ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 5, Issue 3, March 2016

Energy Efficient Approach to Find Complete Node Disjoint Multipath in AODV Using Directional Forwarding Scheme

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Abstract— **A Mobile Ad Hoc Network (MANETs) is a self arranging network and does not have any central administrator. In MANETs its necessary for nodes to maintain their independence and to preserve its resources like battery power, network lifetime etc. The traditional routing protocols such as AODV form the shortest route from source to destination node in the network. MM-AODV also takes the same approach, finding the shortest route from source to destination node. Various factors such as energy of the nodes, their mobility can also be taken into account to optimize the path selection process from source to destination node so that performance of the network can be increased including the lifetime of the network. In the proposed scheme route request messages are directionally propagated towards the destination node using the information about the location coordinates of the destination node. This directional forwarding scheme leads to less energy consumption and less value of delay increasing the lifetime of the network. Lesser movement of nodes in the network will lead to greater value of packet delivery ratio and increased throughput. Performance comparison of Directional Forwarding scheme as well as MM-AODV using NS2.35 has shown remarkable improvement in all the four parameters.**

Index Terms—**AODV, MANETs, Node disjoint paths,NS2**

I. Introduction

Mobile ad-hoc networks are the networks that don't have any fixed infrastructure and are used for communication between two or more nodes without any central administrator. These nodes are connected to wireless medium and their topologies change periodically as shown in Fig. 1. MANETs are useful in medical emergencies, during natural catastrophes and in military applications.

Routing and Power Consumption is the main research issue for these type of networks and refers to discovering and maintaining paths between devices. Moreover, it involves selecting the best route where many routes are available.

Manuscript received March, 2016.

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However, due to the freedom of movement of nodes, new routes need to be constantly recalculated. Most routing protocols use pure broadcasting to discover new routes, which takes up a substantial amount of bandwidth. Intelligent rebroadcasting reduces these overheads by calculating the usefulness of a rebroadcast, and the likelihood of message collisions. Unfortunately, this introduces latency and parts of the network may become unreachable [1].

As ad-hoc networks don't require any base stations so their set up cost is also not high. Nodes in these types of networks are free to move due to which topologies of these network keep on changing from time to time. In MANETs many paths are available to carry data from source node to destination node. These paths consist of various common nodes. So when data is sent over these common nodes load over these nodes increases. As a result many nodes get drained out of their energies. In this paper we have proposed an approach to find complete node disjoint paths from source to destination nodes in the network [18].

The term Node disjoint path means that each node will appear only once in the available path. In this way all the paths will have unique nodes instead of common nodes which will result in better load balancing among the intermediate nodes [17]. This will also reduce energy consumption of nodes enhancing the lifetime of the network.

However, there are many other reasons that cause more energy consumption in the network. First, the nodes usually broadcast the route request messages in the network to find a route to destination node. The broadcasting involves many route request messages being sent from a node to another, which leads to more energy consumption. Also, the nodes are free to move anywhere in mobile ad hoc networks. The movement of the nodes lead to frequent topology changes which might lead to link breakages in the network. In such cases, the nodes again broadcast the route error messages to form a link again[1,4]. Thus, broadcasting of the control packets and mobility of the nodes become the prime reason for the more energy consumption in the network.

The traditional routing protocols such as AODV form the shortest route from source to destination node in the network. MM-AODV also takes the same approach, finding the shortest route from source to destination node. Various factors such as energy of the nodes, their mobility can also be taken into account to optimize the path selection process from source to destination node so that performance of the network can be increased including the lifetime of the network[16].

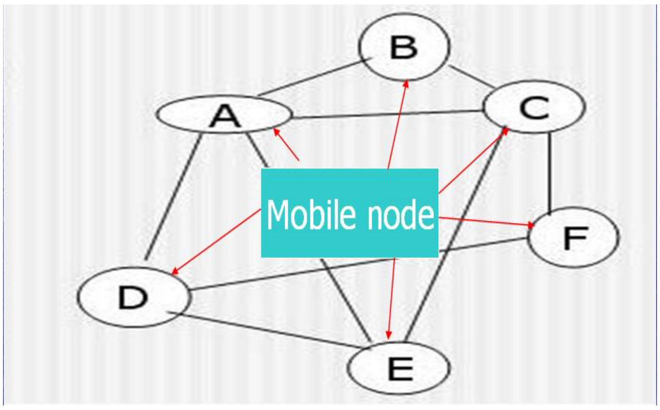

Fig. 1. Mobile ad-hoc Networks

II. AD-HOC ON DEMAND DISTANCE VECTOR ROUTING (AODV)

AODV is a distance vector routing protocol that is used to route messages between mobile devices. Mobile devices or nodes that cannot communicate directly can pass messages through their neighbors using AODV. AODV does this by discovering various routes from source to destination nodes. AODV is a single-path, distance vector routing protocol that uses hop-by-hop routing approach [14],[15]. Two main routing procedures in AODV are:

- Route discovery
- Route maintenance

- Route discovery
  When a supply node wants to wishes to send a message to some destination node and doesn't have a legitimate route to the destination, it initiates a path discovery method to find the other nodes. Route discovery technique begins with the creation of route request (RREQ) packet that is generated by the supply node. It broadcasts a route request (RREQ) management packet to its neighbors, that then forward the request to their neighbors, and so on, either the destination or intermediate node with a replacement route to the destination is found[12]. The AODV protocol utilizes the destination sequence numbers to ensure that all routes contain the foremost recent route information. Every node maintains its own sequence variety. The node which will first receive RREQ packet will first of all create the reverse path to the source using previous hop of RREQ as the next hop on the reverse path. If exact route to the destination is found then intermediate nodes generate RREP otherwise RREQ is rebroadcasted. Destination node will also generate RREP after getting RREQ packet. RREP is routed back to the source via reverse path.

- Route maintenance
  A route discovered between the supply node and the destination node is maintained until required by the supply node. Route is maintained using Resource error (RERR) message. Once a link failure is detected RERR is distributed through its predecessor links to all its neighbors using that unsuccessful link [10, 11]. When a supply node will receive RERR message it will again follow route discovery if it still needs that route.

- AODV Route Discovery

As the method is On-Demand routing protocol, no routes are permanently stored in nodes. The source node will broadcast RREQ message to start route discovery method. When neighbor nodes of source will receive RREQ message they will attach their address to the message[8],[9]. RREQ packet will contain the following information:

a. Source address
b. Source sequence no.
c. Destination number
d. Broadcast id
e. Destination address
f. Destination sequence number
g. Secondary source address
h. Hop count.

Redundant messages will be identified by the intermediate nodes as they uniquely identify source address and sequence number. Sequence number is set in source node and it gets incremented when source node generates route request message. When a node will receive RREQ message it will check destination address. If that node's address matches with the destination address then it will send back RREP message but if the address is different then it will forward RREQ message to all its neighbor nodes[19]. Secondary source will generate multiple routes, first one will be used and second one will be stored. This is done because if first link fails then source node can select the next available route from its routing table thus avoiding delay in sending a message and also to save energy of nodes.

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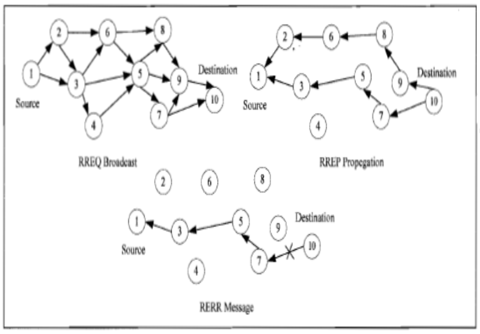

Fig.2. AODV Message broadcasting

If the first link fails intermediate nodes can notify to the source node by sending RERR message by adding next hop by hop count if source node has another valid rout to the destination. In Figure 2 Node 1 is the source node and node 2 is the destination node. Node 1 will broadcast RREQ message to all the nodes with the required information. Each node will match destination address with itself and will forward the RREQ packet further to its neighbors [22],[23]. Once the address matches with the destination i.e. 10 it will send RREP packet to the source node 1 through all its intermediate nodes hop by hop count. If the link fails in between it will send RERR packet to the source node to find out the next possible path that is stored in routing table.

III. Proposed Work

The objective of this section is to propose an approach to find complete node disjoint paths from source to destination node in the network. The term complete node disjoint path means that node will not repeat itself in the available paths. This will lead to better load balancing among intermediate nodes reducing energy consumption and enhancing the network lifetime [20, 21]. Here we will compare MM-AODV protocol with that of the proposed scheme i.e. Directional Forwarding.

In order to optimize the route selection procedure and reduce the broadcasting of the so many route request packets in the network, we will aim to use following techniques:

- Location Aided Routing: In this, the broadcasting of the route request packets is limited in the network as compared to traditional routing protocols where the request is broadcasted to all the nodes in the network[7]. Since the source node knows the location coordinates of the destination node, in the proposed work the source node will forward the destination's location to its neighbor nodes. Each node upon receiving the request, will compare its location with the destination's. If the node is located in the quadrant towards the destination only then it will forward the request else it will discard the request packet received by it.
- Mobility of the nodes - While optimizing the path from source to destination node, the destination node will consider the node disjoint paths [2]. After that the mobility of the nodes in the node disjoint paths will be taken into account to choose the path.
- Energy of the nodes - Another parameter that will be considered while selecting the path from source to destination node will be the energy of the nodes [20], [21].

The network parameters which are taken into consideration are

- Throughput
- Delay
- Energy consumption
- Packet delivery ratio

Our simulations results will show that which of the above mentioned protocol is producing better results with these four network parameters and simulation parameters as shown in Table I.

Table I. Simulation Parameters

Parameter	Value
Channel	Wireless
Propagation Model	Two Ray Ground
Mobility Model	Random Way Point
Routing Protocol	AODV
Number of nodes	50
Mac	802.11
Antenna	Omni Directional
Initial Energy	50 Joules
Network Area	1300m * 1300m
Queue	Drop Tail

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IV. SIMULATION & RESULTS

The proposed scheme as well as the MM-AODV was implemented on NS 2.35 which is open source simulator and is used for simulating various kinds of networks such as wireless sensor networks, mobile ad hoc networks and vehicular ad hoc networks. The languages used in this tool are tool command language (TCL), C++ and awk scripts. The main script is always written in tcl language which is given to the simulator. The simulator creates two kinds of file namely trace file and nam file. These files traces the information about the nodes and the packets that are being routed in the network.

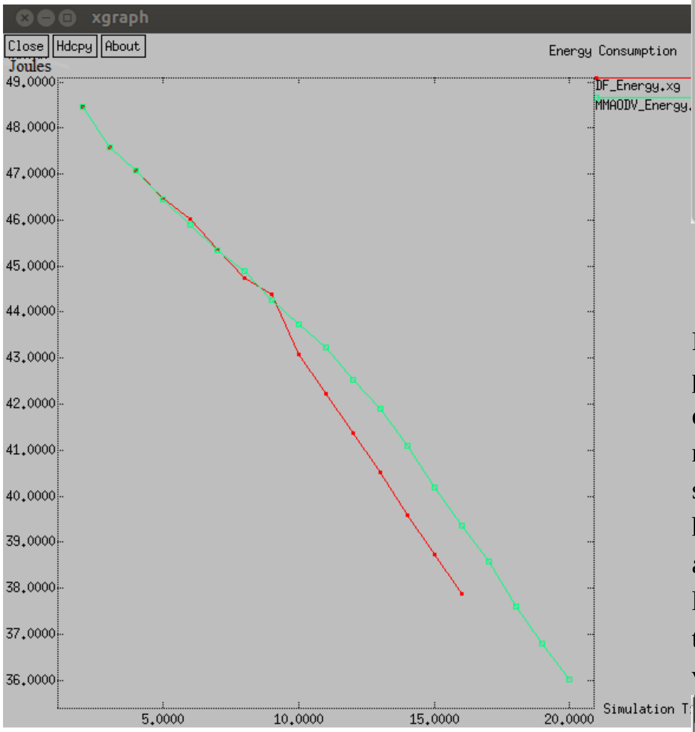

Fig.3 Energy Consumption

In Fig.3 the comparison between energy consumption values achieved during the simulation of the proposed scheme i.e. directional forwarding scheme as well as MM-AODV is shown. The initial energy of 50 Joules was given to the nodes in the network. At the end of simulation the remaining energy in the proposed scheme was 38 Joules showing the consumption of 12 Joules. Whereas in case of MM-AODV the remaining energy was found to be 36 Joules showing consumption of 14 Joules.

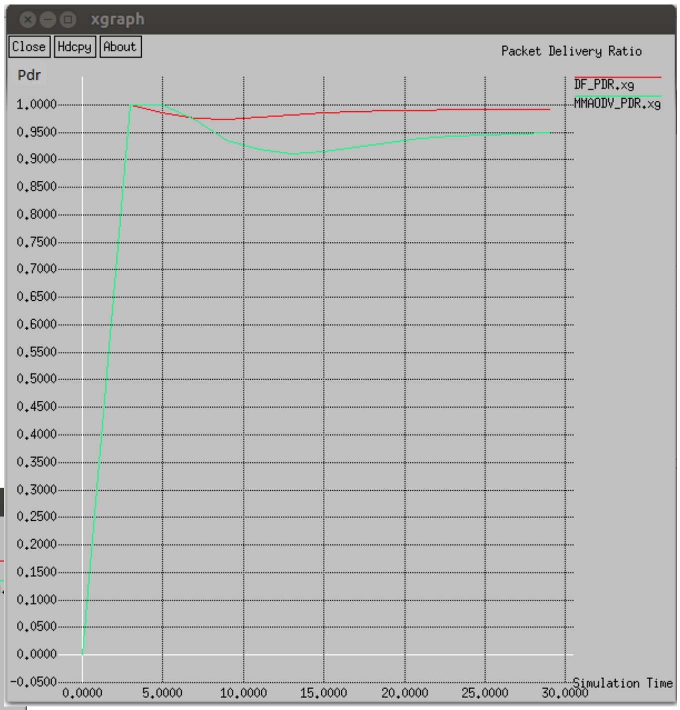

Fig 4. Packet delivery ratio

Fig 4 shows comparison of packet delivery ratio between the proposed and the existing MM-AODV scheme. The packet delivery ratio is ratio of number of packets received to the number of packets sent in the network. In the proposed scheme the packet delivery ratio was found to achieve a higher value of 0.98 as compared to the value of 0.95 achieved in the case of MM-AODV. This would mean that lesser number of packet drops have occurred during the transmission of the data from source to the destination node via chosen path.

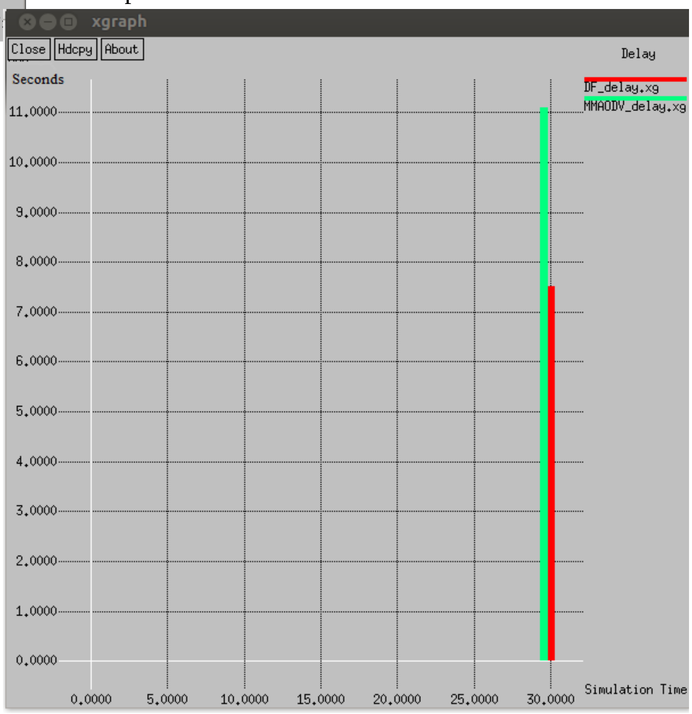

Fig 5. Delay

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Fig 5 shows comparison of Delay that occurred between Directional forwarding scheme and MM-AODV. The proposed scheme was implemented by modifying the route request forwarding phase where the number of route request messages forwarded to the nodes in the route searching behavior is reduced thus also reducing the delay. The amount of time taken in the proposed scheme before the data transmission starts is 7.5 seconds whereas in case of MM-AODV it was found to be 11.1 seconds.

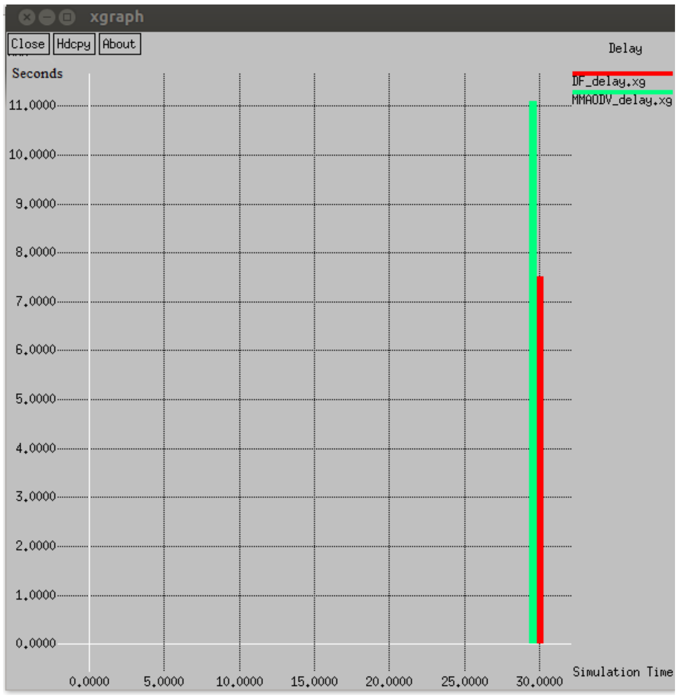

Fig 6. Throughput

Fig 6 shows comparison of throughput between Directional Forwarding scheme and MM-AODV. The throughput is the amount of data received at the destination node per unit of time. Better the throughput would mean that more amount of data is received at destination, better the performance of the network. In case of the proposed scheme, the amount of throughput achieved is 300 Kbps whereas the throughput achieved in case of MM-AODV was found to be 60 Kbps.

V. Conclusion & Future work

The proposed scheme as well as MM-AODV was implemented using NS2.35 and results were analyzed on the basis of parameters: Energy consumption, Throughput, Packet Delivery Ratio and Delay. All the four parameters showed an improved performance over the values achieved during the simulation of the existing scheme as the route request reaches the destination earlier than the existing MM-AODV[3,5]. This is contributed to the reason that route request messages are directionally propagated towards the destination node using the information about the location coordinates of the destination node. Due to early reception of the request messages at the destination, the values of delay are found to be less.

The proposed scheme thus outperformed the existing scheme. In future, we can look forward to modify the scheme further to cope up against many attacks the mobile ad hoc network is prone to, like black hole attack, worm hole attack etc. Thus security of the network can also be added to the proposed energy efficient scheme [6].

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