
5.1 Introduction

It has been demonstrated in Chapter 3 that the performance evaluation of the MAODV is better than ADMR [107]. Still to improve the performance of the MAODV routing protocol, we use the concept of Multipath. The drawbacks of MAODV are long delays and low packet delivery ratios which are due to broken links in situations of high mobility and heavy traffic load.

To improve the QoS metrics of MAODV, we proposed “Some Path Discovery Algorithms” which are explained in chapter 4. This chapter proposes a new Multipath source routing protocol i.e. Node Disjoint Split Multipath Multicast Ad-hoc On-demand Distance Vector (NDSM-MAODV) Routing protocol [17], which provides multiple paths among a source and destination pair to improve the packet delivery ratio in the network. This protocol uses the concepts of Node Disjoint Multipath and Split Multipath routing protocols. The proposed NDSM-MAODV routing protocol is divided into three categories according to the mechanisms of grouping the multiple paths [16]. Here we develop three different routing protocols i.e. NDSM-MAODV-ran, NDSM-MAODV-seq and NDSM-MAODV-opt.
The chapter is organized as follows. Section 5.2 presents the proposed NDSM-MAODV Routing protocol. Section 5.3 presents the mechanisms of the proposed NDSM-MAODV Routing Protocol. Section 5.4 presents the phases of the proposed NDSM-MAODV Routing protocol. Section 5.5 presents the performance evaluation through simulation. Section 5.6 presents the simulation results and Section 5.7 presents the summary of the proposed protocol.

5.2 Proposed NDSM-MAODV Routing Protocol

The proposed “Node Disjoint Split Multipath Multicast Ad-hoc On-demand Distance Vector (NDSM-MAODV)” Routing protocol [17] is an improved version of the MAODV routing protocol which is source initiated on-demand shared tree. The mechanisms used in NDSM-MAODV are Route discovery and Route maintenance. These mechanisms are similar to Split Multipath Routing protocol. The phases of the proposed NDSM-MAODV are Discover multiple paths, Grouping the paths and Load distribution. These concepts are similar to Node disjoint and Split multipath routing protocols. NDSM-MAODV consists of multiple paths from source to destination because it is having both Multicast and Multipath concepts. When the destination receives multiple RREQ packets through different paths, the destination node computes the paths by implementing the Multiple Path Discovery (MPD) algorithm [15] proposed in chapter 4. After computing the multiple paths grouping the paths is performed by using the Group Discovery [GD]
algorithm [16] proposed in chapter 4 and sends them to the source through these groups, there by the source node divides the data by using the Load distribution algorithm which is presented in chapter 4. By using this algorithm the data packet is distributed to the groups according to the priority given to the groups. In the group, it has many paths, the first path is a primary path and the remaining are alternate paths which carries the same data packet. Therefore the source node sends the data to the group by duplicating them. If one path fails then data can be passed successfully by the alternate path. As a result of this, source node need not reinitiate the route discovery process except when both the paths fail. Due to this reason the frequent flooding of RREQ packets is reduced by the source for route discovery and which in turn reduces the control overhead in the network. The duplication of each data packet, grouping the paths and finding the multiple paths in the proposed protocol, may cause slight increase in load on the network compared to other protocols. But in MANETs “Reliability” is particularly important in multicasting and it is also challenging to distribute the data, reliably to group members where topology changes frequently.

5.3 Mechanisms of the proposed NDSM-MAODV Routing Protocol

The proposed routing protocol consists of two main mechanisms i.e. Route discovery and Route maintenance.
5.3.1 Route Discovery Mechanism

The proposed Node Disjoint Split Multipath Multicast Ad-hoc On-demand Distance Vector (NDSM-MAODV) Routing protocol [17] is an on-demand source routing protocol which permits multiple paths between the source and the destination using the route request and route reply packets. Once the source node requests a route to the destination but no information is acknowledged, it floods the route request packet to the complete network. As this packet is flooded many duplicates that traversed during different routes to arrive at the destination. The destination node finds multiple node disjoint routes by using the MPD algorithm [15], grouping these paths by using Group Discovery algorithm [16] and sends route reply packets back to the source by means of the selected routes. Intermediate nodes are not permitted to send RREPs back to the source even if they hold the route information to the destination. If the intermediate nodes are permitted to reply, it becomes difficult for the destination node to compute the maximally node disjoint multiple routes since all the RREQ packets flooded by the source node may not reach the destination and hence the destination node does not identify the routing information provided by the intermediate nodes.

5.3.1.1 Route Request (RREQ)

In MANETs every node maintains the entire route information regarding the accessible routes in its routing table. Once a source node requests to send a packet to destination, it checks its routing table to
discover whether it has any accessible route to the destination or not. If no route is found the source node initiates the route discovery process by broadcasting a RREQ packet to its neighbors. This RREQ packet holds the addresses of the source IP and destination IP, sequence number of the source, destination node and a route request IP address. As a result of receiving the route request, every intermediate node checks whether its own address is included in the route record of the route request (RREQ) packet or not. It updates its own address in the route record and rebroadcasts the route request to its neighbors. In this fashion the destination node receives numerous route request packets from its neighbors.

5.3.1.2 Route Reply (RREP)

Once the source node floods the RREQ packet, it moves all the way through various possible routes and reaches the destination. When the destination node gets the first route request, it adds its own address in the route record and returns it to the source node with route reply (RREP) packet. This certainly becomes the shortest path for the source. This route reply packet comprises of the addresses of source IP and destination IP, destination sequence number and life time of the route reply packet. From the remaining received route requests the destination node computes the maximally node disjoint paths using the proposed Multiple Path Discovery (MPD) algorithm [15], and proceeds to the source by means of the specified path. Now the source node divides the paths
into number of groups using the proposed Group Discovery algorithm [16]. In each group the source node uses the shortest delayed path as primary path and hence is used for sending the data packets. The remaining paths are selected as alternate paths. If the primary path fails in the group then the source node uses one of the alternate paths.

5.3.2 Route Maintenance Mechanism

In the proposed protocol, route maintenance is carried out through route error (RERR) packets and acknowledgment packets. In MANETs if there is an acknowledgement between the nodes in a path then the route is said to be used. If a node does not receive the acknowledgement from the upstream then it is a case of link failure, thereby it creates a route error (RERR) packet and sends it to the source node. The RERR contains the address of the node that has detected the RERR and the address of the next hop which is unapproachable. While the source node receives a RERR packet, it removes all routes from its cache that have the address of the node in error. If the error route is primary path then source node starts using the alternate path that is stored in its secondary cache without any route rediscovery. In case the alternate path fails the source node has to reinitiates the route discovery process. To confirm the stability of the links, intermediate nodes are not only using the error packets but also use acknowledgements packets.
5.3.2.1 Route Error (RERR)

In the proposed protocol a link is said to be disconnected when route fails in two conditions namely a node fails to send the data packet to the next hop of the route and not receiving acknowledgements. In such situations, the node sends the RERR packet to the upstream direction of the route. The RERR packet contains the unreachable destination IP address, unreachable sequence number of the destination, route to the source and the immediate upstream and downstream nodes of the broken link. After receiving RERR packet, the source eliminates all contents in its route table that uses the broken link and continues the transmission of data packet through the alternate path. If all the paths fail, then source again finds a route discovery process by using the Multiple Path Discovery (MPD) algorithm [15] proposed in chapter 4.

5.4 Phases of the proposed NDSM-MAODV Routing protocol

The proposed protocol NDSM-MAODV consists of three phases i.e. Discover multiple paths, Grouping the selected paths and Load Distribution.

5.4.1 Discover Multiple Paths

To find out the multiple paths from source to destination, the major route discovery methods used in DSR and AODV protocols need to be modified. Still one of the most important reasons for using multi path routing is to discover multiple paths which must be node-disjointed or link-disjointed. In node-disjointed paths nodes arranged on the paths
must not be same. In the link-disjointed paths links arranged on the paths must not be same. For this reason the route discovery methods of the existing routing protocols need to be modified to find out the maximum number of node-disjointed or link-disjointed paths. After finding all node-disjointed or link-disjointed paths, we discover the multiple paths by using the proposed algorithm i.e. “Multiple Path Discovery [15]” which is explained in chapter 4.

5.4.2 Grouping the Selected Paths

When multiple paths are discovered, a multi path routing protocol should make a decision to discover a path for transmitting the data packets. At any time if only some paths are used, the performance of a multi path routing protocol should be similar to shortest path routing protocol. If all paths are used then there is a possibility of selecting a very long path which might affect the performance of a multi path routing protocol. To overcome this, we proposed “Group Discovery algorithm” [16] which is explained in chapter 4.

After the computation of Groups, paths in the groups are used in two ways. Firstly, one path is selected as a primary and the remaining all are alternate paths. Only the primary path is used to transmit packets. Alternate paths are used only when the primary path fails. Secondly, if all the paths are used at the same time then packets are split between the paths.
5.4.3 Load Distribution

On-demand multi-path protocols determine multiple paths among the source and the destination in a single route discovery. Thus a new route discovery is required only when all the paths fail. Single path protocol has to invoke a new route discovery each time simply the path commencing the source to the destination fails. On-demand multi-path protocols produce fewer interruptions to the application data when the routes fail. They also contain a lower routing overhead because of the fewer route discovery operations that needs to be performed. The multi-path routing wants a set of paths from source to destination so that the total data may be divided and communicated all the way through selected multiple paths which would perform load distribution and it reduces the congestion and end-to-end delay. In this fashion multi-path routing protocols comprise greater ability to reduce the route discovery frequency than single path routing protocols.

Once the source node receives RREPs, it can transmit data packets through the discovered routes. The proposed protocol uses hop-by-hop method for forwarding data. Source node divides the data according to the number of groups. Number of groups is generated by using the Group Discovery algorithm [16] proposed in chapter 4. After finding the number of groups the source divides the data according to the priority of the group. After dividing the data source node distributes the data into each group as proposed in chapter 4. In each group every node that
receives data packets sends them to the next hops according to the RREPs. Each intermediate node that receives data packets sends them to the next hops according to their RREPs in their Route Table. This procedure causes, all the discovered routes are used and data packets are distributed across all the paths simultaneously.

5.5 Performance Evaluation through Simulation

The Performance evaluation of the proposed NDSM-MAODV-ran, NDSM-MAODV-seq and NDSM-MAODV-opt routing protocols which requires Mobility model, Performance metrics and Scenario setup are explained in section 3.4 and 3.5 respectively.

5.6 Simulation Results

To evaluate and compare the performance of the proposed NDSM-MAODV-ran, NDSM-MAODV-seq and NDSM-MAODV-opt routing protocols with MAODV routing protocol, we considered the varying node mobility, varying nodes and their group sizes. In this we selected a network with varying node mobility ranging from 2mts/sec to 10mts/sec incrementing the steps of 2, varying nodes from 50-200 incrementing the steps of 50 and their group sizes ranging from 1-2 groups incrementing the steps of 1. The Obtained values of different performance metrics and the graphs are plotted for different parameters versus node mobility.
5.6.1 Throughput

Fig 5.1 shows that the proposed protocols NDSM-MAODV-ran, NDSM-MAODV-seq and NDSM-MAODV-opt produce more throughputs as compared to the MAODV. This is due to the fact of alternate paths are available in the proposed protocols.

5.6.2 Packet Delivery Ratio

Fig 5.2 shows that all the three proposed protocols NDSM-MAODV-ran, NDSM-MAODV-seq and NDSM-MAODV-opt produce more packet delivery ratio as compared to the MAODV. This is because MAODV builds a shared tree for delivery of data. If a single tree link is broken then data cannot be transmitted until a new tree is reconfigured. Due to high mobility the tree should be frequently readjusted and packet delivery ratio rapidly decreases.

5.6.3 End-to-End Delay

Fig 5.3 shows that the proposed protocol NDSM- MAODV produces less End-to-End delay as compared to the MAODV. Because in MAODV link fail occurs due to the node mobility. The proposed protocols maintain the alternate paths so that if the primary path fails then alternate paths transmits the data. But in MAODV if one path fails it reinitiate the route request so that End to End delay will be increased in MAODV.
Out of the three proposed protocols i.e. NDSM-MAODV-ran, NDSM-MAODV-seq and NDSM-MAODV-opt protocols, NDSM-MAODV-opt produces more throughput, more packet delivery ratio (less packet collision and retransmissions) and less as End to End delay as compared to the NDSM-MAODV-ran and NDSM-MAODV-seq. This is due to the fact that NDSM-MAODV-opt uses balanced network.
Fig 5.1 Throughput comparisons of MAODV variants
Fig 5.2 Packet Delivery Ratio comparisons of MAODV variants
Fig 5.3 End-to-End Delay comparisons of MAODV variants
5.7 Summary

In this chapter we proposed a new tree based routing protocol i.e. Node Disjoint Split Multipath Multicast Ad-hoc On Demand Distance Vector Routing (NDSM-MAODV) protocol. As per the different mechanisms of Group Discovery algorithms we proposed three protocols namely NDSM-MAODV-ran, NDSM-MAODV-seq and NDSM-MAODV-opt. However NDSM-MAODV-opt have more packet delivery ratio, more throughputs and less End to End delay as compared to the random and sequential methods. This is due to fact that it maintains the network which is balanced. Next chapter proposes a novel mesh based routing protocol by name Node Disjoint Split Multipath Protocol for Unified Multicasting through Announcements (NDSM-PUMA).