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Energy-Efficient Routing Protocol For Mobile Ad Hoc Networks

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ABSTRACT

Adhoc on demand distance vector routing protocol(AODV) is specially designed for mobile adhoc networks with reduced overhead using Expanding Ring Search technique. But energy consumption should also be considered in MANET due to battery constrain of the nodes. In this paper, we choose an energy efficient route discovery process for AODV based on Expanding Ring Search(ERS). We want to saves energy of the nodes to avoide the redundant rebroadcasting of the route request packets. The relaying status of the node is decided based on the broadcasting of its RREQ packets by its neighbors. And it helps in reducing routing overhead incurred during the route discovery process. Simulations are performed to study the performance of Energy Efficient AODV (E2AODV) protocol using NS2, the Network Simulator. This E2AODV reduces energy consumption by 80-90% compared to AODV. It also reduces routing overhead of around 70-75% and there by reduces 65-70% collisions.

Keywords: Mobile Ad-hoc Networks, Ad-hoc On-Demand Distance Vector Routing Protocol, Expanding Ring Search, Energy Consumption.

I. INTRODUCTION

Networks are classified into two main types based on connectivity, wired and wireless networks. A wireless network provides flexibility over standard wired networks. Only with the help of wireless networks, the users can retrieve information and get services even when they travel from place to place. The single-hop and multi-hop Mobile Ad-hoc Networks (MANET) are the two major classifications of wireless networks. Base stations are used in single-hop networks to accomplish communication between nodes. MANETs [1] are infra structure-less, self organizing networks of mobile nodes without any centralized administration like base stations. The communication between nodes is accomplished via other nodes which are called intermediate or forwarding nodes. So there is a need of a routing procedure between nodes. And hence the routing protocol plays a major role in MANET.

The routing protocols in MANET are mainly classified using their routing strategy and network structure. [2]. Flat routing, hierarchical routing and geographic position assisted routing are the three major classification of routing protocols based on the network structure. Based on routing strategy, the routing protocols are grouped as Table-driven and source initiated on-demand driven [3]. Table-driven protocols usually find routes constantly and maintain in routing table for all source-destination pairs at the expense of high routing overhead. On-demand protocols such as AODV and DSR [4] incur less routing overhead by finding path between a sourcedestination pair only when it is necessary. Compared to tabledriven protocols, on-demand protocols utilize less bandwidth and energy consumption. Ad-Hoc On-Demand Distance Vector Routing Protocol (AODV) [4] finds route between nodes only when it is necessary. It does not maintain topology information about all other nodes in the network. In AODV, each time the node initiates the route discovery for some destination using simple flooding for broadcasting the Route Request (RREQ) across the network. Energy efficiency is an important issue in MANETs where nodes rely on limited power and computational resource, yet are required to cooperate in all sorts of fundamental network activities including routing. So, to control the network wide broadcast of the RREQs, the source node uses the Expanding Ring Search (ERS) technique[5], which allows a source to broadcast the RREQ of increasingly larger areas of the network if a route to the destination is not found. Unfortunately, some nodes in ERS technique rebroadcast the RREQs unnecessarily. For extending the lifetime of the nodes in MANET, many energy efficient protocols have been designed. In this paper, we propose a simple but energy efficient design for AODV Routing Protocol which makes some nodes silent without forwarding the redundant rebroadcasting of the RREQ packets which is not used by any other node in the network for finding routes. Using NS2, we evaluate the performance of our energy consumption design to AODV, which is named as Energy Efficient AODV (E2AODV), in MANET. In the rest of the paper, Section II reviews the related work. The E2AODV, a new energy efficient approach is described in Section III. The simulation model and result analysis are provided in Section IV. Finally in Section V, we present our conclusions.

II. THROUGHPUT OF AODV ROUTING

A. Overview

The Ad Hoc on-demanded Distance Vector (AODV) routing protocol is a method of routing messages between mobile computers. It allows these mobile computers, or nodes, to pass messages through their neighbors to nodes with which they cannot directly communicate. AODV does this by discovering the routes along which messages can be passed. AODV makes sure these routes do not contain loops and tries to find the shortest route possible in terms of hops. AODV is also able to handle changes in routes and can create new routes if there is an error.

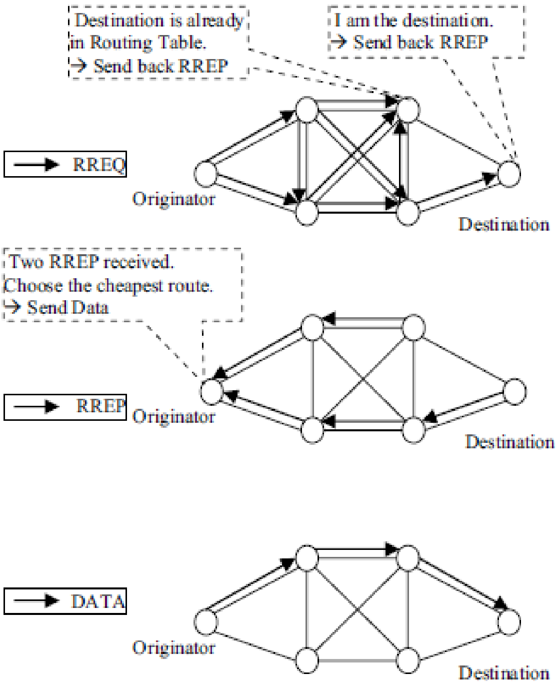
B. Algorithm

The AODV protocol deals with a routing table. Every node is associated with a routing table. When a node knows a route to the destination, it sends a route reply to the source node. Its entries are as follows. Destination Address - Destination Sequence Number – Next Hop Address - Lifetime (expiration or deletion time of the route) - Hop Count (number of hops to reach the destination). Nodes that can be communicated with are directly considered to be neighbors.

A node keeps track of its neighbors by listening for a ‘HELLO’ message that each new node broadcast and nodes broadcast at set intervals. When one node (the originator) needs to send a message to another node that is not its neighbor, it broadcasts a Route Request (RREQ) message. The RREQ message contains the following information: the source, the destination, the lifespan of the message and a Sequence Number, which serve as a unique ID.

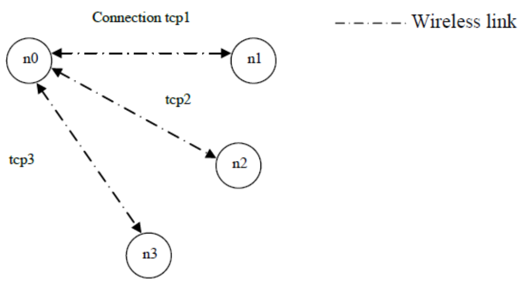
When the originator node’s neighbors receive the RREQ message they have two choices: if they know a route to the destination or if they are the destination they can send a Route Reply (RREP) message back to originator, otherwise they will rebroadcast the RREQ to their set of neighbors. The message keeps getting re-broadcasted until its lifespan is completed. If the originator does not receive a reply in a set amount of time, it will rebroadcast the request except that this time the RREQ message will have a longer lifespan and a new ID number.

All of the nodes use the Sequence Number in the RREQ to insure that they do not re-broadcast a RREQ. Sequence numbers allow nodes to compare how “fresh” their information on other nodes is. Every time a node sends out any type of message, it increases its own Sequence number. Each node records the Sequence number of all the other nodes it talks to. A higher Sequence numbers signifies a fresher route. In this way, it is possible for other nodes to determine which one has more accurate information.



SIMULATION SCENARIO

Simple topology with 4 nodes is used. Each node is connected to other by wireless link. A simple MANET example script available in ns-2.30/tcl/ex is used as a base script. The node movement patterns are generated by giving commands as given in script. A node is situated at random position at the start of simulation and moves toward random destination in the script with random velocity as specified in command. The traffic is generated manually using commands in script. We have used ftp as TCP traffic.



We have established three TCP connections, tcp1, tcp2, and tcp3. We have configured Energy Model which is implemented in *ns*, is a node attribute. The energy model represents level of energy in a mobile host[10]. The energy model in a node has an initial value which is the level of energy the node has at the beginning of the simulation. This is known as initialEnergy_. It also has a given energy usage for every packet it transmits and receives. These are called txPower_ and rxPower_. Timings for traffic are given below.

ftp1 – 1s to 38 s ftp2 – 1s to 38 s ftp3 – 1 s to 38 s
Each and every node consumes energy in transmitting DATA packets, CONTROL packets and ACK packets.

III. E2AODV

In the ERS, the source node will broadcast the RREQ to its neighbors to find route. If the neighbor nodes receive it for the first time, it will relay the RREQ. Or else it will just drop the packet. Hence there will be useful information regarding the sender and last hop, dropping the duplicate packets wastes the neighbor's information. Therefore we propose a design which helps in utilizing the information before dropping the duplicate RREQ packets to make decision about node's relay value. This helps in making some nodes silent without forwarding the redundant rebroadcast of the RREQ and thus reduces energy consumption for AODV routing protocol. This improved ERS scheme is named as E2AODV, Energy Efficient AODV. In E2AODV, the state of the node is determined as relaying or being silent by using the Relay Value of each node in the network. Initially the Relay and Forward value of all the nodes is set to be 1, which means that it will relay the RREQ. It is shown in Fig.2. And the Relay and Forward value will be updated based on the TTL value and the P-Addr field in the RREQ packet. The connectivity between nodes in Fig. 2 implies that it can be reachable in one hop that is within the nodes transmission range. The Relay value will be changed based on the information provided in the duplicate RREQ packets. Generally in the RREQ packets, other than the hop count, source and the destination sequence number, there will be three node address fields mentioned in it.

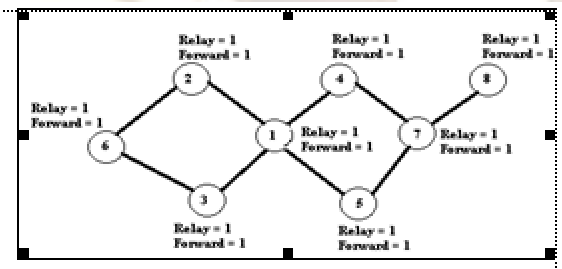


Figure 2. Initial Relay and Forward Value in E2AODV

TABLE I. MODIFIED RREQ PACKET FORMAT

AODV Pkt Type	Bcast ID	Dest Addr	Dest Seq	Src Addr	Src Seq	Last Addr	P-Addr	Hop count

When a node receives a RREQ with TTL value as 0 or the duplicate RREQ, i.e. with the same broadcast ID that has been processed before, it will check for the P-Addr field in the RREQ. If that particular node address is same as the P-Addr in RREQ, then the Relay value of that node will be set to 1. It means that the node will participate in the search process of the destination. Else, the node will not participate in the route discovery process.

TABLE II. FIELDS THAT ARE USED IN RELAY FORWARD TABLE

Source Address	Destination Address	Lifetime	Relay Value	Forward Value

Initially it will be set to null. And when a node receives a RREQ packet to process, the TTL value will be checked and the SD pair with the processed relay and forward value as in Fig.4 will be stored in the table then only the node will forward the RREQ. And when a node receives a RREQ, it will check in relay forward table to find out whether it is processed before or not. Then based on the Relay and forward value, it will decide whether to relay the RREQ or to just drop the RREQ. The lifetime field is added so that of the particular entry will be deleted after particular time i.e., it will be deleted when the RREP is received for that source destination or when there is any route n breakage during the forwarding of the RREP or data packets. Or the entry will be automatically deleted by the MAC layer when the particular node is not participating in the forwarding of the data. This has been identified when that particular node doesn't receive any RREP.

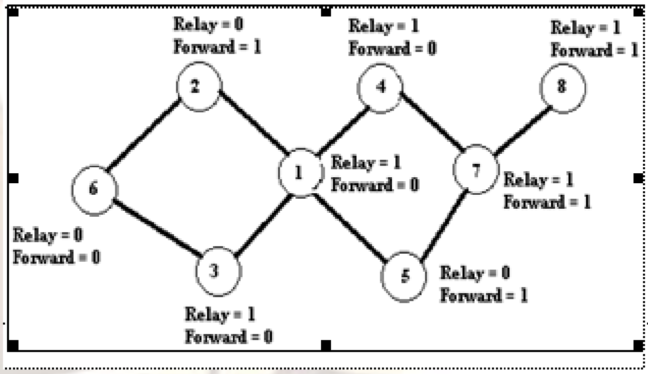


Figure 3. Final Relay and Forward value in E2AODV

IV. POWER CONTROL

By default, the packets are transmitted with maximum power, which represents a considerable loss on energy. The aim is to adapt the transmission power levels on a perpacket basis for each neighbor. The needed power level to reach a neighbor will be determined during the 'HELLO' process. Instead of sending one 'HELLO' message, the node will broadcast four 'HELLO' messages with a power level of 100%, 75%, 50%, and 25% respectively. When a node receives a 'HELLO' message, it starts a timer to listen to the maximum messages it can. Once the timer expired, it sends back to the initiator an acknowledgement with the last power level it received. The nodes then update their routing table with the power level required to communicate.

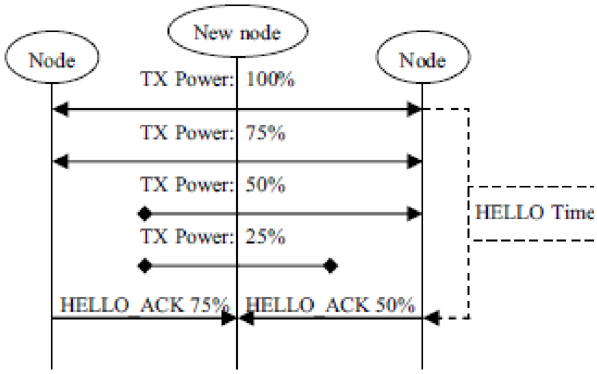


Figure 2 - The 'HELLO' process

When a link breakage occurs, the sending node tries to send once more the packet with a power level of 100%. If the packet is received and acknowledged by the destination, both the routing tables are updated. Otherwise, the destination node does not acknowledge the packet and the RERR process is start again.

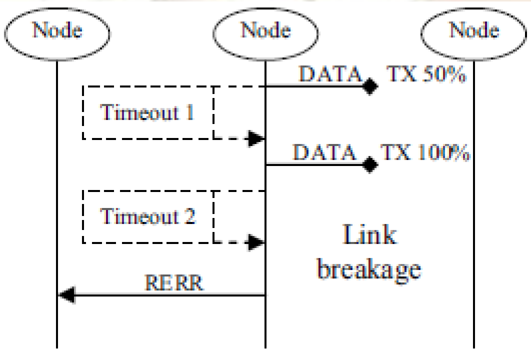
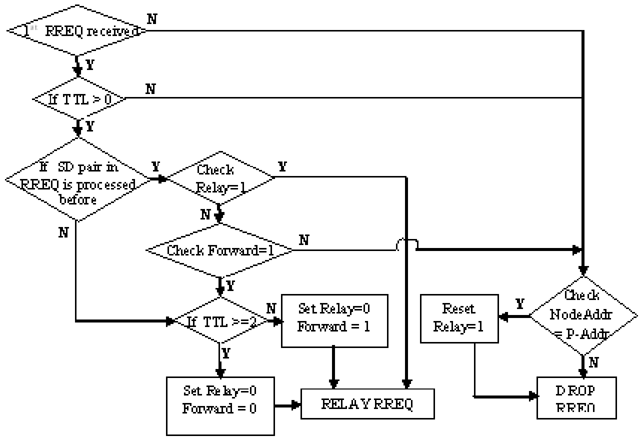


Figure 3 - The RERR process

Given the same sequence number, the traditional AODV routing protocol selects the route with the fewer number of hops to the destination, without specifically accounting for the quality of links. AODV is used for ad hoc networks to determine the shortest routes in terms of hops that are not representative of the energy spent.

To improve the energy efficiency for the AODV protocol, we will consider a metric that takes into consideration the total amount of energy necessary to reach the destination node, and the battery level of intermediary nodes.



A. Performance Metrics:

Three performance metrics are used to evaluate the protocol Variants.

1) **Energy Consumption***:*

Total energy consumed for transmitting and receiving
packets by all the nodes in the network.

2) **Normalized Routing Load:**

The ratio of the total number of packets received at the destination to the total number of RREQ packets transmitted by all the nodes in the network.

3) **Collisions:**

The total number of collisions incurred at the MAC layer during the transmission of data and control packets is
considered.

B. **Varying Node Mobility for Dense and Sparse Network**

Performance comparison of AODV and E2AODV has been done for dense and sparse networks such as 30 and 50 and 80 nodes respectively by varying the node speed from 0 m/s to 30 m/s.

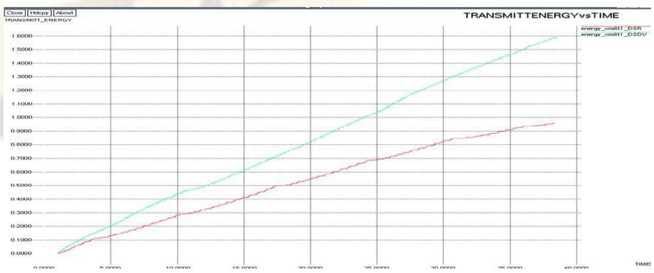
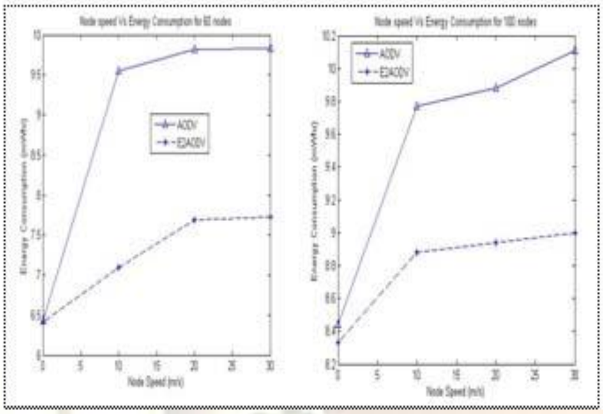


Fig. comparison of transmit energy for node 1 using DSR and DSDV as a routing protocol

Energy consumption is generally high when the number of nodes in the network is increased. But by making some nodes silent, the E2AODV saves 80-90% of energy when compared to AODV in dense networks. And in sparse network, 70-75% less consumption of energy in E2AODV when compared with AODV.

Table 3. Energy Level For Routing Protocols

Receiver Node	Proactive Routing - DSDV		Reactive Routing - DSR	
	Transmit Power	Receive Power	Transmit Power	Receive Power
Node 1	1.591	13.177	0.961	13.510
Node 2	0.816	13.622	1.061	13.538
Node 3	1.401	13.249	1.800	13.101



V. Conclusion

Energy consumption plays significant role in network lifetime. So It is important to study how to reduce the power consumption while at the same time fully-utilize the bandwidth resource. The traditional AODV protocol was improved by introducing a procedure to adapt the transmission power levels on a per-packet basis for each neighbor as well as by changing the hop-count metric for an energy aware metric. At the network layer, routes are determined in such a way as to minimize energy consumption, and to avoid the nodes with low battery. E2AODV provides efficient energy consuming routing protocol with reduced routing overhead.

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