation Unit, MHRD, New Delhi for their support and encouragement.

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