Performance Analysis of Load Balancing in MANET using On-demand Multipath Routing Protocol

Monika Malik, Partibha Yadav, Ajay Dureja

***Abstract*— A collection of autonomous systems which are dynamically connected with each other via wireless links are known as Mobile ad hoc network (MANET). As MANET is an infrastructure less network without any centralized control of distribution of resources, the problems of network congestion, traffic load and depletion of energy of nodes are very often. Because of these problems the performance of network degrades and it becomes unstable. Therefore, load balancing among nodes becoming a vital part in MANET now-a-days. To achieve load balancing in MANET the most prominent way is to use multipath routing protocol so that the overloaded traffic is distributed among the multiple paths. In this paper, we approach LBA-AOMDV, an efficient load balancing algorithm using AOMDV (Ad-hoc On-demand Multipath Distance Vector) protocol for multipath route discovery and their maintenance. To analyze the performance of load balancing we focused on those nodes which have least load and can give maximum throughput. The simulation results are carried out by using NS-2.35.**

***Index Terms*— AOMDV, load balancing, MANET, multipath routing, performance**

I. INTRODUCTION

Mobile Ad hoc network is a collection of mobile nodes which are connected via wireless links, forming an infrastructure less network without any central administrator. The applications where Mobile ad hoc network is used include military field, search rescue, emergency and data acquisition. The topology of network is changes dynamically because wireless mobile nodes are free to move arbitrary. These mobile nodes act as sender, receiver and intermediate router depending on situation of network. Each node consists of a limited battery power which gets reduced by time. In order to perform a network consistently, it's essential that we should distribute the load among the nodes properly so that the depletion of energy will get decreased and network lifetime increases.

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II. ROUTING PROTOCOLS

In MANET, routing protocols are basically categorized as proactive routing and reactive routing protocols. Proactive routing protocols are also known as table-driven routing [1] protocols like DSDV which maintain and up-to-date routing information at each node. Reactive routing protocols which are also known as on-demand routing protocols like AODV [2] , DSR [3] which does not always maintain the routing information at each node, it just create the path only when it is needed. On-demand routing protocols are most prominent one for routing the packets. There is another category of routing protocol known as hybrid protocol. ZRP [17] (Zone Routing Protocol) is one of hybrid routing protocol. In this paper, our focus is on AOMDV [4] protocol as it provides multiple loop free and disjoint paths.

A. Ad-hoc On-Demand Distance Vector Routing Protocol (AODV)

AODV routing protocol uses on-demand technique, to transfer the data to destination. In on-demand technique, mobile nodes which are not involved in any transmission, do not maintain any routing information. AODV makes use of DSDV [16] (Destination-Sequenced Distance Vector) protocol to maintain the destination sequence numbers in order to ensure that most recent routing information is get selected in between nodes. This sequence number increases monotonically whenever a new message is sent. As greater the sequence number of route has, the fresher the route is. If there are two or more routes to a destination, then that node will be selected which has greatest sequence number. AODV establishes route table entries dynamically at intermediate nodes according to which packet is forwarded to next hop node which is listed in the route table entry. The packet size in AODV is always same. The Route discovery process is initiated only if a source node wants to establish a path to a destination node for which it has no existing route in its route table entries. For Route Discovery process, source node broadcast the Route Request (RREQ) message which is destined for the destination and waits for the Route Reply (RREP) message. Each RREQ control message carries the following format:

Type	Reserved	Hop Count
Broadcast ID		
Destination IP address		
Destination Sequence Number		
Source IP address		
Source sequence number		

Fig 1. RREQ Packet Header Format

Destination sequence number is the last destination sequence number known by the source for any route towards the destination. Hop count is the number of hops from the source node to the node that received this RREQ. Broadcast ID is a sequence number which is used to identify RREQ uniquely together in conjunction with the source IP address. The < Broadcast ID, Source IP address > pair uniquely identifies each RREQ. The Broadcast ID is incremented whenever the node sends out a new Route Request control message. The destination sequence number ensures loop-free routes and Source sequence number is used to maintain most current information of the reverse route to the source node. When a relevant node responds to RREQ message it sends a RREP (Route Reply) message which carries the following information in its header format:

Type	Reserved	Hop Count
Destination IP address		
Destination Sequence Number		
Lifetime		

Fig 2. RREP Packet Header Format

If a destination node is sending a RREP message, it attaches its most recent sequence number to the RREP. The destination node also set the Lifetime for the route and set Hop count to 0. If an intermediate node is responding to the RREQ message then it attaches its last sequence number for the destination in its RREP and also set a Lifetime for the route and the Hop count equal to the number of hops between itself and the destination node.

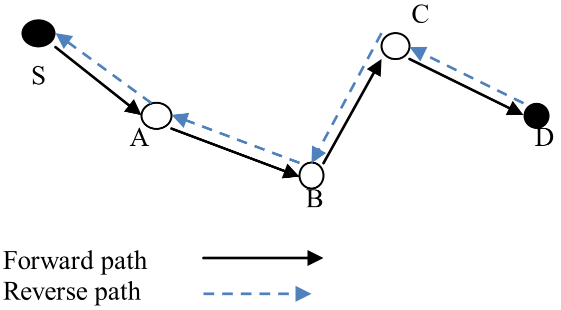

Fig 3. Unicast RREP back to the source node

The figure 3 shows how a forward path is set up using this forward path a unicast reply is sent back to the source. S is the source node and D is the destination node and A, B, C are the intermediate nodes.

B. Ad hoc On-demand Multipath Distance Vector Routing protocol (AOMDV)

AOMDV protocol is an on-demand routing protocol and an extended version of AODV protocol. It is designed such that it identifies multiple loop-free paths during route discovery. When a single path on-demand routing protocol such as AODV is used in network then for every route break, a new route discovery process is needed. But AOMDV is primarily designed for such ad hoc networks where link failures and route breaks occur frequently. The AOMDV protocol consists of two main parts first one is a route update rule to establish and maintain the multiple loop-free paths at each node and second is to find link-disjoint paths. AOMDV replaces hop count in its routing table with the Advertised hop count. Advertised hop count is the maximum number of hop count among the multiple paths for a destination and it cannot be changed for the same destination sequence number. In the transmission process of data packets between source and destination, each node maintains the number of hop counts for all the routing paths which is helpful in announcing the route to destination from source node. Alternate paths consist of less number of hop counts than the advertised hop count to the destination; such paths are accepted by the nodes. If a destination receives the route with a greater sequence number, then the advertised hop count and next-hop list is reinitialized. The following figure shows the differences between routing table entries of AODV and AOMDV routing protocol:

Destination IP address
Sequence number
Hop count
Timeout
Next hop IP address

Fig 4. Structure of AODV routing table

Destination IP address
Sequence number
Advertised hop count
Timeout
Route list {(next hop1, hop count1), (next hop2, hop count2),…}

Fig 5. Structure of AOMDV routing table

III. RELATED WORK

In MANET, load balancing strategies are classified as two types. First one is Traffic-size [11-15] based, in which traffic is distributed evenly among the network nodes to balance the load and another one is Delay [10] based, in which nodes with high delay are avoided to balance the load. Soundararajan et. al. **[5]** have proposed an algorithm for finding multi-path routes, in which all the intermediate nodes on the primary path are provided with multiple routes to destination. This computes fail-safe multiple paths which include the nodes with more battery power and least load and more residual energy. If the average load of a node along the route is beyond a threshold, then it distributes the traffic over disjoint multi-path routes so that traffic load is reduced on a congested link. Souihli *et al*. [6] have proposed a load-balancing method which pushes the traffic further from the center of the network. They used routing metrics that consider nodes degree of centrality and this node degree is used for both proactive and reactive routing protocols. But this method uses only single path routing, which causes extra overhead. Sivakumar and Duraiswamy [7] have proposed a routing algorithm for a variety of traffic classes to establish the best routing paths to distribute the load. In this approach, cost metric is calculated based on the link loads. Here multimedia traffic is given as high priority and its routing is carried out over the lightly loaded links such that the links at the lighter loads are selected as an alternative to links holding heavier loads. In the lack of multimedia traffic, lightly loaded path is used by normal traffic. Qin and Liu [8] have proposed a multipath source routing protocol with some QoS (Quality of Service) guarantee. During the route discovery process, the source node first ensures whether it has the routing information to the destination node. If not, then it begins to broadcast RREQs to its neighborhood nodes and finally to the destination. The destination node then from the received RREQs, can construct a certain topology for network and the path having maximal disjoint from the shortest delay path is selected as the desirable routing. Bin *et al*. [9] have proposed a novel adaptive load balancing routing algorithm which is based on a gossiping mechanism in ad hoc networks. In this mechanism, gossip based routing and load balancing scheme are merged efficiently. It adaptively adjusts the forwarding probability of the routing messages as per the load status and distributes the nodes in the phase of route discovery.

IV. PROPOSED WORK

In this paper, we present an algorithm which is based on AOMDV protocol which analyses the load on the neighbor nodes of the current node to choose a path to the destination. The neighbor nodes are analyzed under the different parameters such as loss rate, communication rate and delay. According to this analysis, priorities such as high, low and medium are assigned to the neighbor nodes. The nodes having energy less than threshold value are placed at low priority. Then those neighbor nodes are get selected which are placed with high priority. Then load is analyzed on these selected nodes, and that node will be chosen for the path to the destination which having minimum load. Here load is referred as the packets that a node consists in its queue length. The following are the steps need to be followed:

Step 1: Define a network with N nodes with Source and Destination node specifications.

Step 2: Set the current node as the source node and repeat the process until the destination node is arrived.

Step 3: Identify the neighbor nodes of current node and represent them as neighbor list. And process all the neighbors.

Step 4: Analyze the neighbor list under different parameters called Loss Rate, Communication Rate and Delay and set priorities (high, low, medium).

Step 5: The nodes in neighbor list with energy less than threshold valve is set to be low priority.

Step 6: Identify the nodes with high priority.

Step 7: Perform the load analysis under Communication Count and identify the node with minimum load.

Step 8: Set next hop with selected nodes and form a path to the destination.

The LBA-AOMDV (Load Balancing Algorithm with AOMDV) gives better results than ordinary AOMDV in the process of selection of path to reduce the load of a network.

V. SIMULATION PARAMETERS

The performance analysis of load balancing using AOMDV and LBA-AOMDV routing protocol in MANETs is performed by using NS 2.35 [7]. It provides a simulated environment under Linux (ubuntu 12.04) or windows platform for simulation. The load balancing analyses are performed by following simulation parameters for both protocols.

Simulator	NS-2.35
Protocol	AOMDV, LBA-AOMDV
Simulation Time	100 seconds
Simulation area	550m x 550m
Number of nodes	40
MAC Layer Protocol	IEEE 802.11
Link Type	Duplex-link
Queue size	50
Transmission range	250
Traffic Type	FTP
Agent Type	TCP
IdlePower	1.0 W

Tab1: simulation parameters used in evaluation

VI. SIMULATION RESULTS AND ANALYSIS

A. Performance Metrics

We analyzed the performance of load balancing using AOMDV and LAB-AOMDV routing protocol, based on three performance metrics which are Packet Loss Rate, End-to-End Delay, and Throughput.

- ***Packet Loss Rate***

It is defined as the rate of number of packet lost in transmission from source to destination.

- ***End-to-End delay***

It is defined as time taken by a data packet to arrive in the destination and also includes the delay caused by route discovery process and the queue in data packet transmission. Only those data packets that successfully delivered to destination is counted.

$\sum$ (arrival time – send time) / $\sum$ Number of connections

The lower the value of end to end delay, the better is the performance of protocol.

- ***Throughput***

It is the average number of packets that are successfully delivered per unit time

Throughput=ΣTotal number of received packets at destination/time taken

B. Simulation results

Figure 6 shows the packet loss rate which clearly shows that number of packet loss is decreases when we are using LBA-AOMDV instead of simple AOMDV protocol.

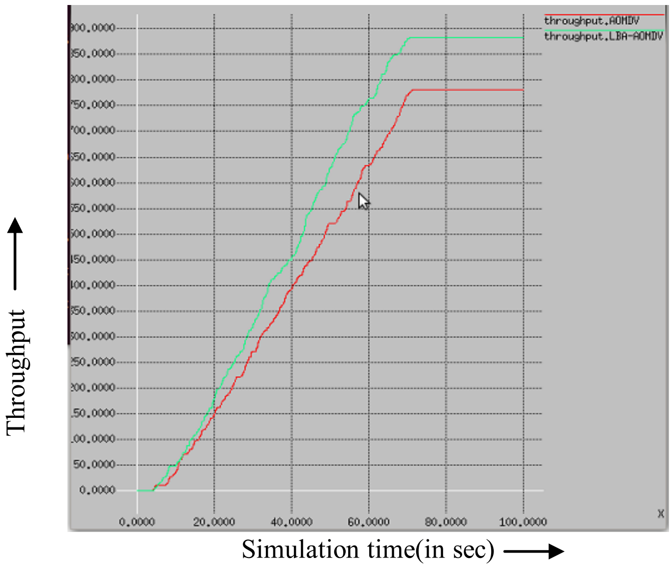

Fig 6. Throughput

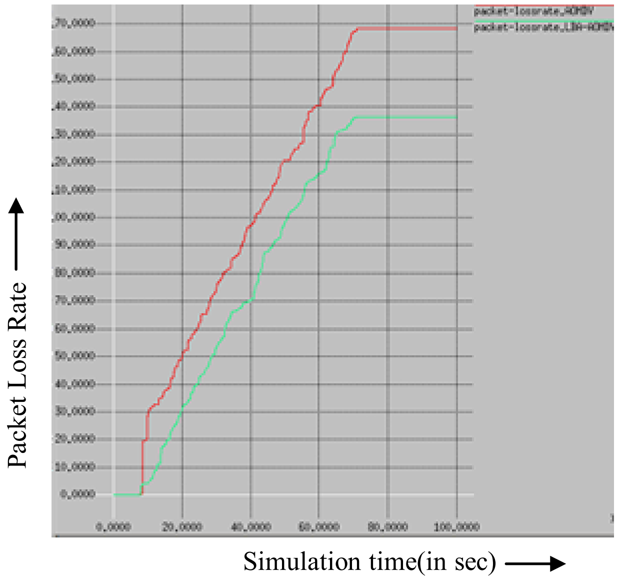

Fig 7. Packet Loss Rate

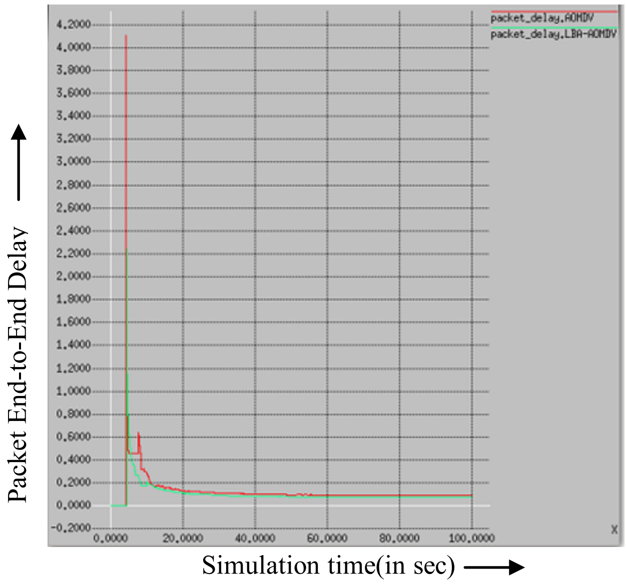

Fig 8. Packet End-to-End delay

Figure 7 shows that the packet loss rate is more when using AOMDV as compared to LBA-AOMDV. It means that by using proposed solution the number of packet loss rate is decreased and number of packet delivered is increased. Figure 8 shows the Packet End-to-End Delay. When using AOMDV, packet end-to-end delay is more than the proposed LBA-AOMDV. It is because LBA-AOMDV handle congested traffic efficiently than the AOMDV protocol and hence packet end-to-end delay is reduced.

VII. Conclusion

From the simulation results that we have seen, can conclude that LBA-AOMDV performs better load balancing than ordinary AOMDV protocol. The proposed solution analysis the neighbour node's load status and energy and then selects the path to the solution. We concluded that the metrics throughput, packet loss rate and packet end-to-end delay is performance is better than the ordinary AOMDV protocol.

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