NCMDSDV: A Neighbor Coverage Multipsth DSDV Routing Protocol for MANETs

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***Abstract*—A mobile ad-hoc network is a set of mobile nodes in which data is transmitted wirelessly amongst all nodes. Due to the mobility of wireless nodes, network topology changes frequently. Consequently, routing protocols used in mobile ad-hoc networks must be adaptive. The routing protocols enabling data transfer within MANETs are classified into reactive, proactive, and hybrid protocols. Proactive routing protocols, such as the Destination Sequenced Distance Vector, are table-driven protocols that use stale paths in case of broken links which causes loss of data in the network. This research study will explore A Neighbor Coverage Multipath DSDV as a potential solution for data loss by finding alternate routes to the destination when a link is broken. Simulations have been carried out for the three routing protocols: DSDV, FSR, and the proposed NCMDSDV. Results showed that the proposed routing protocol has better efficiency compared to DSDV and FSR routing protocols.**

Keywords-MANET; proactive routing; reactive routing; DSDV; FSR; NCMDSDV

I. INTRODUCTION

A Mobile Ad-hoc Network (MANET) is a type of multi-hop network in which information is exchanged temporarily between mobile nodes via wireless transmission. These nodes freely and dynamically self-organize, allowing connections within a specific range. Evolving from single-hop networks, MANET has been around for two decades and is currently applied in various consumer electronics and military applications, such as vehicular communications, military applications, emergency first response, environment monitoring, health applications, and public safety response.

All MANET nodes are capable of acting as both source and destination. Connectivity exists among all nodes at any given point in time, depending on the position of the mobile nodes and coverage pattern of the transmitter and receiver, as shown in Fig. 1. Since the nodes are mobile, the topology amongst the nodes may vary depending on the movement of the nodes and their subsequent transmission and reception parameters. In order to keep up with this changing topology, the routing protocols used in MANETs must be adaptive [1].

Results have shown that multi-hop networks demonstrate significant improvement in throughput and overall efficiency when compared to single-hop networks. A key feature of multi-hop networks is the direct communication within range, unlike in single-hop networks. This type of network is highly suited for use in situations where a fixed infrastructure is not available. These types of networks are widely applied to consumer and military applications [1].

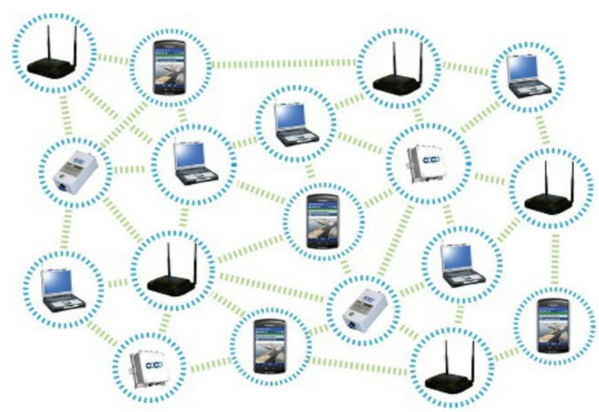

Figure 1. Mobile Ad-hoc Network

Routing is the process of sending information from a source to a destination in a MANET. During this process, at least one intermediate node within the internetwork is encountered. Destination Sequenced Distance Vector (DSDV) protocol, Optimized Link State Routing (OLSR) protocol, Fisheye State Routing (FSR) protocol, Wireless Routing Protocol (WRP), Global State Routing (GSR) and Cluster-head Gateway Switch Routing (CGSR) are existing proactive routing protocols.

In this paper, we propose a Neighbor Coverage Multipath DSDV (NCMDSDV) routing protocol to find non-linked paths that do not have any common nodes between source and destination. The non-linked paths are determined by adding two new fields in the routing table which are generated by the destination. Additionally, when a link failure occurs, the nodes in the network using this protocol will update their routing table by deleting the broken link entry and finding an alternate path to transfer data instead of dropping it.

Simulations have been carried out for three routing protocols: DSDV, FSR, and the proposed NCMDSDV in Network Simulator-2 (NS2). These protocols are compared based on different performance metrics. Results show that the NCMDSDV performs more efficiently when compared to the other two routing protocols.

The organization of this paper is as follows. Section II discusses related research. Section III presents the proposed NCMDSDV protocol. Section IV discusses simulation set up and results justification. Finally, Section V concludes the paper.

II. RELATED WORKS

Routing protocols in MANETs can be divided into three categories: reactive protocols (AODV, DSR), proactive protocols (DSDV, FSR), and hybrid protocols (TORA, ZRP) as shown in Fig. 2.

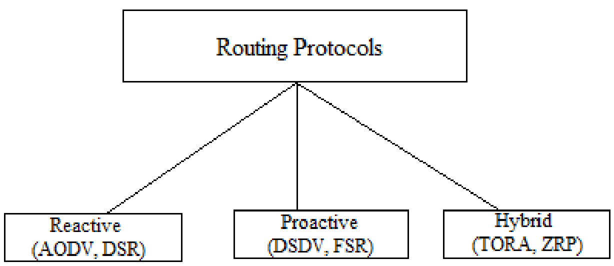

Figure 2. MANET Routing Protocols

A. Reactive Protocols

Reactive protocols are on-demand routing protocols in which a route can be determined whenever data is sent. The nodes in the network do not maintain routing information or routing activity if there is no communication. A route generation mechanism will generate a route by searching for the route in an on-demand manner and establishing a connection in order to transmit and receive the packet any time a node needs to forward data to a destination. Route discovery usually occurs by flooding the route request packets throughout the network. Once a route has been established, it is maintained by a route maintenance process until either the destination becomes inaccessible along every path from the source or the route is no longer desired. [1]

B. Proactive Protocols

Proactive protocols are table driven routing protocols. These protocols maintain routing information even before it is needed by maintaining routing information from one end of the network to the other. The routing table of the nodes is updated from time to time to maintain up-to-date routing information for data transfer across the network. This allows for efficiently forwarded packets, as the route is known at the time when the packet arrives at the node. Each node sends a broadcast message to the entire network if there is a change in the network topology [2]. In proactive routing protocols, routing information is periodically transmitted throughout the network in order to maintain routing table consistency.

C. Hybrid Routing Protocols

Hybrid routing protocols are a combination of both reactive and proactive routing protocols. In hybrid protocols, nearby routes are kept up-to-date proactively, while far-away routes are set up reactively. This type of routing protocols were proposed in order to reduce latency caused by route discovery in reactive routing protocols and also to control overhead of proactive routing protocols. [3, 4].

III. THE PROPOSED NCMDSDV PROTOCOL

In the DSDV routing protocol, all nodes will have a path to the destination node by exchanging HELLO messages and broadcasting routing tables to neighboring nodes. A node that receives a HELLO message will update its table and add the sender node as a neighbor node. By doing this, every node will recognize its neighboring nodes, rendering them capable of sharing entire routing tables. Therefore, every node in the network will have a valid path to every destination node [5-8].

In MANETS, the connectivity within the network changes frequently due to mobile nodes. The probability that data will reach the destination node can be increased by maintaining multiple non-linked paths. Non-linked paths do not have any common nodes between the source and destination nodes. By maintaining these non-linked paths, the data can be transferred efficiently through the other known paths instead of being dropped in the case of a broken link. Quality of service can be enhanced by maintaining multiple paths in MANETs that have bandwidth constraints. The use of non-linked paths proves to be a less expensive alternative compared to network flooding [9, 10].

In the proposed protocol, the number of non-linked paths which do not have any common nodes between the source and destination are found by adding two new fields in the routing table. These new fields, generated by the destination, are “second hop” and “link-id.” Every node in the ad-hoc network has a routing table and a neighbor table.

- Routing Table: Data is transmitted through the ad-hoc network, which consists of all paths to every destination node. The routing table of every node is updated whenever a change occurs in the network. The routing table structure is shown in Table I.

TABLE I. THE ROUTING TABLE STRUCTURE

Field	Description
Destination node	Address of the destination node
Next hop	First hop to destination
Second hop	Second hop to destination
Number of hops	Number of hops to destination
Link-Id	An ID generated by new node for the new routers
Sequence number	A number that distinguishes between stale and fresh routers
Time	The time when the path was discovered

- Neighbor Tables Neighbor tables contain all neighbors of a node and help in determining the status of any node. If the neighbor table is empty, the node is considered isolated and has to broadcast a HELLO message. Additionally, the neighbor table is used whenever a new node wishes to initiate update messages. Whenever a node receives a HELLO message or any of its neighbors move away from the transmission region, this table will be updated. The neighbor table structure is shown in Table II.

TABLE II. THE NEIGHBOR TABLE STRUCTURE

Field	Description
Neighbor ID	Address of the neighbor node
Link-Id	Link number between new node and this neighbor

A. Initializing a Route

In this stage, every new node in the network will get multiple paths to all other nodes. Once a new node enters a network, it will broadcast a HELLO message to all neighbor nodes as shown in Fig. 3.

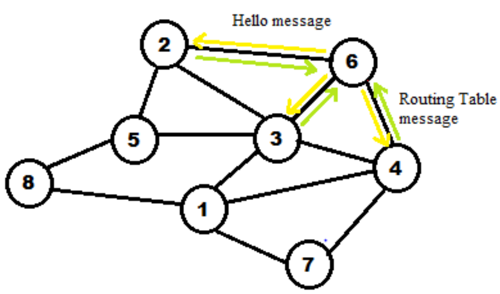

Figure 3. Hello message and Routing Table message

An entry will be added in the neighbor tables of all nodes that receive the HELLO message. Entries will also be added in the routing table of these nodes which shows the new path to the new neighbor node. The link-id in the routing table is initially set to “0.” Once these tables are updated, all neighbor nodes will broadcast their routing table to the new node. After the new node gets the routing tables from its neighbor nodes, it will start creating its own routing table and neighbor table. Also, the new node selects the entries that have link-ids equal to 0 and assigns a new link-id to each one. The node then initiates and broadcasts update messages to all neighbors to update their link-ids equal to 0 and to get new routes to the new node’s neighbors.

B. Propagating a Route

This phase shows how various nodes in a network can get multiple paths to a new node and how other nodes get new paths that pass through the new node as shown in Fig.4. After assigning new link-ids, the new node will generate and broadcast an ‘update’ message to all its neighbor nodes which tells them to update their link-ids in the routing table. The neighbor nodes, after updating their routing table, will also generate and broadcast ‘update’ messages to all neighbor nodes. This way, every node in the network will now have multiple paths to the new node through its neighbor nodes.

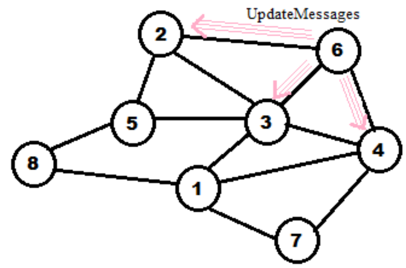

Figure 4. Update message

The number of update messages depends on number of entries with link-ids equal to 0.

C. Maintaining a Route

At any point when a path to a node is broken, a failure message will be generated and broadcast to all the neighbors by the node which detects this broken path as shown in Fig. 5.

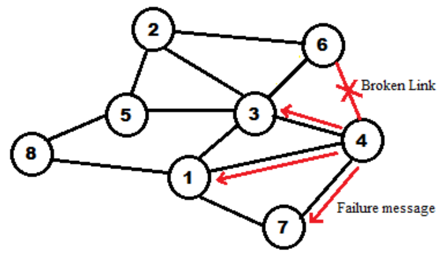

Figure 5. Failure message

The failure message will include the link-id of the path that is broken as shown in Table III. Once the node broadcasts the failure message, it will update its routing table by deleting the entries in its routing table which have the link-id of the broken path and use the unreachable node as the first hop. Also, the nodes that receive this failure message will check their routing table and delete all the entries that have the broken path. By doing so, all nodes in the network will delete all paths to the destination through the node that detected this broken path and update their respective routing tables.

If any node still uses the route with the broken path to send data, a node that detects the broken path will use an alternate path to send the data. It will also generate and send an error message to its previous node, asking it to delete or update this path. The error message includes the link-id of the broken path and the alternate path that was used to send the data. This message will be forwarded until it reaches the source node.

TABLE III. FAILURE MESSAGE

Field	Description
Sender	Address that sends the failure message
Destination	Address of destunation
Link-Id	Link of the broken path

IV. Simulation Results and Justification

The proactive routing protocols, DSDV and FSR have been compared with the proposed protocol, NCMDSDV, by carrying out simulations based on a few performance factors on Network Simulator [10-13].

A. Simulation Set Up

The simulations have been carried out using a wireless network simulator called the Network Simulator 2. The operating system used is Linux Ubuntu. Table IV shows the simulation setup used for this project [14, 15].

TABLE IV. Simulation Setup

Parameter	Value
Operating System	Ubuntu 14.04
Simulator	NS-2 (ns-2.35)
Channel Type	Wireless Channel
Number of Nodes	10,60,100
Speed (m/s)	10
Data Type	UDP
Simulation Time	100
MAC Protocol	802.11
Data Packet Size	512
Simulation Area	1200*1200
Radio Propagation Model	Propagation/TwoRayGround
Routing Protocols	DSDV,FSR, NCMDSDV

Simulations for all the three protocols were carried out and the following performance factors were calculated:

- Packet Loss: Packet Loss is the difference between the number of packets sent and number of packets received.

  Packet Loss = *Packets sent – Packets Received*

- Packet Delivery Ratio (PDR): PDR is the ratio between the number of packets received by the destination and the number of packets generated by the source.

$$\text{PDR}= \frac{\textit{Packets received}}{\textit{Packets generated}}$$

- End-To-End Delay (ETED): ETED is defined as the time taken for a packet to reach the destination.

  ETED = *Time at which packet is received –*

  Time at which packet was sent

- Throughput: Throughput is the ratio of the packets received to the simulation time.

$$\text{Throughput} = \frac{\textit{Packets received}}{\textit{Simulation time}}$$

Simulations are carried out on the MANET with 10, 60, and 100 nodes.

B. Simulation Results

The simulation results of Packet Loss, PDR, ETED and Throughput for DSDV, FSR, and the proposed NCMDSDV are shown in Fig. 6, Fig. 7, Fig. 8 and Fig. 9 respectively.

No. of nodes	DSDV	FSR	NCMDSDV
10	6075	9892	5993
60	4390	9586	4123
100	4398	8350	4089

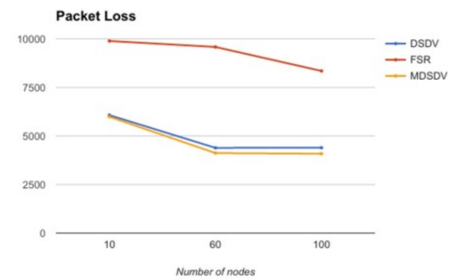

Figure 6. Packet Loss

No. of nodes	DSDV	FSR	NCMDSDV
10	80.9642	81.2418	81.9844
60	78.9234	75.5863	79.9624
100	75.4861	74.9822	76.8642

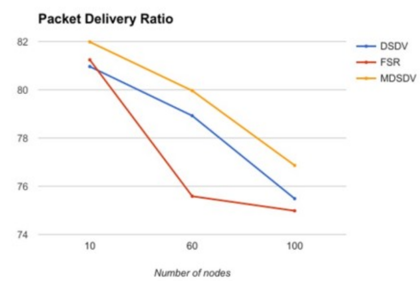

Figure 7. Packet Delivery Ratio

No. of nodes	DSDV	FSR	NCMDSDV
10	0.1473	0.1461	0.1435
60	0.1536	0.1643	0.1518
100	0.1592	0.1684	0.1569

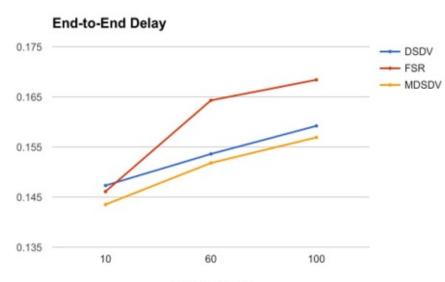

Figure 8. End-to-End Delay

No. of nodes	DSDV	FSR	NCMDSDV
10	398.7826	399.2482	401.8297
60	398.1849	388.5823	399.9698
100	397.2983	385.4129	399.0127

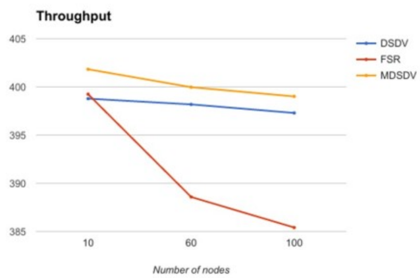

Figure 9. Throughput

C. *Simulation Result Justification*

From the simulation results, we can draw the following conclusions.

- As number of the nodes increased, Packet Loss, PDR, and Throughput are increased for all routing protocols on the MANETs. Only ETED is decreased.
- The NCMDSDV protocol shows significant improvement in Packet Loss compared to the DSDV and FSR routing protocols.
- The proposed NCMDSDV protocols performs better in PDR than the DSDV and FSR protocols, though the results are competitive.
- The proposed NCMDSDV achieves lower ETED and higher Throughput compared to the other two routing protocols.

V. Conclusion

A new proactive routing protocol named NCMDSDV is proposed to create multiple paths to a destination which helps in recovery from link failures. This is done by adding two fields in the routing table called the ‘Second-hop’ and ‘Link-id’ which calculate the non-linked paths between the source and destination node. The nodes in the network also generate and broadcast failure and error messages in case of link failures which helps in updating the routes by discarding the broken paths and finding alternate paths to transfer data within the network. Simulation results show that the NCMDSDV produces better PDR and throughput, as well as lower ETED and Packet Loss compared to two existing protocols, DSDV and FSR. The authors hope to show in the future that many real-world MANET applications can benefit from the proposed NCMDSDV routing protocol design.

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