An Optimal Routing Approach for Improving Energy Efficiency in Wireless Ad-hoc Networks

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***Abstract*—Mobile ad hoc network is coordinated without fixed infrastructure. In the conservative AODV routing protocol, source node always forwards RREQ (Route Request) packet to neighbor for finding path to the destination node. The intermediary (neighbor) node having less lifetime or energy, as well forwards RREQ and lifetime expires after some certain time, i.e. node goes down; it cannot forward RREP (Route Reply) on reverse path and source node has to regenerate RREQ that results in needless RREQ rebroadcast, less packet delivery ratio, throughput and more end to end delay. The solution of the above problem, here we propose energy optimal AODV (EOAODV) routing protocol based on reactive routing protocol. In this proposed approach, source node does not send any RREQ; no enough energy (battery life time) and received RREP until the node density in its neighboring exceeds a particular threshold. The performance of the proposed protocol has been examined and evaluated with NS-2.29 simulator for various statistics using these parameters, when applying routing discovery and needs to avoid the unnecessary information sending efficiently. Finally we concluded that the proposed protocol i.e. EOAODV improves network throughput, energy efficiency and network lifetime as well about minimize delay. The new protocol is much better than all existing routing protocols in terms of battery lifetime and throughput.**

Keywords— Energy efficient routing protocol, battery lifetime, throughput, QoS, EOAODV, Wireless ad hoc network.

I. INTRODUCTION

mobile ad hoc network is a self-directed system of mobile nodes. The scheme may operate in isolation, or may include gateways to and interface with a set network. MANET nodes are equipped with wireless receivers and senders using antennas which may be broadcast, highly-directional (point-to-point) and probably steerable, or some combination thereof. Mobile ad hoc networks consist of mobile nodes which activate on battery. A mobile node has a fixed and decreasing energy. Thus, these nodes need to be energy conserved to maximize the battery life time. Energy consumed by the sleeping state node is radically less than the transmit/idle/receive state node. To minimize energy consumption, pathway which consumes less power is also can be chosen [4]. Routing process is one of the key issues in MANETs due to their highly dynamic and distributed ad hoc network.

In exacting, *energy efficient routing protocols* may be the most important design criteria for MANETs since mobile nodes will be powered by batteries with limited capability. Power or link failure of a mobile node not only affect the node itself but also its ability to forward packets on behalf of others and thus the overall system lifetime. For this motivation, many research efforts have been dedicated to developing energy aware routing protocols. A mobile node consumes its battery energy not only when it dynamically sends or receives packets but also when it stays inactive listening to the wireless medium for any possible communication requests from other nodes between networks. Therefore, energy efficient routing protocols minimize either the *energetic* communication energy required to transmit and receive data packets or the energy during *stationary* periods. The modern development in the energy efficient wireless network is interfaces, powerful, energy efficient microcontrollers and high capacity batteries provide new functions of Mobile Ad Hoc Networking approaches (MANETs).

In Section 2 presents a general discussion on ad hoc existing routing protocols .Section 3 presents a general discussion on route discovery operations where the goal is to find the optimal paths. Section 4 presents energy efficient routing process and proposed algorithms to deter mine an energy efficient routing path. Section 5 presents the various goals and performance metrics used to determine energy efficient routing protocols. Finally, Section 6 provides a conclusion.

II. REVIEW OF ROUTING PROTOCOLS

In 1994, Charles Perkins [8] presented DSDV, which is a proactive routing protocol. It is a modification of Bellman Ford mechanism. In this protocol, source node always has a path to destination in the form of route table at all times i.e. paths are available the moment they are needed. DSDV advertises periodic and event triggered advertisements throughout the network whenever there is a change in topology. Each node changes its sequence number after receiving updates. The node having greatest sequence number is chosen. Each node is having IP address of source and destination, current sequence number and hop count in its route table. The node removes stale entries from route table to guarantee loop problem. System wide updates consume some amount of battery and bandwidth, even if the network is idle. So, DSDV protocol is not suitable for highly energetic networks.

This paper tells that, reducing power consumption and efficient battery life of nodes in an ad hoc network requires an integrated power control and routing strategy. The power control is achieved by new route selection mechanisms for MANET routing protocols. In 2005, K. Murugan and S. Shanmugavel [12] proposed Energy Based Time Delay Routing (EBTDR) and Highest Energy Routing (HER). These algorithms try to increase the operational lifetime of an ad hoc network by implementing a couple of modifications to the basic DSR protocol and making it energy efficient in routing packets. The modification in EBTDR is such that if the nodes' remaining energy is less, then packets are forwarded after some time i.e. delay is introduced. If nodes' remaining energy is high then packets are forwarded immediately i.e. there is no concern of delay. In HER, the route selection is based on the energy drain rate information in the route request packet. It is observed from the simulation results that the proposed algorithms increase the lifetime of mobile ad hoc networks, at the expense of system complexity and realization.

In 2008, Thriveni and et al. [13] proposed an algorithm to improve the flooding performance of an ad-hoc on-demand distance vector (AODV) routing protocol called, Probabilistic Mean Energy Flooding (PMEF) which periodically performs an averaging. As the word Mean Energy is there, algorithm calculates average energy say Eavg. Remaining energy is also calculated called Er. Route selection depends on the probability which is drawn on the basis of difference between residual energy Er and mean energy Eavg. This algorithm is used in route discovery process to make a rebroadcast decision by the node. If, nodes does not have sufficient energy, then rebroadcasting of packet is not done. As compared to the existing AODV, proposed schemes in forwarding a route request are more effective in reducing the flooding overhead and increase the network lifetime and throughput thereby decreasing the network latency. In 2009, Zhang Jianwu, Zou Jingyuan and Zhao Qi [14], proposed modifications to improve the broadcasting mechanism of AODV protocol. They presented an improved mobile ad hoc network on demand routing protocol which is based on AODV. It controls the broadcasting of RREQ information. This protocol analyzes the lifetime of node, when implementing routing discovery, and avoiding the unnecessary information sending efficiently. By comparing AODV with OAODV in the same scenario, the new protocol is much better than AODV protocols for packet delivery ratio as well as routing load.In 2011, Sunil Taneja and et al. [15] proposed a scheme that takes into consideration power status of each and every node in the topology and further ensures the fast selection of routes with minimal efforts and faster recovery. Battery strength of nodes is divided into three states namely danger state, critical state and active state. The nodes which are in active state participate in route selection. The results have been derived by carrying out experiments over network simulator NS-2. The performance evaluation of new AODV and existing AODV has been done on the basis of packet delivery ratio and exhausted nodes. The proposed scheme in new AODV works on a reactive approach and utilizes alternate paths by satisfying a set of energy based criteria. This scheme can be incorporated into any ad hoc on demand routing protocol to reduce frequent route discoveries. Alternate routes are utilized only when data cannot be delivered through the primary route. Simulation results indicate that the proposed scheme provides robustness to mobility and enhances protocol performance. Average increases in terms of packet delivery ratio for different network scenarios.

III. OPTIMAL ROUTE DISCOVERY OPERATION

The general operation of on demand protocol is loop-free, and by avoiding the counting to infinity problem offers immediate convergence after the ad hoc network topology changes. The major procedures Route Requests (RREQs), Route Replies (RREPs), and Route Errors (RERRs) are the message types defined by reactive routing. On demand protocols builds directions using a route request / route reply messages. When a source node searches for a route to a destination, which it does not before now have a route, it transmits a route request (RREQ) message. Packets are transmitted in whole network and nodes are receiving this data packet, update their routing information for the each source node and store the information in the node's buffer of routing table. This depicted in Fig. 1. In addition to the source node consists IP address, source sequence number and broadcast ID and the RREQ message contains the generally recent sequence number for the destination node of which the source node is alert. When node receiving the RREQ message may send a route reply (RREP) if it is either the destination node or if it has route information to the destination with consequent sequence number always greater than or equal to that enclosed in the RREQ. Which is depicted in Fig. 2 Destination node always sends the reply to source node and maintain unicasts a RREP back to the source node. Otherwise, it retransmitted the route request (RREQ) message to the destination node. Source nodes always maintain path of the RREQ's source IP address and broadcast ID [10].

A. Ad hoc On Demand Distance Vector Routing (AODV) Route Discovery

When source node needs to communicate with destination and if path does not exist to destination then source floods or broadcasts RREQ i.e. route request packet to all its neighbours in the network. RREQ request message contains source and destination node's IP address, sequence number of destination, current sequence number, hop count and RREQ ID. RREQ ID is monotonically increasing number. It obtains incremented after each node initiates new RREQ. Fig. 1 illustrates this flooding procedure [16][23].

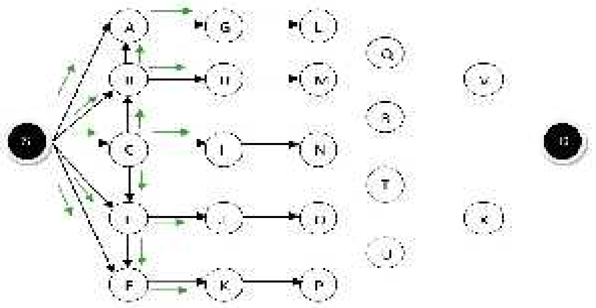

Fig 1: RREQ Broadcast [23]

When the intermediate node receives RREQ, create reverse link to previous node. They initial of all check whether, valid route to destination is there or not. If, valid route is there then another condition must hold i.e intermediate node's sequence number should be at least as immense as destination sequence number in RREQ packet. If both conditions grip, then that node generates RREP message i.e. reply packet. If valid route is not there then RREQ message is further forwarded. While RREQ is forwarded and hop count is incremented. Whereas sending RREQ, intermediate nodes start a timer. If reply doesn't move towards within that time means, there is no more energetic route or link failure has occurred [11][23]. RREP message contains IP address of source as well as destination route, and destination sequence number. Once the node creates the RREQ forward route entry, it forwards the RREP to the destination node. The RREP message is consequently forwarded hop by hop to the source node, as indicated in Fig. 2. Once upon a time the source node receives the RREP; it can use the path for the transmission of data packets in a network [4].

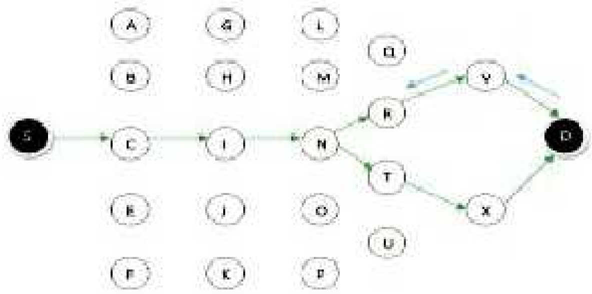

Fig 2: RREP Propagation [23]

B. AODV Route Maintenance

MANET is dynamic i.e. mobility and topology of nodes always change, link was broken. When path was broken, both the nodes inform their end nodes regarding link failure, which were using that path by sending RERR i.e. error message as illustrated in Fig. 3. End nodes dropped their entries from route table, as path is no longer valuable. If source node still desires to communicate with destination node, it reinitiates RREQ means of communication or path finding procedure or repair broken link [11][23].

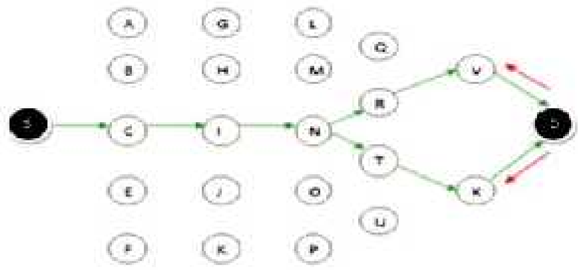

Fig 3: RERR Message [23]

C. Problem Statement

In general conservative AODV routing mechanism, a node broadcasts or floods RREQ message to its neighbours when it needs to communicate with a destination node [18]. If intermediate nodes' lifetime is not as much of that node expires after some time. Therefore, it could not be able to forward the RREP message on the reverse path. Hence, the source node would have to rebroadcast the Route Request (RREQ) message in order to find an optimal path for communicating to the destination node. This may possibly cause congestion in the network, reduce the packet delivery ratio; raise the end to end delay and needless rebroadcasting of RREQ packets [19] and message can be changed for insider attacks including route disturbance, route attack, node separation, and resource consumption AODV lacks an efficient route maintenance method. The routing information is always obtained on demand routing and it include for common cause for traffic.

IV. PERFORMANCE OF THE SYSTEM

The Proposed solution for this type of problem is given by EOAODV which is based on reactive routing protocol (AODV).

A. Energy Optimal Ad hoc On-demand Routing Protocol

In MANET each node has a certain battery life and node density in its surrounding which is saved in the routing table of proposed EOAODV protocol [14]. The intermediate node doesn't forward the RREQ message immediately if there is find a route to destination. In detail, first check its lifetime of the node and calculate the node density of its neighboring. The Second parameter is taken into thoughtfulness because; there should be sufficient number of nodes to forward RREQ messages. In general Hello messages are used to determine neighbor connectivity or node density of its neighboring [20].

Two thresholds are introduced say RREQ for min-power path rebroadcasting and RREP for node density maximizing the network life time of the environment. If battery life and alternate path of the intermediate node, who received the min-power path is greater than RREQ and network lifetime, it can be concluded that, the broadcast of Route Request successfully reached into the destination node and the neighbor node can rebroadcast RREQ message. If the ratio is less than the RREQ and network life time, the neighbor node buffers the data packets and repeats the above process interactively until either transmit is successful or the total number of attempts exceeds a threshold. This mechanism can helps to decrease unnecessary data packet rebroadcasting and increase the throughput

B. Proposed Algorithms

Begin

Step 1: A Route Request (RREQ) message is transmitted when a node wants to find out route information to a destination (Energy Optimal broadcast mechanism)

Step 2: If Route Request (RREQ) Message is accepted then "The destination route is given reply through uncasing a RREP Message back to the source route and as well make an entry of next to next node in the specific Routing Table"

Step 3: If (Hello Message Timer Expire or Link Breaks between them)
Check own battery life time
{ {
"Recover the Route information by Next to Next Node"
Else if "pick up the Route by Local Repair or Recover by alternate route"
Else if
Remain silent, drop RREQ
"Send RRER (Route Error), RREQ is broadcasted further"
}
Else "Send Data Packet from stored node's buffer"
}
Step 4: End of algorithm.

V. RESULTS AND PERFORMANCE ANALYSIS

Network Simulator with 2.29 versions is used on red hat 5.4 operating system for the simulations. As declared earlier, study of AODV.DSR and Energy Optimal AODV protocol (EOAODV) performed.

A. Random Waypoint Mobility Model

The Random Waypoint Mobility Model consists of pause times between changes in route and/or speed. An MANET begins by staying in one position for a definite period of time (i.e., a pause time). Once this time terminates, the MANET chooses a random target in the simulation region and a speed that is equally distributed between [0, Maxspeed].The MANET after that travels toward the recently elected destination at the chosen speed. In the lead arrival, the MANET pauses for a specified time period before starting the process again.

B. Simulation Environment

The IEEE 802.11 Medium Access Control (MAC) Distributed Coordination Function (DCF) protocol is used in simulations [21]. Following are the simulation parameters.

TABLE I. SIMULATION PARAMETERS

Experiment Parameter	Experiment Value
Simulation Time	599S
Range transmission	300 meter
Carrier sensing range	300 meter
Number of nodes	10, 20, 30, 40, 50
Topology area	500m x 500 m
Mobility model	Random way point
Traffic type	TCP
Maximum speed	10 m/s
Packet size	512 bytes for TCP
Initial energy	60 Joules
Pause time	2 sec
Type of antenna	Omni directional
Channel type	Wireless channel
Maximum packets in queue	50
Radio propagation model	Two ray ground
Network interface type	WirelessPhy
Interface queue type	Drop tail / PriQueue

C. Evaluation Performance Metric:

Battery Lifetime: In wireless network remaining energy is a decrease in energy consumption of network for EOAODV as compared to AODV and other reactive routing protocol because each node is now attentive of its energy constraints for data communication as shown in Fig. 4, Fig. 5.

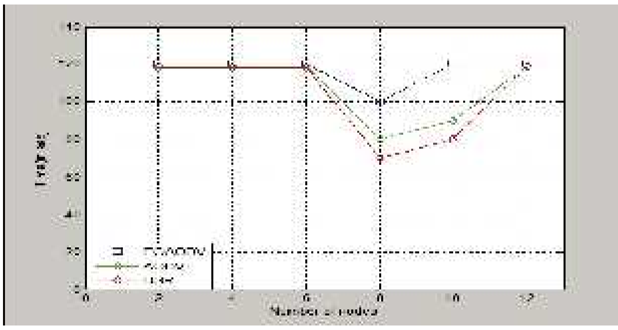

Fig 4: Fig.4.Comparison of AODV and Optimized AODV in terms of battery lifetime for ten nodes

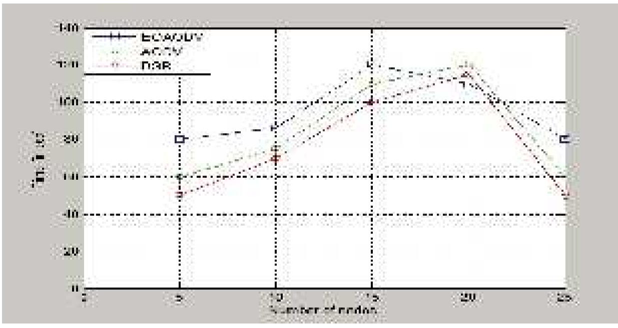

Fig 5: Fig.5.Comparison of AODV and Optimized AODV in terms of battery lifetime for twenty nodes

CONCLUSION

This paper we discusses how energy is one of the important factors for MANET. Energy efficient Optimal AODV routing protocol is proposed. This paper presented an Energy Optimal Mobile Ad Hoc Network on Demand routing protocol, which modifies broadcast mechanism of conservative AODV routing protocol. Successful delivery of RREP is significant in MANET. In this process if reply is lost, new route detection procedure has to be reinitiated. EOAODV avoids unnecessary broadcasting of RREQ information. In this scheme, the node does not broadcast the routing request (RREQ) if it does not have enough energy (battery lifetime), and until the node density in its neighboring exceeds a particular threshold. After comparing reactive routing with EOAODV in terms of battery lifetime and throughput, it is experiential result shown that the new protocol is much better than AODV and lengthens the battery lifetime. In prospect, there is a need to discover the effect of this algorithm for different mobility models in ad hoc network.

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