A CONNECTED DOMINATING SET BASED ROUTING IN MOBILE ADHOC NETWORKS (MANETS)

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Abstract: Mobile Ad- Hoc network is a collection of mobile hosts which is self-organized, self-maintained network. It forms a wireless network without any backbone infrastructure and centralized administration. Due to the lack of fixed infrastructure the control overhead increases in the network. The main objective of the paper is to reduce the control overhead in the network by using the domination set based routing. A node is a dominating node if it connects all other nodes in the network and the set of dominating nodes forms a domination set. This paper we propose a new routing technique for finding the route and reducing the reroute establishment delay. The effectiveness of the technique is demonstrated through simulation study using NS2.

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1. Introduction

1.1 MANET

Cellular/Mobile Ad Hoc network is a cluster of mobile hosts which is self organized and maintained network. It forms a wireless network without any back-end infrastructure or central administration. The nodes in MANET (Mobile Ad Hoc NETwork) are self sufficient and each node acts as either a router or source. The topology of the network is dynamic and change in it is rather frequent. Due to the nature of wireless networks, the data transmission in these networks is basically a one-hop broadcast, in which the message transmitted by the node is received by all nodes within the node's coverage area. Any two nodes which are not within each other's coverage area communicate through intermediate nodes, ie., relays. General routing algorithms are not suitable for MANET. There are many algorithms proposed for routing, throughout the years. However, mainly, routing algorithms are categorized into two - Proactive, and Reactive [8].

Proactive algorithms are extensions of wired routing protocols. In these routing algorithms, all nodes keep the routing information in the routing table at the time of network initialization. All nodes interchange this information periodically with their respective neighbors/adjacent nodes, which, in turn, causes very high routing overhead.

In the Reactive routing protocol, however, the route is decided (using control packets) only at the time when a node wants to transmit some data. In this case, some delay occurs in order to establish a route since the routing information is not readily available. Many control packets are used for finding a route which also brings overhead in the network. It has been reported, according to a study, that the reactive algorithms are more efficient than proactive ones [8].

The prime constraints in MANET include - High Mobility, Low Bandwidth, and Low Energy. Due to the high mobility, frequent disconnections are abound in MANET. In all reactive algorithms, when the route is broken, route regeneration process diminishes the performance of the network by inducing more overhead. Since the mobility of nodes is very high, route failure is, thus, more frequent. Under normal circumstances, if any route failure is reported, then the source node is responsible for finding and alternate route [5]. This entire re-route establishment process stipulates high delay and overhead due to frequent exchange of control messages. Some improvements have been done to overcome this hurdle, but nonetheless, in all cases, packet loss is still very high.

The biggest challenge for MANET is to provide a stable route for packet delivery [7]. Most of the routing protocols used hop count as a selection metric and found that the routes discovered are not stable. The node's mobility may directly affect both - the quality of the selected path, and their durability. Therefore, the route selection process should also consider the link stability criterion, which allows to maintain the characteristics of the selected paths/routes. Recently, there seems to be a flourishing interest in the research towards applying CDS to support various network functions, like, Multi-hop communications [12]. In MANET, link failures occur frequently because of node mobility, therefore, formation of a robust and long-lasting backbone or CDS considerably improves the network performance.

This study proposes a procedure to reduce the reroute establishment delay and routing overhead by utilizing the dominating nodes in the network. Based on the study of Domination based routing, and comparison of performance alongside other well-known algorithms, it is justified that the proposed work is more efficient in terms of packet delivery ratio, control overhead, and packet drop. In this process, initially, all the dominating nodes in the network grid are identified. From this, a domination set is created. A set is a dominating set if all the nodes in the network grid are either in the set or the neighbors of the nodes in the set [11]. The route is established via the nodes in the domination set only. All nodes in the network can be contacted with, through the domination nodes. When the route fails, it is simple to find the new route by using the domination nodes. This makes certain that the reroute establishment has no delay and overhead, thereby, enhancing the routing performance, even when the route fracture occurs. The problem of finding the Minimum Connected Dominating Set (MCDS) is considered as an NP-Complete problem.

1.2 Network Simulator (NS2)

.NS stands for Network Simulator. It is an open-source, discrete-event based network simulator mainly used for research purpose and for teaching. It provides help in simulating routing protocols like IP, TCP, UDP etc. It creates a simulation environment for studying the network. Following steps are followed while creating a simulation environment:

- Topology Definition
- Development of the model
- Configuration of the link
- Execution
- Analysis of the problem
- Visualization

1.3 Domination Set & Connected Dominating Set

Suppose G = (V, E) be a connected, undirected, simple graph, where V is the vertex set and E is the edge set. A set of vertices S in the graph G is a dominating set if every vertex not in S is adjacent to at least one vertex in S. The set of least number of vertices which dominate the graph G is called Dominating Set. A set of vertices S is independent if no two vertices in S are adjacent. A connected dominating set (CDS) is a subset S of a graph G such that S forms a dominating set and S is connected.

2. Calculation of Domination Set

Every node (vertex) in the network can be reached via the domination nodes. An example of mobile Ad- Hoc network is shown in Fig. 2.1 with domination nodes 3, 6, and 8, and Fig. 2.2. with domination nodes 3, 6, and 9. There is multiple minimum dominating sets but the number of nodes in the set must be the same in domination set. For same network Fig.2.1 and Fig. 2.2 shows two different domination set

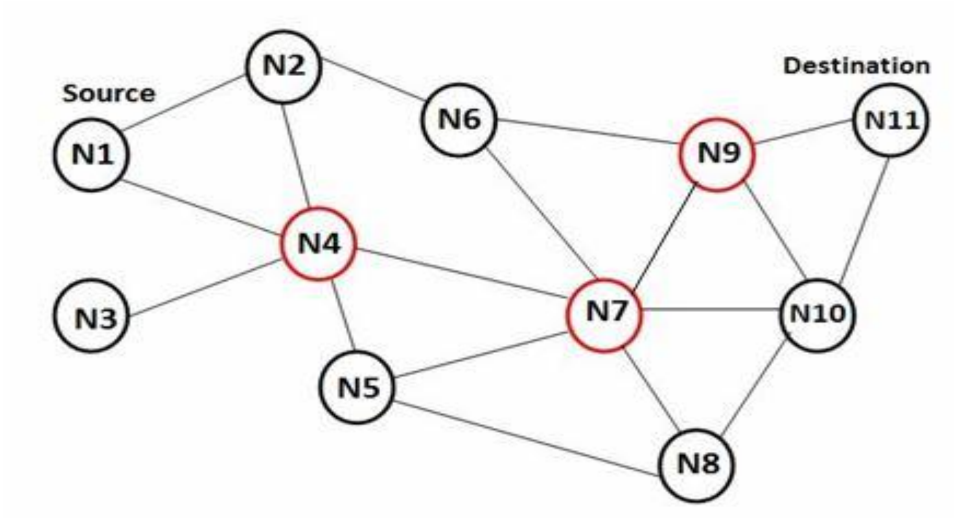

Fig. 2.1 Domination node {3,6,8} in a typical Mobile Ad hoc Netw

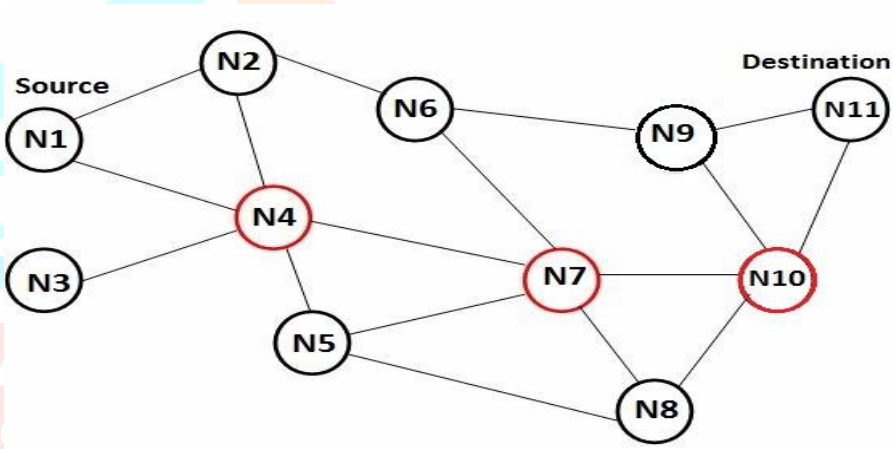

Fig. 2.2 Domination node {3,6,9} in a typical Mobile Ad hoc Network

Algorithm for finding Domination Set

The algorithm given below creates the domination set by calculating the adjacency matrix and collecting the nodes corresponding to the maximum connected node, from the row sum.

```
Node (p);
If (q is a neighbour)
{
    Add to neighbour list
    Send this list to its neighbours
}
If (p is a neighbour of q)                    //Find adjacency matrix
{
    Set adj[p][q]=1
    else
    Set adj[p][q]=0
}

for_each row in adjacency matrix adj {                  // Calculate the domination matrix.

    Calculate the row sum in adjacency matrix
```

Find the node with maximum degree

Append this to the domination set

If any node is not connected to the nodes in the domination set, then add this also to the domination set.

}

3. Domination Set Based Routing

A MANET is described as a graph G (V, E), where V is the set of nodes in the network and E is the set of edges connecting the nodes, enabling communication. A homogeneous network where each of the nodes has the same transmission range is assumed. The given algorithm first locates the domination set, a path is then established to the destination only via the domination nodes. The nodes in the domination set connect all the nodes in the network rapidly, so, it is easy to get the destination within a very short duration. Whenever the route failure occurs, the corresponding domination node identifies the problem and fixes it locally. It can reach the destination through other nodes if possible, otherwise , it will broadcast the route failure report to the other domination nodes. In the initial phase, the domination nodes are determined from the adjacency matrix, for which, each node determines its neighbor node by sending the **Hello package**. After determining the neighbors, the neighboring list is sent to the adjacent nodes and each node prepares the adjacency matrix. From this matrix, it is easy to determine the dominating nodes and finally domination set by utilizing the aforementioned algorithm. If we use flooding mechanism for transmitting packet from one node to another, then each dominating node needs to keep a record of all other neighbor dominating and non dominating nodes. When the sender is a non dominating node, first packet is received by the nearest dominating node and then the dominating node checks the address of destination. If the destination node is its adjacent nondetermining node, it will send to that non dominating node. Received successfully by the dominating node. But, if we simply calculate a path using, say, *Dijkstra's Algorithm* (using dominating node) for each node, there is no requirement to flood the packets in the network. As we know that flooding generates congestion over the network, we, therefore, simply calculate path for the destination nodes. Whenever any link gets broken, same method is used to calculate the route from the source to destination node.

Consider a network shown in Fig.3.1. Having 11 nodes (N1, N2, N3, N4, N5, N6, N7, N8, N9, N10, N11) the minimum connected domination set is {N4, N7, N9}. N1 is the source and N11 is the destination nodes. N11 can be reached from N1 through N4, N7 , and N9. In the initial route discovery process each node tries to connect the domination node from the source node. The route to destination is always through the dominating nodes even if the shortest link exists. In the initial stage, the cost of establishing the route is higher than the other routing algorithms; but this is very useful in the dynamic networks, because mobile ad hoc network is highly dynamic in nature. So this is helpful for finding the alternate route easily. The source N1 wants to send packet to the destination N11. Fist the path is established through the dominating nodes. The packet passes though In the given example if link N10-N11 is broken, then need not to worry about the link because still we reach all the nodes easily. Suppose we have domination set {N4,N7,N11} In fig. 3.1 if the link N10-N11 is broken in fig. 2.2 then the node N9 can easily set up the connection N9-N11 to the destination.

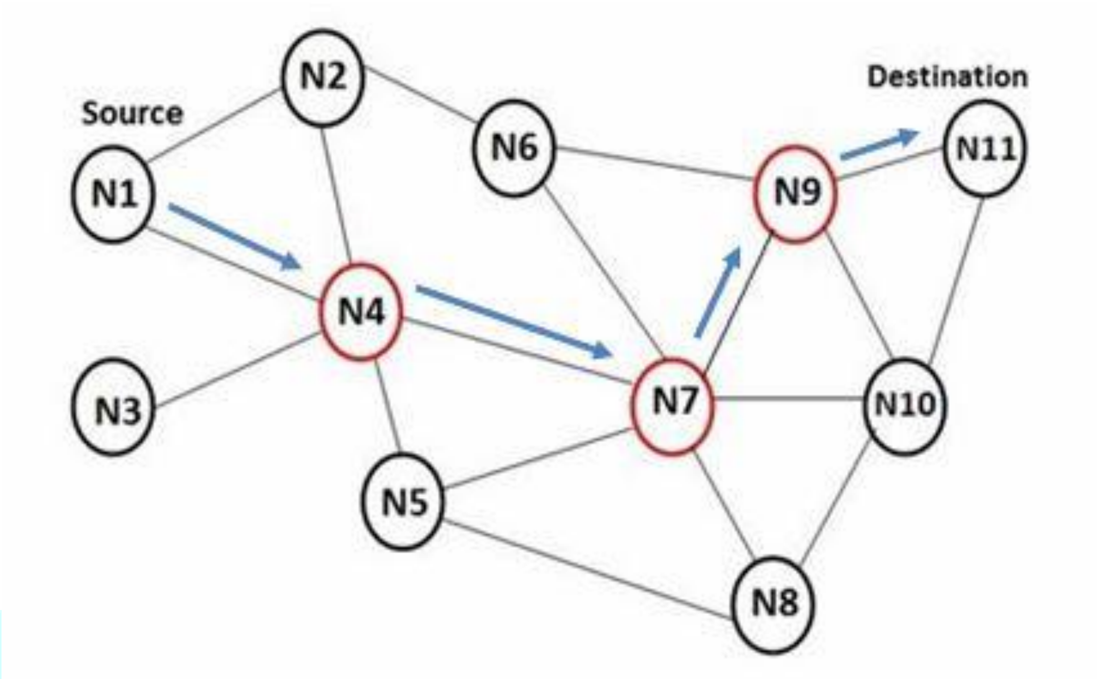

Fig.3.1: Discovery of Route through Dominating Node

4 Results Analysis

The performance evaluation of the proposed algorithm has been done by utilizing simulation tool **NS2**. The performance of DBR is compared with existing algorithms AODV and DSR. The metrics used for performance analysis were packet delivery ratio, number of packets dropped, and the routing overhead. It has been observed that DBR performs better than AODV and DSR. The simulation parameters are listed in Table 1.

Parameter	Value
Algorithm	AODV, DSR, DBR
Routing protocols	IEEE 802.15.4
Number of nodes	5, 10, 20, 45, 100
Simulation area	500m x 500m
Packet size	256 bytes
Packet sending rate	4 packets / second
Simulation time	500 seconds

$$\text{Packet delivery ratio (PDR)} = \frac{\sum \text{Number of recieved data packets}}{\sum \text{Number of sent data packets}}$$

$$\text{Network Overhead} = \frac{\sum \text{Number of packets Transmitted}}{\sum \text{Number of data packets Transmitted}}$$

In case of AODV or DSR, whenever a route failure is detected, it will be reported by the intermediate node and the source node re-initiates the route discovery process. This will most certainly reduce the performance and throughput because of some of the packets being lost during transmission. Using local repair of route failure, this issue can be resolved in DBR. The domination nodes are responsible for locating an alternate route to destination. All the nodes in the network can be reached through the dominant nodes. Number of packet drops can be significantly reduced alongside the time required to find out the route, as shown in Fig. 4.1.

Fig. 4.2 shows a comparison of three algorithms in terms of packet delivery ratio. Number of control packets (routing overhead) transmitted for each successful data packet transmission with varying network size is shown in Fig. When the number of nodes increases, the packet drop is quickly increased in AODV and DSR. But in DBR, the packet drop is not significant. Packet Delivery Ratio is almost similar in all algorithms. When the number of nodes are increased, the routing overhead is reduced in DBR because, if any link failure occurs, it's very easy to resolve in DBR.

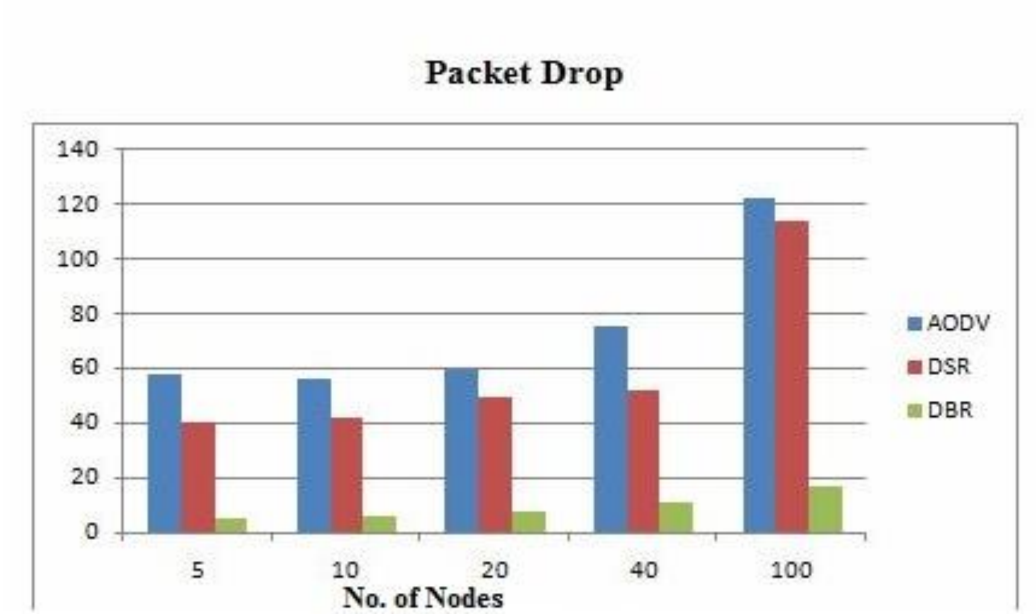

Fig 4.1 Packet delivery ratio v/s Number of nodes

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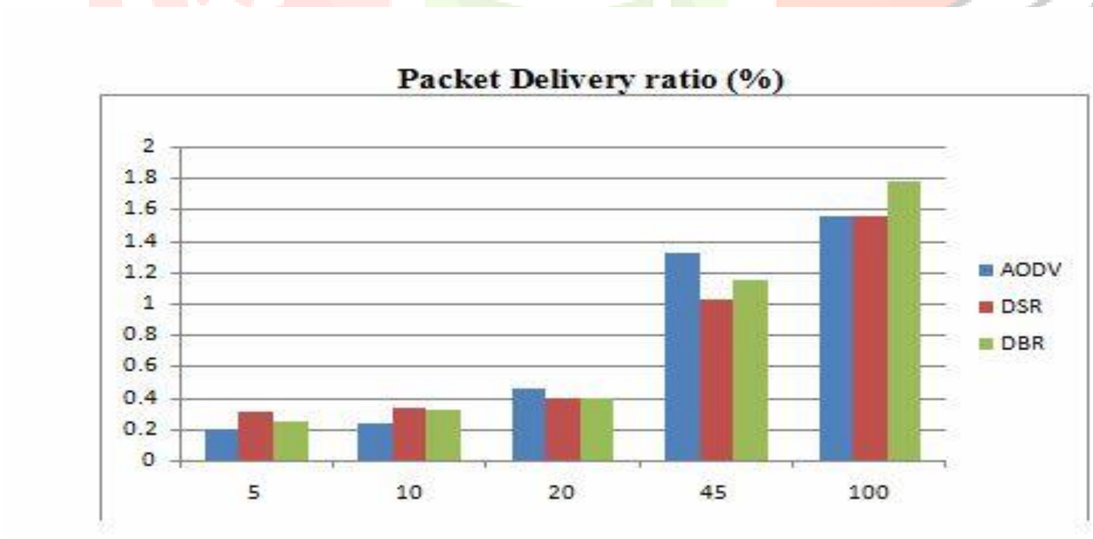
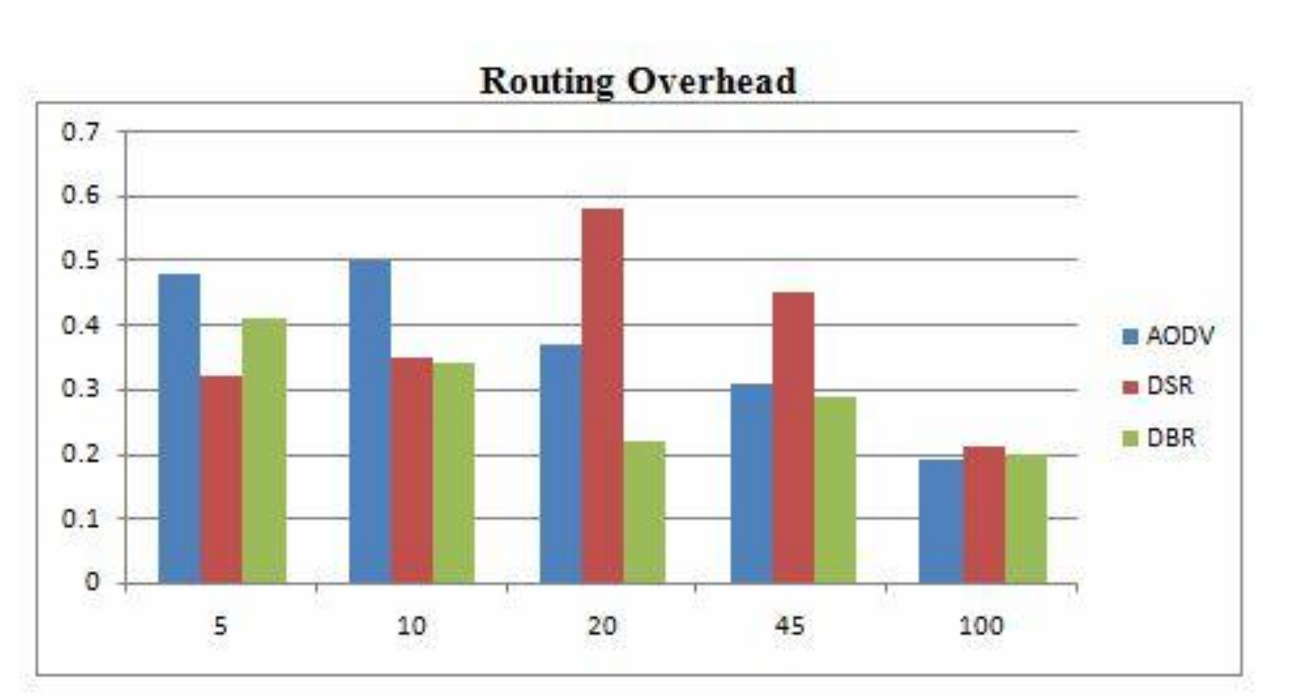


Fig. 4.2 Number of packets dropped during transmission vs Number of Nodes;

The DBR approach is better than the other two.

The results in Fig. 4.3 show that the DBR maximizes the packet delivery ratio when the number of nodes grows in the network.



Number of nodes

Fig 4.3 Routing overhead v/s Number of nodes. Overhead is low in DBR.

5. Conclusion

This paper provides the description of the route discovery process in MANET and analyzes the problems & hindrances during the process of route establishment. Whenever any route fails, the route establishment process starts from the beginning in normal case. Since the route re-establishment procedure beings in the form of preliminary stage, it causes many packet losses and the re-transmission count of the lost packets is high. As in the case of Domination set Based Routing (DBR), the delay gets reduced as the route re-establishment is realized with the aid of dominant nodes and thus the delay gets reduced, which is being proposed here. Therefore, additional new route discovery process is not required, during which, the active communication can be resumed. The performance increases in terms of Packet Delivery Ratio (PDR), and the number of packets dropped. The proposed algorithm also works fine in large networks. However, the determination of domination set, although required only seldomly, could be a prime matter of concern with respect to overall computational complexity.

6. Future Work

Designing a routing algorithm which is combination of Domination Based Routing (DBR) and Shortest Path Algorithm.

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