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Implementation of Load Balancing in Multipath Routing Protocol for Mobile Adhoc Networks

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Abstract—A mobile ad hoc network (MANET) consists of mobile nodes that are capable of communicating with each other in multihop trend without centralized control and fixed based station. Multipath Routing permits the flow of data from source to destination over multiple paths through the network. In ad hoc network, basic goal of routing protocols is to efficiently establish a route between the pair of nodes so that data can be reached to destination correctly. This paper proposes an improved AOMDV(I-AOMDV) which is extension of AOMDV, uses the load balancing mechanism that avoids packet loss due to congestion, improves packet delivery ratio and throughput and also reduces end to end delivery of data packets. Also this paper proposes the comparison and evaluation of performance metrics of two routing protocols – Adhoc On-demand Multipath Distance Vector (AOMDV) and Improved Adhoc On-demand Multipath Distance Vector (I-AOMDV) based on various simulations.

Keywords— MANET, Multipath, AOMDV, I-AOMDV.

1. Introduction

MANET[25] is a network having dynamic topology that consists of mobile nodes without Base Station or centralized control. MANET is a self-organized and self configuring multihop wireless network. Due to the less transmission range of mobile node, multihop pattern is followed for passing the information. Packets passed through intermediate nodes while moving from source to destination. All mobile nodes perform functioning of routers that search and maintain routes to other nodes in the network. Problem in adhoc network is that for communication with other nodes, a node must be in the transmission range of base station but sometimes a node moves and network fails. MANET has solved this problem as in MANET nodes follow multihop pattern for communicating with other nodes. Routing is the process of moving information across internetwork from source to destination by selecting best outgoing path that a packet has to take in internetwork. To perform this, a set of routing protocols needed that uses metrics to find optimal path for a packet to travel. Routing protocols designing goals are optimality, simplicity, low overhead, robustness, reliability and flexibility. It is very difficult to design an efficient routing protocol. Routing protocols are classified in MANET in many ways. According to routing strategy routing protocols are classified in two categories, proactive and reactive protocols. Proactive protocols are also known as table driven protocols. In table driven protocols like DSDV, nodes maintain one or more routing tables about nodes in network and there is regular exchange of network topology packets between nodes of network. The main drawback of proactive routing protocols is that due to the periodic exchange of messages routing overhead increases and it results in more use of bandwidth and power. That's why proactive protocols are not suitable for MANET. Next category is reactive routing protocols like DSR[2], AODV[1]. Reactive protocols overcome the problems of proactive protocols. These protocols are also known as On-demand routing protocols[25]. This protocol initiates a route only when a node wants to start communication with another node. Route request and Route reply messages are used to discover and store the paths found from the source to destination. After finding the paths, shortest path is selected by the source node. Paths discovered by shortest path algorithm cause problems like congestion problems as the centre of network carry more traffic. This results in poor performance. To remove all these shortcomings, multipath routing protocols have been proposed. In single path routing protocols, a single route is discovered between source and destination. Multipath routing[12] requires multiple routes between source and destination. Multipath Routing is the process of distributing the data from source node to destination node over multiple paths. Multipath algorithms permit traffic multiplexing over multiple lines. Multipath Routing provides better performance by proper utilization of network resources. Multipath routing protocols provides better throughput and reliability than single path protocols.The objectives of multipath routing protocols[12] are to maintain reliable communication, to reduce routing overhead by use of secondary paths, to ensure load balancing, to improve quality of service, to avoid the additional route discovery overhead.

2. RELATED WORK

AOMDV extends AODV[1] to discover multiple paths between Source and Destination in route discovery. Multiple paths must be loop free and disjoint. Two main components of AOMDV[3] are- Route Update Rule that calculates Loop free paths and the Distributed Protocol to find Link disjoint paths. AOMDV[1] is derived from AODV. In AODV, when a source needs a route to a destination, it initiates a route discovery process by flooding a RREQ for destination. RREQs should be uniquely identified by a sequence number so that duplicates can be recognized and discarded. After receiving a non-duplicate RREQ, an intermediate node records previous hop and checks whether there is a fresh route entry to the destination in routing table. If valid route is present then the node sends back a RREP to the source; if not it rebroadcasts the RREQ. A node updates its routing information only if a RREP contains either a larger destination sequence number or a shorter route found. But in AOMDV[3], source node sends RREQ to neighbours and this process repeats until it reaches the destination. In case of RREP, node builds reverse path to source. For each RREQ, respective RREP arriving at a node defines an alternate path to source or destination. When link breaks, RERR packets are broadcasted till it reaches the source node. Source node then removes every entry in the routing table and then uses shortest backup paths. M. Marina et.al[4] explained how to maintain loop free multipaths, each node maintains a variable known as 'advertised hop count for each destination. This variable is set to the length of the 'longest' available path for the destination at the time of first advertisement. Each duplicate route advertisement received defines an alternate path to destination. When route advertisement received then next hop list and hop count reinitialized. Loop freedom achieved by accepting paths if it has less hop count. A *route_list* replaces the nexthop, and essentially defines multiple next hops with respective hopcounts. A node i updates its *advertised_hopcount* for a destination d whenever it sends a route advertisement for d[4].

$$advertised\_hopcount_i^d := \max_k \{hopcount_k \mid (nexthop_k, hopcount_k) \in route\_list_i^d\}$$

In AOMDV, duplicate copies of a RREQ are not immediately discarded. Each packet is examined to see if it provides a node-disjoint path to the source. For node-disjoint paths all RREQs need to arrive via different neighbors of the source. This is verified with the *firsthop* field in the RREQ packet and the *firsthop_list* for the RREQ packets at the node. There are also certain enhancements in existing protocols for e.g. in [7], Improved AODV is proposed and compared with original AODV using different IEEE standards. This improved AODV routing protocol reorganize a new shortest routing path during sending packet. The simulation results showed that in case of fixed nodes both protocols give similar throughput but for moving nodes improved AODV presents good results. Also in [8], an INOVEL protocol is also an improved form of AODV that avoid congestion by distributing the load of the congestion affected node (CAN) to the nodes nearer to it with buffer management. As the near sink node has a multiple routing paths towards sink, i.e. it has one primary route that connect it the sink and more than one alternate routes toward the sink from each sensor node. So INOVEL allows highest use of alternate routes during the congestion phase to avoid congestion. Wang and Crowcroft [22] also proposed a protocol that also uses an alternate route only when data There are some related work on protocols using multiple routes in ad hoc networks; the scheme by Nasipuri and Das [14], [15], Temporally-Ordered Routing Algorithm (TORA) [16], and Routing On-demand Acyclic Multipath (ROAM) [18], but these algorithms require additional control message to construct and maintain alternate routes.

3. NEW TECHNIQUE: IMPROVED- AOMDV

I-AOMDV is a multipath routing protocol that is same as AOMDV in addition to this, the concept of load balancing added to this protocol.[23] Because of buffer overflow in transport layer congestion occurs. Data has to pass through intermediate nodes while travelling from source to sink. Due to the nature of wireless network is event driven, so network load is unforeseeable. Therefore, congestion problem can occur as the intermediate nodes receive data more than their capacity which results in data loss. That's why the concept of load balancing is introduced. Load balancing is performed by load distribution of the congested node to the nearby nodes having high buffer occupancy. All the nodes maintain the routing table containing information like its own IP address, neighbour's IP address, distance between the nodes and queue occupancy of each node. The dynamic nature of wireless network supports the periodic updating of routing table information of all the nodes. The routing algorithm is followed to send data from source to destination. If the network is congestion free then data reaches destination successfully but if congestion occurs then routing table of congested node is checked to find nearby node having high queue occupancy and less response time. Then that first nearer node is then become a child node of congested node. As the child node receives the packets from the congested node then it forwards the packets to the destination.

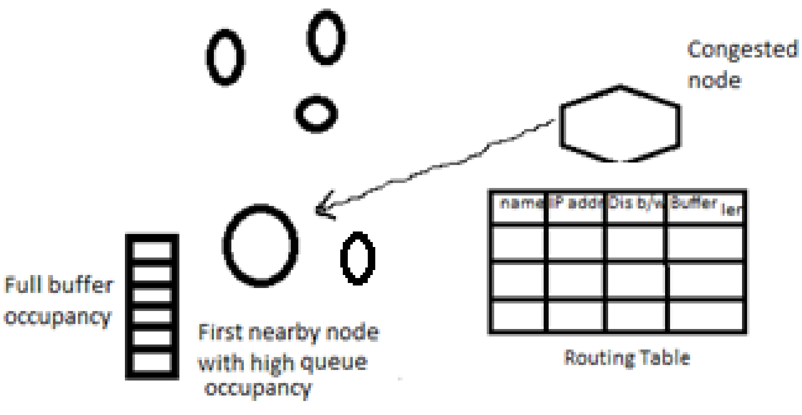

Fig.5 Congested node with its routing table

Figure.5 shows that by looking up the routing table of congested node, a nearby node with high queue occupancy is found out and that nearby node becomes the child node of the congested node. Then the child node forwards the packets to the destination node.

4. EXPERIMENTAL SETUP & PERFORMANCE METRICS

The NS-2 which is a discrete event driven simulator developed at UC Berkeley is used in this simulation process. Network Simulator NS-2 is useful in designing new protocols, comparison of different protocols and for evaluating the traffic. It is an object oriented simulation written in C++, with an OTcl interpreter as a frontend. A scenario file is taken as input in the NS-2 simulation process that shows the motion of each node and the originating packets by each node. The trace file generated is stored to the disk and that is observed using scripts like *.tr that calculates the number of successfully delivered packets and covered path length by each packet. This data is further observed by AWK scripts. The simulation models are built using the Network Simulator tool (NS-2) version 2.34 and it is run under bandwidth of 2Mbps. The experiments use a fixed number of packet sizes (512-bytes). The simulation uses 50 nodes. Maximum number of nodes in queue length is 50. The mobility model used is a random waypoint model in a rectangular field having dimensions 1000m X 1000m and the stations are assumed to be evenly distributed in the area. Here, each packet starts its journey from a random location to a random destination with a randomly chosen speed. Once the destination is reached, another random destination is targeted after a pause.

TABLE 1. SIMULATION PARAMETERS

Sr. No.	Parameter	Value
1	Transmission range	300 meters
2	Bandwidth	2Mbps
3	Simulation time	1000 secs
4	Packet size	512 bytes
5	Topology size	1000m x 1000m
6	Node Placement	Through .tcl file
7	Pause time	0-50s
8	Number of nodes	50
9	Mobility model	Random waypoint model
10	MANETs Routing Protocol	Aomdv.I-Aomdv
11	No. of trials	50
12	Data Traffic	CBR

Following parameters are evaluated by performing simulation experiments:
Throughpu[24]t: Throughput is, bits per second delivered to destination, so that unicast network throughput is sum of bits delivered to all destinations over time. It is one of the dimensional parameters of the network which gives the fraction of the channel capacity used for useful transmission selects a destination at the beginning of the simulation, information whether or not data packets correctly delivered to the destinations.

Packet Delivery Ratio (PDR)[24]: Packet delivery ratio is calculated by dividing the total number of data packets received at all the nodes, by the total number of data packets sent out by the CBR sources. Packet delivery ratio forms an important metric for performance evaluation of an ad hoc routing protocol because, given similar scenarios, the number of data packets successfully delivered at the destination depends mainly on path availability, which in turn depends on how effective the underlying routing algorithm is in a mobile scenario. This number represents the effectiveness and the throughput of a protocol in delivering data to the intended receivers within the network. Number of successfully delivered legitimate packets as a ratio of number of generated legitimate packets.

$$PDR = \frac{\text{Total no of packet received}}{\text{Total no of packet sent}}$$

Average end-to-end delay[24]: Average end to end delay is the time a data packet takes in traversing from the time it is sent by the source node till the point it is received at the destination node. This metric is a measure of how efficient the underlying routing algorithm is, because primarily the delay depends upon optimality of path chosen, the delay experienced at the interface queues and delay caused by the retransmissions at the physical layer due to collisions. Routing overhead is a major factor affecting the interface queuing delay as well as the retransmissions. Because the higher the routing overhead the delay experienced at the queues will be longer as well as the number of collision would be high. This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times.

5. RESULTS AND DISCUSSION

The results for the mentioned simulation experiment are shown with the help of xgraphs. In this section Simulator ran for 1000sec for given scenarios and the comparison of AOMDV and Improved –AOMDV is made by varying pause times from 0 to 50 s. Packet delivery ratio, Throughputand end to end delay calculated for AOMDV and I-AOMDV. The results are summarized below with their corresponding graphs.

PACKET DELIVERY RATIO (PDR) :

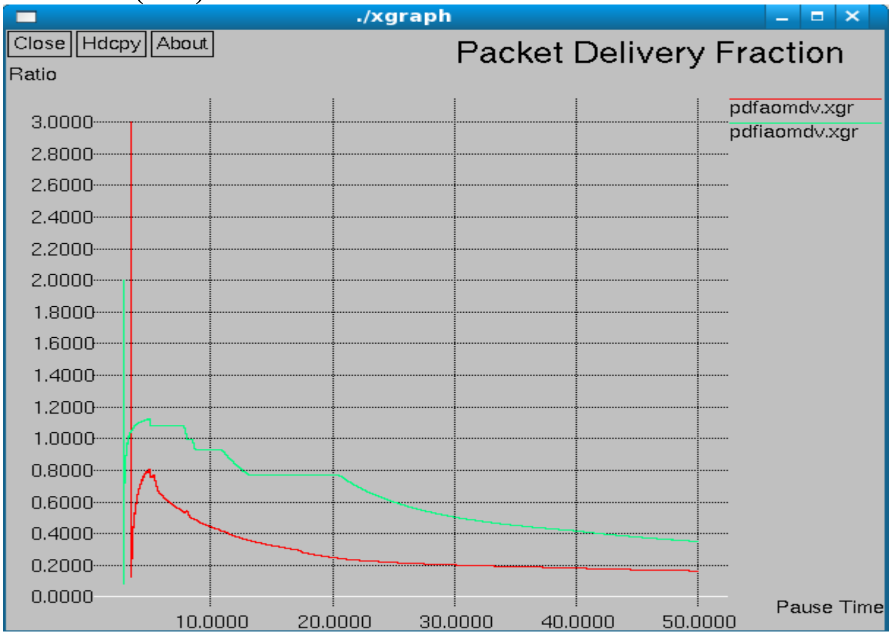

Fig.6 Xgraph shows Packet delivery Ratio comparison between AOMDV and I-AOMDV.

Fig.6 indicates the effect of mobility on the packet delivery ratio of I-AOMDVand AOMDV.It clearly shows that I-AOMDV is better than AOMDV. As the mobility increases (i.e., pause time gets shorter), the performance gain by alternate routes becomes more important. Because I-AOMDV attempts to use multiple alternate paths for data delivery in the presence of route breaks, the protocol is able to deliver more packets to the destination than AOMDV.

THROUGHPUT:

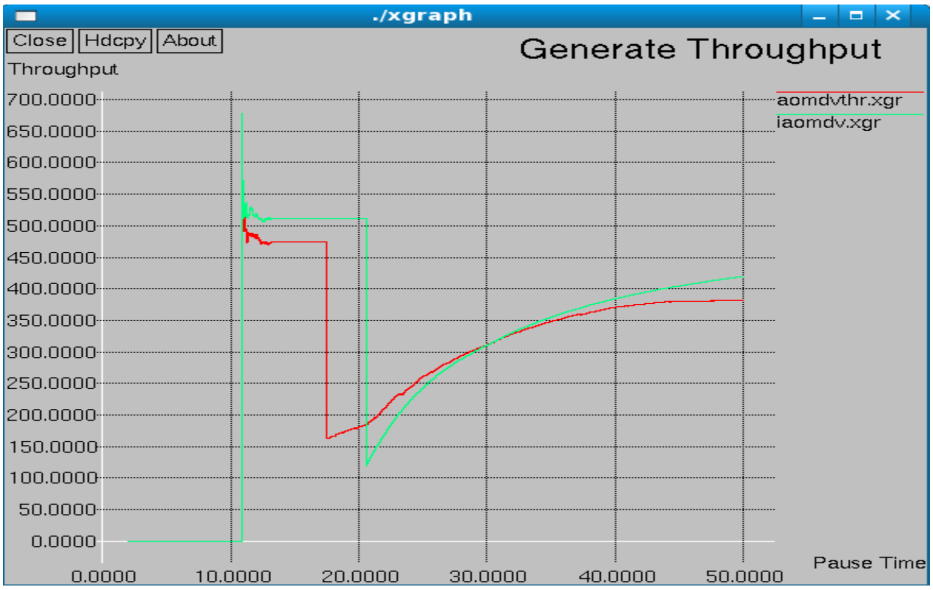

Fig.7 Xgraph shows Throughput comparison between AOMDV and I-AOMDV.

Fig.7 indicates the effect of mobility on the Throughput of I-AOMDVand AOMDV. It clearly shows that I-AOMDV is better than AOMDV. Both the routing protocol using the multipath but congestion avoiding ability of I-AOMDV gives better throughput then the AOMDV. I-AOMDV uses the buffer space of the neighbouring node so packet drop is less as compared to the AOMDV. So it shows that I-AOMDV is better then AOMDV.

END-TO-END DELAY: Figure 8 indicates that the End to end delay of I-AOMDV is less than AOMDV. Due to buffer utilization of the neighbouring node IFQ overflow is less hence the delay is improved in I-AOMDV. Number of packet loss is less in I-AOMDV as compared to AOMDV. Hence the performance of I-AOMDV is better than AOMDV. It clearly shows that I-AOMDV outperforms AOMDV.

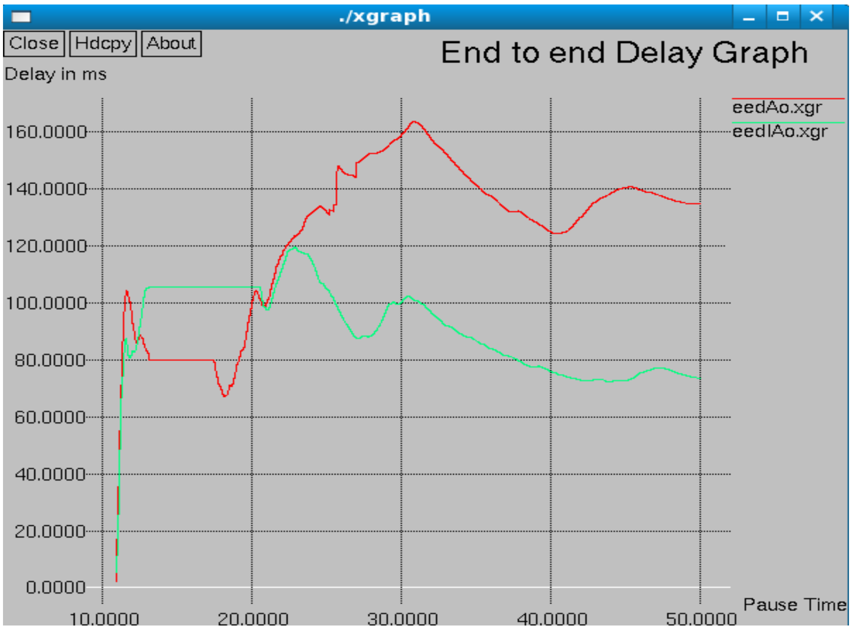

Fig.8 Xgraph shows End To End Delay comparison between AOMDV and I-AOMDV.

6. CONCLUSIONS AND FUTURE WORK

The technique implemented in AOMDV results in its better performance. This implemented technique is efficient in using network resources in useful manner by distributing the load of congested node to the nearby nodes so as to improve the end to end delay time, packet delivery ratio and throughput. Simulation results show that the improved AOMDV protocol performs better. Future work includes the simulations performed on the basis of other metrics. Concept of power consumption or security can be included to explore the future areas of research.

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