Queuing Based Load Balancing Approach for Improving Network Performance in MANET

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Abstract: Mobile ad hoc Networks (MANET) consists of mobile nodes that not only forward data but also perform wide range of computations. One of the vital issues in these networks is the substantial differences in terms of energy and processing power of the nodes, introducing a load imbalance. Load balancing is a vital requirement of any multi-hop networks. In general, a biased load leads to network congestion which influences the throughput, end-to-end and packet delivery ratio. Thus, in this paper a cache queuing technique has been proposed for fair distribution of loads among the nodes. Here, dynamic source routing (DSR) protocol has been utilized for routing process. The simulation results indicate that the proposed approach achieves high throughput and packet delivery ratio whereby minimizing the delay.

Keywords: MANET, load imbalance, dynamic source routing, cache queuing.

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1 Introduction

In ad hoc network it is vital to utilize effective routing protocols for providing high quality transmission. Since the nodes of the MANET have limited battery power, buffer space and battery power it is essential to distribute the loads among the nodes of the MANET. An unbalanced load degrades the network performance. Because of unbalancing nature, some nodes are heavily loaded with routing tasks that causes high packet delay, packet loss ratio, power consumption and queue size. Thus need for load balancing in MANET necessary.

A crucial challenge in the design of mobile ad hoc network is the effective routing protocol that enables high quality communication. In shortest path routing, the nodes present along these paths will get heavily loaded. Containing a heavily loaded node can exhaust the useful resources of the nodes. Moreover, if a node is overloaded it leads to network congestion leading to longer delay and loss of the connection [1]. Hence, it is vital that some kind of load balancing should be resent in the system.

Several load balancing techniques [2] need the source to forward a probe packet to the target node and waits for those packets to be returned by the target node. By doing so, the probe packet has to travel two times along the same path, produces more overhead. Thus, it is not efficient. Hence, an effective load balancing technique has been proposed in this paper. Here, the load is fairly distributed among the nodes based on cache queuing technique. The cache queuing technique is based on prefetching mechanism and the loads are distributed by utilizing this pre-fetched information. Moreover, the routing is achieved using dynamic source routing (DSR) protocol.

The rest of the paper is organized as follows: section II presents the existing researches made for achieving load balancing, section III presents the proposed technique for achieving load balancing, section IV presents simulation results and finally section V concludes the paper.

II. Related Work

Several research works have been carried out in order to achieve load balancing among the nodes of the MANET.

In [3] the DSR protocol is extended with load balancing function. When the source needs to forward data to the destination, the DSR protocol is utilized in order to find the paths to the destination. Here, the number of congested packets is also estimated on every path based on the data forwarded by the destination the RREP packet. The destination updates the number of congested packet time to time based on the load packet being sent to the source and according to the updated information load balancing decision is made.

Alternate path routing [4] provides load balancing by distributing load among set of multiple paths. [5] Proposed a load balancing technique in which the traffic is distributed based on average interface queue length, residual battery capacity and hop count with related weight values. It helps in achieving load balancing and the life time of the entire network is extended.

In [6] load balancing is achieved by distributing the traffic on a set of alternative paths. This is done by employing
alternate path routing where if one path fails transferring the data, an alternate path is chosen. Since the route coupling is give rise to geographic proximity of diverse paths between common nodes, alternate path routing is not employed fully.

[7] Presented a high performance queuing technique in order to implement a shared queue intended for collaborative clusters of servers. A local queue is maintained in each cluster and queues of several clusters combined to form a shared queue that assigns tasks to the server available. A novel randomized algorithm is presented in order to send request in overloaded queue to a shared queue depending on the load information of the neighboring cluster.

[8] employed a (CPR) cost-to-progress ratio in position based greedy routing algorithm for reducing and balancing the load. The CPR routing is a local parameter less technique that optimizes the ratio of load in the node and the geographic progress.

[9] Proposed fuzzy neural network (FNN) based approach for solving load balancing issue in ad hoc networks. In this approach, the fuzzy neural system is placed at each network point in order to make load balancing in nodes utilizing two FNN. One FNN is based on queue length that allows queue size to categorize the state of the queue (underflow or overflow). The second FNN utilized the queue state that indicates the output of the first FNN. Here, Gaussian membership function combined with back propagation algorithm is used to train the neural network.

III. Materials And Methods.

Route Discovery: The proposed methodology uses AODV-multipath in order to find the routes to the destination. AODV Multipath is an extension of the AODV protocol intended to discover numerous node- disjoint paths. Intermediate nodes forward RREQ packets towards the destination [10]. Duplicate RREQ are not discarded and maintained in the RREQ table. The destination node replies to all route requests focusing at maximizing the number of computed multiple paths. RREP packets are sent to the source through the reverse route traversed by the RREQ. To guarantee node-disjointness, when intermediate nodes listen to RREP message from neighbor nodes, they remove the corresponding entry of the transmitting node from their RREQ table. In AODV Multipath, node-disjoint paths are established amid the forwarding of the route reply messages towards the source.

Methodology:

In cache queuing technique, the load balancing is performed based on the prefetching mechanism that is bandwidth and other information of the nodes are recorded in prior and the load is transmitted to the node based on these prefetched information.

Fig 1 Cache queuing for achieving load balancing

Fig 1 illustrates the process involved in this approach. If a source has to transfer data to the destination, first the availability of the node is checked through routing process. Here, dynamic source routing is employed for the process of routing. If a node is available for transferring the load, next it is required to ensure that whether the queue is occupied or free.

The queue occupancy is calculated using the following equation [11]

\[ qoc = \frac{qoc + \sum_{i=1}^{n} n_{qoc_i}}{n+1} \]

Where \( qoc \) is the average queue size, \( n \) is the number of neighboring nodes and \( n_{qoc} \) is the occupancy of node’s neighbor.

If the queue is not available, the node has to waiting for a certain time quantum. Once, the queue is available, the underflow and overflow condition of the queue is checked. If queue satisfies the underflow condition, the data is transferred. Once the data has been transferred completely, the queue is releases and the connection is terminated. Fig 2 shows the algorithm for load balancing.

Algorithm for efficient load balancing

Let \( S \) be the source, \( D \) be the destination and \( t_s \) be the waiting for queue

Step 1: Initialize the number of packets ‘p’

Step 2: Initialize Route Discovery Process and Establish route to the destination

Step 3: At D, check for queue occupancy \( qoc \)

\[ qoc = \frac{qoc + \sum_{i=1}^{n} n_{qoc_i}}{n+1} \]

if \( qoc > p \) then

Wait for \( t_s \) secs for queue to release

else

Transfer packets from \( S \) to \( D \)

End if

Step 4: End

Fig 2 Load balancing Algorithm
IV. Simulation Results

The performance of the proposed techniques is evaluated using network simulator 2 (NS2). The simulation is carried out in a 1500 X 1000 meters network, consisting of 50 mobile nodes. Table 1 shows the parameters considered for simulation.

<table>
<thead>
<tr>
<th>Simulation and Network Parameters</th>
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<tbody>
<tr>
<td>Network Area</td>
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<td>Routing Protocol</td>
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<tr>
<td>No. of Mobile Nodes</td>
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<tr>
<td>Network Topology</td>
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<td>IEEE Standard</td>
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<td>Simulation Time</td>
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<tr>
<td>Data Transfer Protocol</td>
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<td>Connection Type</td>
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Table 1 Simulation Parameters

Performance Metrics

The following metrics are utilized to measure the performance of the proposed approach.

Throughput:

Throughput is the amount of data packets transmitted from source to the destination in a specified time interval.

Delay:

The average time taken by the packet to arrive at the destination, including the delay occurred during the route discovery mechanism and waiting time in the queue. Only the packets that are delivered successfully are considered.

\[
\text{delay} = \frac{\text{sum of arrival time} - \text{departure time}}{\text{total number of connections}}
\]

Delivery Ratio:

Packet delivery ratio is defined as the ratio of the number of packets delivered to the destination. This describes the level of data delivered at the destination. The greater the packet delivery ratio, the better the performance of the routing protocol.

\[
\text{packet delivery ratio} = \frac{\text{total number of packets received}}{\text{total number of packets sent}}
\]

Results and Discussion:

Fig 2 shows the throughput attained in case of the proposed technique. In case of proposed technique though, the load of the network increases the most of the packets are successfully transmitted. The delivery ratio of the packets is more when employing the proposed technique as shown in fig 3.

V. Conclusion

In this paper, load imbalance in MANET is solved by employing the cache queuing technique. The proposed technique is based on the prefetch mechanism in order to fairly allocate loads among the nodes. The routing is achieved using the dynamic source routing protocol. The simulation results show that proposed technique increases the throughput and delivery ratio of the packets and minimizes the delay.
References


