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# Congestion Avoidance in Wireless Mesh Networks Based On Multicast Routing Protocols

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***Abstract*—** Congestion is a major challenge in Wireless Mesh Networks (WMNs) that rely on high mobility, dynamic topology, and limited resources. Congestion is the instability of the network due to unmanaged traffic resulted in exceeding the capacity of the network's resources which leads to bottleneck stage that can occur at any intermediate node. Therefore, the performance of the network is deteriorating in packet drops, high delays, and low throughput. Therefore, an extensive research has been done for searching an effective algorithm for congestion problem in WMNs. Hence, the demand for effective management of the resources is immensely needed to enhance the network performance with multicast processes that lead to more congestion in the networks due to the high demands of resources in WMNs. Hence, a new scheme has been proposed in this paper to avoid the congestion in WMNs using the concept of target rate that is applied in the MAC layer and based on (MAODV) Multicast Ad-hoc on Demand Distance Vector routing protocol. The simulation results through NS2.26 simulator show the performance of the proposed scheme outperforms the original scheme. Thus, proving a fair distribution of resources among nodes is maintained due to resolving the congestion problem which leads to increases packet delivery ratio and the throughput and reduces the delay thereby increasing the network performance on the whole which is suitable for the emerging applications in WMNs.

***Keywords*—**Congestion, Routing, Wireless Mesh Network, Target Rate.

## I. INTRODUCTION

Wireless Mesh Networks (WMNs) is a communication network that consists of Mesh Routers and Mesh Clients, as shown in Figure 1. The mesh routers in WMNs are relatively static; which represents the wireless mesh backbone and provides multi-hop connectivity from mesh clients to mesh clients or to the Internet via access points (Gateways). The mesh clients can be static or mobile; they can form a Wireless Local Area Network (WLAN) or a Mobile Ad-hoc Network (MANET). WMNs is dynamically self-organized and self-configured with nodes in the network automatically establishing and maintaining mesh connectivity among themselves. These features bring many benefits to WMNs such as low installation cost, large-scale deployment, reliability, and self-management.

Multicasting is the process of delivering a stream of packets to a group of receivers simultaneously. Which used by lots of multicast applications such as video conferencing, public safety, transport systems, campus networks, and chat groups [1]-[2].

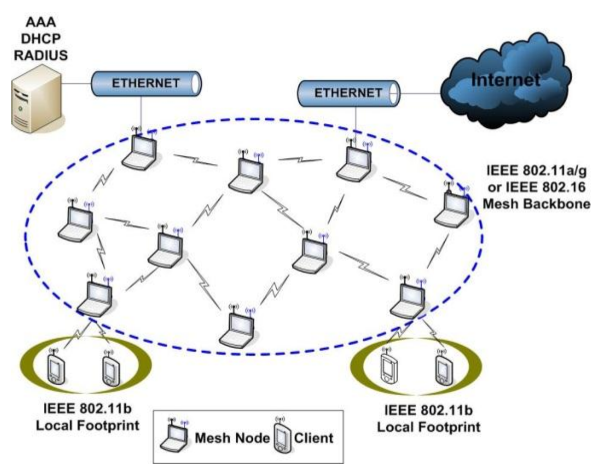


Figure 1. Architecture of a WMNs

Congestion that occurs with multicast routing protocol is a critical issue that must be considered when designing a WMNs multicast routing protocol because congestion control and routing protocols in WMNs are not seen to have overcome this recurrent problem of congestion being experience most times in the wireless network. Routing techniques may lead to a congestive scenario and the congestion control should detect and probably avoid such situations. Furthermore, congestion causes lower throughput, longer delay and packet loss [3].

Multicast protocol is a key technique to the group team application, which benefits in the significant reduction of network loads when packets need to be transmitted to a group of nodes. The Multicast protocol must guarantee the performance requirements: adaptable to the dynamic change of network topology, timeliness, minimizing routing overhead and efficiency. Multicast is a communication approach for groups on information source using the single source address to send data to hosts with same group address. Multicast Ad-hoc On-Demand Distance Vector **(**MAODV**)** topology is based on multicast tree adopting broadcast routing discovery mechanism to search multicast routing, which sends data packets to each group nodes from the data source. MAODV is the multicast extension of AODV. Both Ad-hoc On-Demand Distance Vector (AODV) and MAODV are routing protocols for ad-hoc networks and Mesh Network, with AODV for unicast traffic and MAODV for multicast traffic, so it is a good illustration for tree-based multicasting. In this protocol, the route discovery is based on a route request RREQ and route reply RREP cycle as shown in Figure 2. When MAODV discovers multicast routers it originates a route request (RREQ) message. Then the members of the multicast group respond to the route reply message. If a node is a non-member of the multicast group and receives a route RREQ, it rebroadcasts RREQ to its neighbors. But if the RREQ is not joining request, any node of the multicast group may respond [4]-[5]

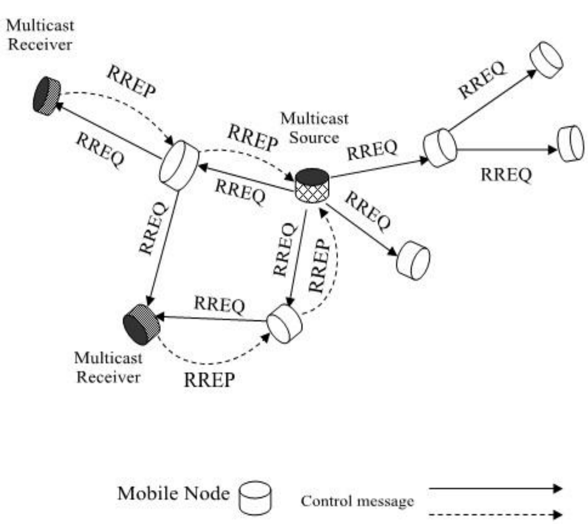


Figure 2. MAODV Routing

Rest of the paper is organized as follows, Section II contains the related work, Section III explain the methodology, Section IV contains simulation environments, section V describes result and discussions, and section VI contains the conclusion and future scope, and finally the reference.

## II. RELATED WORK

A brief survey of the related work in this research direction is presented below.

In [6], proposed a new congestion control scheme to alleviate congestions at the Mesh Nodes (MNs) around gateways to an outer network such as the Internet for layer 3 in WMNs. In the proposed scheme, MNs composing WMNs backbone monitors their transmission queue periodically and detects congestion. When an MN detects congestion, it identifies MNs that makes the overload of traffic causing congestion and sends a congestion control message to these MNs. When the MNs receive the congestion control message, they control the bandwidth of the traffic toward the congested MN. This work performed a simulation of the proposed scheme using a simple network model and evaluated the effect of congestion control. This work has shown that the proposed method is effective to reduce average queue length of the bottleneck MN and to improve the total throughput significantly.

In [7], proposed algorithm for congestion control in WMNs, to solve congestion control in WMNs, a random routing algorithm based on path weights (WA) is presented. The algorithm adopts multi-gateway wireless mesh network routing protocol to solve the congestion problem of a single gateway. In addition, unicast service was used to ensure the success rate of service requests. Simulation results show that WA is a better algorithm as it has a less average wait time and the success rate of service requests. On the basis of taking into account the distance vector and the load of gateway nodes, the algorithm can select the most appropriate gateway nodes for data packets. The algorithm can effectively solve the congestion problem, and make the network stable and efficient. Simulation results show that: WA can effectively balance the load of gateway nodes, and reduce the transmission delay of packets.

In [8], proposed a priority based congestion control routing in WMNs, In WMNs the information is forward using the best possible route to any destination. The best path can be determined using the routing protocol. The congestion problem occurs when every time routing protocol determines the same best path due to which traffic load takes place on that path while other paths seldom used. Due to the abrupt use of single path the packets may drop causes the greater effect on the network's performance. In this work, a technique is used to overcome such congestion problem that faced by the network. The technique of priority based selection mechanism for the paths is adopted which can ensure the performance of the network. The proposed technique improves the performance of networks in such a way that overhead of packet loss is minimized because the packets are transmitted from one access point to other. On the other hand, it can distribute the traffic on different routes according to the priorities of each route while this algorithm is helpful for determining the shortest path and store it into the memory for next time. So when communication occurs it uses the path which is at the topmost in the routing table. But after some specified interval of time, the traffic is distributed among second highest priority route so that the problem of packet loss is minimized and the performance of the network is improved. But what happens if a node is moving, this node is still a part of the wireless network. At this situation distance from that node to each access point is changed continuously. Also at each time, multiple possible routes are changed. Now for every time the session break and again priorities assigned to each route.

In [9], proposed an algorithm to reduce the congestion in WMNs. This algorithm using buffers is implemented in which the number of packets related to each destination present in the buffer is checked against a certain threshold. The proposed work reduces the congestion by adopting the buffer scheme in a modulated form. Once congestion is detected, the congested route is not used for some time as the data is forwarded through alternate routes. The simulation is carried out in the NS-2 simulator, different parameters of the network have been considered, and a comparative study is done. The simulation results conclude that the proposed algorithm performs much better and improves the network performance by increasing throughput and decreasing the delay.

As mentioned above, a lot of schemes have been developed to overcome the congestion problem in WMNs. These schemes only consider unicast processes while, multicast processes does not consider that have high demands of resources in WMNs. Therefore, unmanaged multicast traffic resulted in exceeding the capacity of network resources. This leads to network congestion, which is experienced, by high packet loss, low throughput, and a longer delay.

## III. METHODOLOGY

This section introduces a proposed scheme that has been designed to deal with issues of congestion control algorithm in WMNs. Therefore, the main goal of this paper is tailored to get more reliable and stabile networks when the load on the network is greater than the capacity of the network. So, the proposed scheme for a congestion problem in WMNs will be use the Target Rate (TR), which is defined as the maximum rate of transmission that will not cause congestion in the downstream nodes. TR function is applied in the MAC layer based on MAODV routing protocol-using buffers that store the packets. The TR has been computed by the following equation (1) [10]:

$$TR = \min(L, \min(\frac{1}{n}\frac{TidleC}{P + CH}, F)) \qquad (1)$$

Where / L / is the offered load of upstream link, / n / is the number of average active nodes (links), / $T_{idle}$ / is the channel idle per measurement window, / C / is the average transmission rate, / P / is the packet size, / H / is the overhead per packet in time units and / F / is the forwarding capacity of the downstream link.

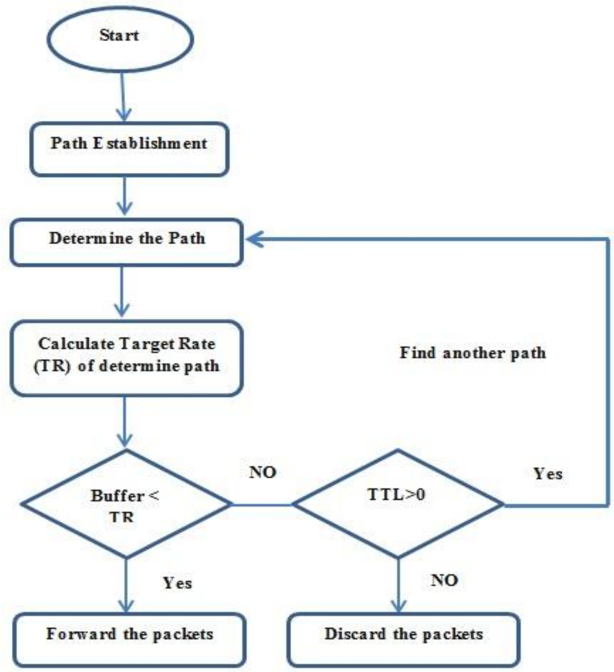


Figure 3. Proposed Scheme (*Flowchart*)

Figure 3, shows the flowchart of the proposed scheme. When the route is established and determined from source to destinations. The function of TR must be invoked to compute the TR of the determine route before forwarding the packets. After that, TR is compared with buffer. If the buffer value is less than the TR, the packets will be forward through the determine route, otherwise, the packets should be forwarded through an alternative path when the specified (TTL) Time to Live is greater than zero, otherwise, the packets will be discarded. Repeat this workflow until all the destinations for which packets are available are received. The proposed scheme resolves the congestion problem by preventing the buffers from being overflow, so this will increase the throughput and the network performance will be enhanced.

 

## IV. SIMULATION ENVIRONMENT

To investigate the performance of the proposed scheme; we use NS-2.26 for network simulation. NS2 is a discrete event simulator targeted at networking research. NS2 provides substantial support for simulation of TCP, routing, and multicast protocols over wired and wireless (local and satellite) networks. The routing protocol has been used in this work is MAODV routing protocol.

To measure the performance of the proposed scheme in WMN for comparison purposes, a performance metrics have been used in this work as follow:

- **Throughput**: It is the rate of delivery of packets. When the value increased the performance of the network enhanced.
- **End-to-End Delay**: It is the average time to reach the packet from source to destination. It is expected to be minimized.
- **Packet Delivery Ratio (PDR)**: It is the ratio of the number of data packets actually delivered to the receivers contrasted with the total number of data packets supposed to be received under ideal conditions.

The simulation is carried out in a grid of area 1500mx1500m. The simulation parameters values used in the simulation shown in Table 1.

Table 1. Simulation Parameters

| Description | Value |
|---|---|
| Number of Nodes | 49 |
| Simulated Area | 1500 m X 1500m |
| Simulation Time | 80 Sec |
| Routing Protocol | MAODV |
| Traffic Type | CBR |
| Packet Size | 1024 bytes |

## V. RESULTS AND DISCUSSION

In this section, the discussion of the performance analysis depends on the simulation experiment that has been performed for the two schemes. The proposed scheme deploys the target rate in MAC layer. While, the original scheme does not deploy the target rate in MAC layer that has been used for comparing purposes. The simulation runs, considering time and traffic load against different metrics mentioned earlier to measure the performance of the network.

The simulation runs, considering time and traffic load against different metrics mentioned earlier to measure the performance of the network.

- **Packet Delivery Ratio (PDR):** As shown in Figure 4, the graph represents the PDR analysis with respect to time and traffic load. The Graph below clearly shows that the PDR of the proposed scheme is better than the original scheme that means the proposed scheme gives better results in case of PDR; therefore, it increases the performance of the network.

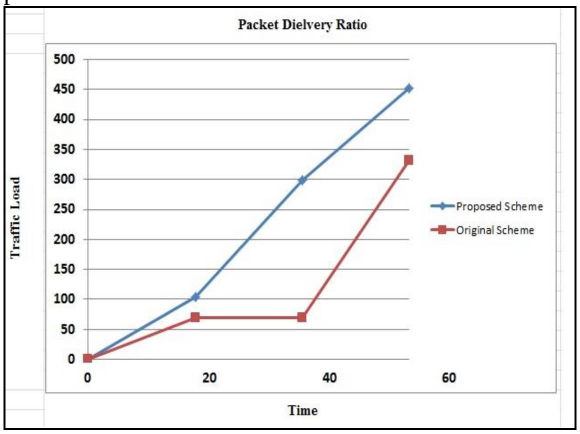


Figure 4. PDR

- **Throughput:** As shown in Figure 5, the graph represents the throughput analysis with respect to time and traffic load. It is obvious that the throughput of the proposed scheme has increased when compared to the original scheme. Therefore, the proposed scheme gives better results in case of throughput, so the performance of the network is improved.

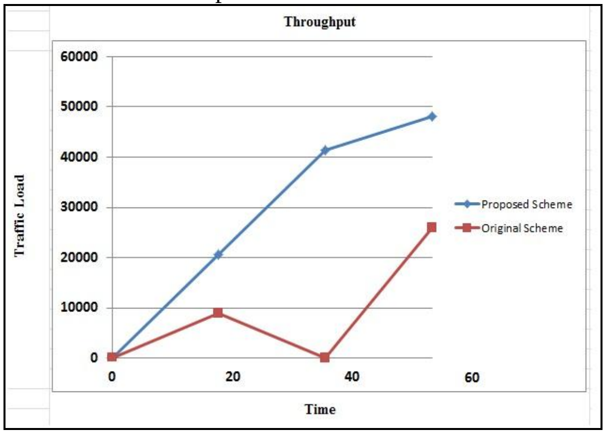


Figure 5. Throughput

- **End-to-End Delay**: As shown in Figure 6, the graph represents the end-to-end delay analysis with respect to time and traffic load. The graph represents the decrease in the delay in proposed scheme when compared with the original scheme. The decrease in delay obviously shows that the proposed scheme reduces the congestion problem and enhances the performance of the network.

 

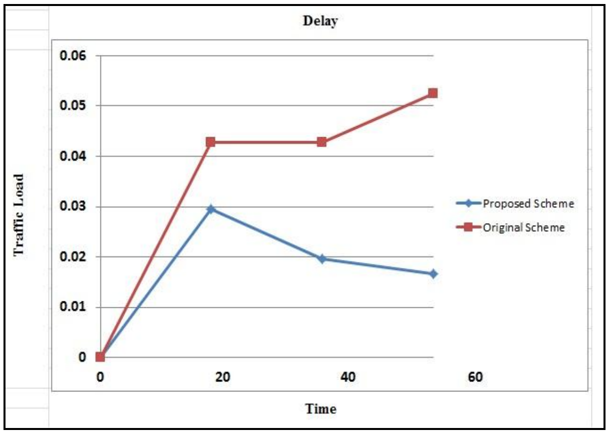


Figure 6. End to End Delay

## VI. Conclusion and Future Scope

In this paper, the proposed scheme based on MAODV routing protocol uses the TR that is applied in the MAC layer to avoid the congestion in WMNs. The simulation results are a proved that they achieve an improvement in the network performance via increases packet delivery ratio and the throughput and reduces the delay. In addition, the results ensure efficient congestion control scheme within multicast traffic and a fair distribution of resources among nodes. Therefore, the results of the proposed scheme indicate a promising performance in WMNs for the emerging applications. Although congestion is reduced in this study, it is still a need to make efforts for enhancement in WMNs that has emerged as growing area of research for next generation wireless networking.

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