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An Enhanced Approach for Finding an Optimal Path in MANET using Energy Aware Reverse Reactive Routing Protocol (EA-RAODV)

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***Abstract* – *In* MANET, ad hoc network is an energetic topology, hosts, and infrastructure less multi-hop wireless ad hoc environment. The efficient node-energy consumption in wireless ad hoc networks is essential as ad-hoc nodes operate with limited battery power. Thus, failure of node in ad hoc network leads to loss of communication in the network and down frequently due to mobility of nodes. It maintaining alive node for longer time i.e. growing network lifetime is one of the important factors in design of ad-hoc networks.**

In this paper, we introduced energy aware efficient modified RAODV (EA-RAODV) reactive routing protocol is proposed which performs routing based on the combination of least hops, power and minimum remaining energy. An effort has been done to perform analysis and find out optimal path using random way point mobility model. The outcomes have been derived using self created network investigation scenarios for varying parameter of network. The performance of the proposed protocol has been examined and evaluated with NS-2.34 Simulator in terms of network lifetime, consumed energy, remaining energy, packet delivery fraction, routing overhead and normalized routing load. Finally we concluded that the proposed protocol i.e. EA-RAODV provides more energy efficient, secure and stable routing strategy for wireless ad hoc networks.

Keywords: Mobile Ad-Hoc Network, MANET Routing Protocols, EA-RAODV, AODV, DSDV

I. INTRODUCTION

Mobile Ad-hoc network is a set of wireless mobile nodes dynamically forming a short-term network. The goal of this structural design is to provide communication facilities between end-users without any centralized infrastructure. Energy management in Ad-hoc networks is of paramount importance due to the limited energy availability in the wireless devices. As wireless communication consumes a significant amount of energy, it is important to minimize the energy costs for communication. Existing literatures about energy efficient or power aware routing protocols can generally be divided into three categories: (i) switching on/off radio transmitters to conserve energy [1], (ii) power and topology control by adjusting the transmission range (power) of transmitters [2], and (iii) routings based on the energy efficient metrics [3].

In this paper, we consider the cost of data packets sent in the network, and the cost of control packets used to maintain the network. To do this, we define ERAODV (Energy Reverse Ad-hoc on-demand Distance vector routing), is a reactive routing protocol based on a policy which combines two mechanisms used in the basic AODV (Ad hoc On-Demand Distance Vector) protocol [4]. We prefer AODV as one of the on demand MANET routing protocols because; it consumes less energy than other related routing protocols such as DSDV (Destination Sequenced Distance Vector) and TORA (Temporally Ordered Routing Algorithm) as shown in [5]. AODV and most of the on demand ad hoc routing protocols use single route reply along reverse path. Immediate change of topology causes that the route reply messages (RREP) could not arrive to the source node, i.e. after a source node sends several route request (RREQ) messages, the node obtains a RREP, and this increases in power consumption. To avoid these problems, we propose a mechanism which tries multiple route replies. In this way we achieve a routing path with less RREQ messages**.**

In the AODV routing process, a minimum hops algorithm is useful to establish routes between sources and destinations. To improve the routing in term of energy preservation we propose the second mechanism witch consider another metric in the route establishment process. This parameter includes in route cost computation the speed of energy consumption. We believe that by this way we avoid nodes that participate in communications more than other and we choose nodes that participate less than the other in the communications.

II. RELATED WORK

The scheme needs traffic overhead to maintain the network connectivity and to assume data transmission in spite of congestion. Significant reduction in cost (function of remaining battery power) can be obtained by using shortest – cost routing as opposed to shortest hop routing. This power aware routing protocol for mobile ad hoc networks can be easily incorporated in existing routing protocol [8]. In Span: An Energy Efficient Coordination Algorithm, proposed by Chen B, Morris R etc [9], a distributed coordination technique reduces energy consumption without significantly diminishing the capacity or connectivity of network. It adaptively elects coordinators and rotates them in time. The performance of ad hoc routing protocols greatly depends on the mobility model it runs over [7]. Ad hoc routing protocols [6] are classified based on the manner in which route tables are constructed, maintained, and updated. They are classified as Table-driven, Source initiated or demand-driven. In situations where nodes move in groups, source initiated protocol perform better than table driven protocols in terms of energy consumption

III. AD HOC ON DEMAND DISTANCE VECTOR ROUTING

The Ad hoc On Demand Distance Vector (AODV) is a reactive routing protocol [6]. In fact, it is self-starting, enables multi-hop routing between participating mobile nodes wishing to establish and maintain an ad hoc network. This protocol builds routes between nodes only as desired by source nodes. It discovers routes quickly for new destinations, and does not require nodes to maintain routes to non-active destinations. AODV ensures link breakages and breakdowns are handled efficiently.

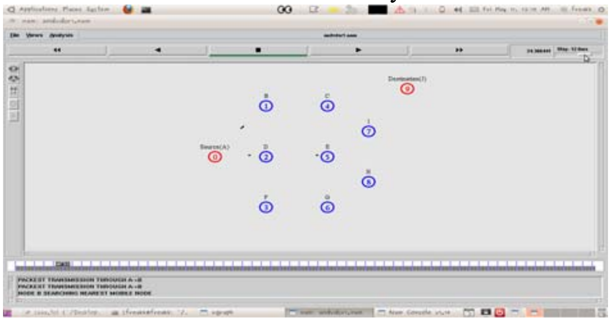

Figure 1: Flooding of RREQ messages

The AODV protocol establishes routes using a Route Request (RREQ) / Route Reply (RREP) query cycle. So, when a node requires path to destination, it broadcasts RREQ message to its neighbors which includes latest known sequence number for that destination. This message is flooded, until information required is complete by any means. Each node receiving the message creates a reverse route to the source. The destination sends back RREP message which includes number of hops traversed and the most recent sequence number for the destination of which the source node is aware. Note that if an intermediate node has a fresh route to the destination it doesn't forward the RREQ and it generates a RREP toward the source.

Each node receiving the RREP message creates a forward route to the destination. Thus, each node remembers only the next hop required to reach any destinations, not the whole route. Each node receives a duplicate of the same RREQ, it drops the packet. Moreover, AODV uses sequence numbers to ensure the freshness of routes. In fact, the routes to any destination are updated only if the new path toward that destination has greater sequence number than the old one or it has the same sequence number but with less number of hosts. So, AODV protocol builds routes between nodes regarding the shortest path parameter.

AODV Limitations: Routes, in AODV protocol, are established based on minimum hop count. This consideration might have a bad effect when the number of communications increases. So it is more likely to include other parameters that have a significant effect on, network connectivity and lifetime. Furthermore, power is a very important constraint in wireless network. If a node that participates in a route establishment has very low energy, this later will break very soon. Moreover, this can have also a awful effect on the network lifetime: there are some nodes that will dead very faster than another one. To deal with these problems, the power should be taken into account in the route establishment algorithm. To this end, we propose a mechanism that considers the residual energy of mobile nodes when making routing decisions.

IV. REVERSE REACTIVE ROUTING PROTOCOL (RAODV)

By analyzing the existing protocols, we can say that most of on-demand routing protocols, except multipath routing, uses single route reply along the first reverse path to create routing path. As we mentioned before, in high mobility, pre-decided reverse path can be disconnected and route reply message from destination to source can be missed. In this case, source node needs to retransmit route request message. Specifically, the proposed R-AODV protocol discovers routes on-demand using a reverse route discovery procedure. During route discovery procedure source node and destination node plays same role from the point of sending control messages. Thus, after receiving RREQ message, destination node floods *reverse request* (R-RREQ), to find source node. When source node receives an R-RREQ message, data packet transmission is started immediately.

However, the RAODV protocol reduces the latency time of the routing discovery and determines efficient routes between nodes. After flooding the RREQ messages in a network, a route is established between source and destination. The RAODV routing protocol determines a least hop-count path between a source and a destination, thus minimizing the end-to-end delay of data transfer. Since the protocol uses the shortest route for end-to-end data delivery, it minimizes the total energy consumption.

However, if two nodes perform data transfer for long time on the specific path, nodes belonging in this path use more battery power than other nodes, resulting in earlier powering out of nodes [10-12]. The increase of power-exhausted nodes creates partitions in the wireless sensor network. The nodes belonging to these partitions cannot transfer any further data, thus killing the lifetime of the network.

In order to extend the lifetime of the network, one possible solution is to make equally balanced power consumption of sensor nodes. Since RAODV routing mechanism does not utilize the residual energy of nodes at the routing setup, and since it considers only routing hop count as a distance metric, such unbalanced node energy consumptions occurs. Hence, energy efficient routing algorithm is developed [11] by considering both node hop-count and node energy consumption.

V. PROPOSED APPROACH

We have proposed an Energy Efficient Reverse Reactive Routing (ERAODV) which aims to maximize the lifetime of the network and improve the performance obtained by the basic AODV routing protocol. Thus, the goal is to reduce the cost of control packets used to maintain the network by incorporating the mechanism called "Reverse AODV", and routing around nodes that we imagine have more residual energy than other by integrating mechanism "Energy AODV" into our protocol.

A. *ENERGY AWARE AD HOC ON DEMAND DISTANCE VECTOR ROUTING PROTOCOL*

Energy Aware reverse Ad hoc on demand distance vector routing protocol In ERAODV protocol, residual energy of wireless nodes is considered along with the hop count to avoid unbalanced energy consumption of wireless nodes. Since, the protocol can make the node energy consumption balanced and extend overall network lifetime without performance degradation compared to the AODV routing algorithm. The optimum route is determined by using the value of parameter α .

$$a = \frac{\text{Min}(R_E)}{n(N_0 - H_0)}$$

Where

$\text{Min}(R_E)$ is the minimum residual energy on the route .

$N_0 - H_0$ is the hop count of the route between source and destination.

n is the weight coefficient for the hop count.

Where $\text{Min}(R_E)$the minimum residual energy on the route is $N_0 - H_0$ is the hop count of the route between source and destination n is the weight coefficients for the hop count. The destination node calculates the values of α for received routes and chooses a route that has the largest value ofα . That is, the ERAODV protocol collects routes that have the minimum residual energy of nodes relatively large and have the least hop-count, and then determines a proper route among them, which consumes the minimum network energy compared to any other routes.

B. EA-RAODV (Energy Aware RAODV)

In EA-RAODV, routing is based on the metric of minimum remaining energy. The node with minimum remaining energy in the route is marked and the route having maximum of minimum remaining energy is selected. For this purpose Minimum Remaining Energy (Min-RE) field is added in RREQ and RREP. Min-RE this field gives the node with minimum remaining energy in the route. Other parameters are as same as RAODV route request.

C. OPERATION of EA-RAODV:

The source node starts communicating as soon as it receives the first valid route reply. However, once the source S receives the next route reply, it runs an algorithm, which is described as follows:

1. Send a ROUTE REQUEST to neighbors.
2. Get various routes available to destination.
3. Compare parameters of routes with respect to remaining energy level and least count.
4. Then the appropriate route for destination is selected.

VI. ANALYSIS OF ROUTING PROTOCOL

To understand the operations of the EA-RAODV Routing protocol, the following operations are considered in the protocol

Case 1: A route with the minimum hop count between source and destination is chosen in AODV protocol

Case 2: A route with the large minimum residual energy and less hop count is selected. This methodology is used in EA-AODV routing protocol to achieve longest network lifetime.

Case 3: Choose a route with the large minimum residual energy and less hop count i.e. with the longest network lifetime (EA-RAODV our proposed routing protocol)

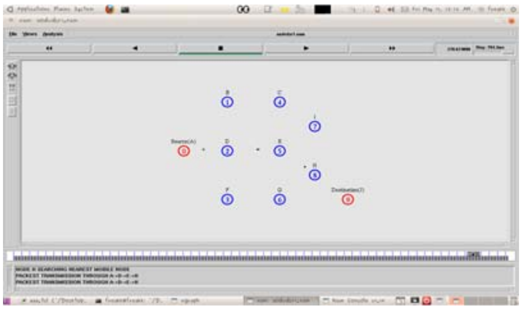

Figure 2: A sample network for re-establishment of routing paths

The operation of EA-RAODV routing protocol is illustrated in Figure 2. Here a simple reverse routing is considered to setup route from source to destination node D. The number written on a node represents the value of residual node energy. Since the case 1 considers only the minimum hop count, it selects <A-F-G-J> which has the hop count of 3.In the Case-2, select route <A-B-C-I-H-J> which has Min-RE 5 is chosen because the route has the largest minimum residual energy among routes. Proposed model needs to compute the value of Min-RE by Hop count, and selects a route with largest value. Thus Case-3 selects route <A-D-E-H-J> is selected which has largest α value of 1 (α= (4/4) =1).

Case 1 selects the shortest path without considering residual energy of nodes, which is the same as the AODV routing algorithm. This case does not sustain a long lifetime in the network as described. Case 2 selects a route with largest minimum residual energy to extend network lifetime but it has serious problem in terms of the hop count. Case-3 improves the drawbacks of Case 1 and Case 2 by considering both residual energy and hop count. It extends network lifetime by arranging almost all nodes to involve in data transfer.

VII. SIMULATION SETUP

A discrete event Network Simulator NS2 2.34 was used for the simulation purpose [6]. Parameters considered for the simulation:

Channel type:	**Wireless Channel**
Radio-propagation Model:	**TwoRayGround**
Antenna type:	**Omni Antenna**
Interface queue type:	**Drop Tail /PriQueue**
Maximum packet in Queue:	50
Network interface type:	**Phy/WirelessPhy**
MAC type:	**802_11**
Topographical Area:	**800 x 800 Sq.m**
TxPower:	**4.00W**
RxPower:	**3.00W**
Idle Power:	**1.0W**
Transition Power:	**0.01W**
Transition Time:	**0.003s**
Sleep Power:	**0.004W**
Total simulation Time:	**110 ms**
Initial energy of a Node:	**200.0 Joules**
Routing protocols:	**EA-RAODV/AODV/ DSDV**
Traffic Model:	**FTP**
Packet Size:	**1060 Bytes**
Number of mobile nodes:	**5, 15,25,35,45,55,65,75, 85, 95**
Mobility Speed:	**10 m/s**

Table 1: Simulation Parameters

VIII.COMPARISION RESULTS OF METRICS ANALYZED FOR SIMULATION

A discrete event Network Simulator NS2 2.34 was used for the simulation purpose [6]. Parameters considered for the simulation:

A. NO. OF SENT PACKETS:

The number of nodes in the network versus the total no. Of sanded packets

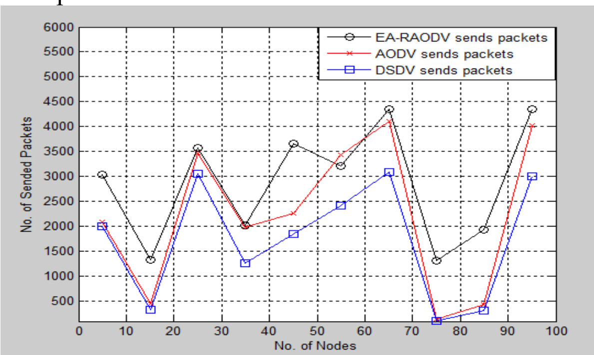

Fig.3: Number of sent packets for EA-RAODV, AODV, DSDV

See fig.3, AODV protocol can send more number of packets compared to DSDV protocol. AODV protocol will increase the network lifetime, but in-between the performance goes down because more number of packets is dropped due to link failure.

B. CONSUMED ENERGY:

The number of nodes in the network versus the total consumed energy is considered as a metric.

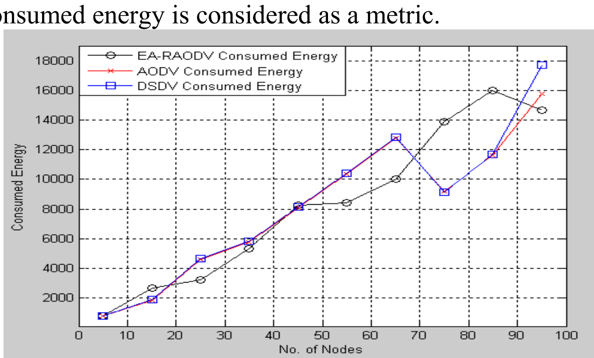

Fig.4: Number of consumed energy for EA-RAODV, AODV, DSDV

See fig.4, when comparing to DSDV protocol, ADOV consumes less energy for data transmission. DSDV needs more amount of energy for data transmission.

C. REMAINING ENERGY:

The remaining energy available in each node after the transmission.

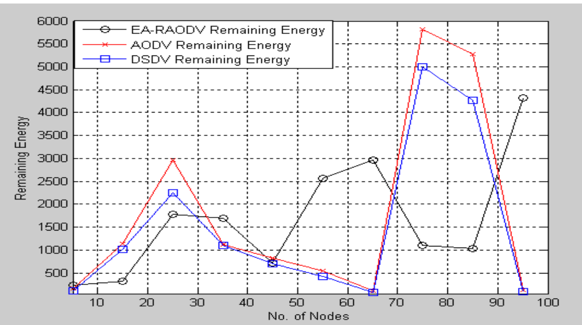

Fig.5: Number of remaining energy for EA-RAODV, AODV, DSDV

See fig.5, when compared to AODV protocol DSDV consumes more amount of energy needed for data transmission so the remaining energy will be high in DSDV.

D. PACKET DELIVERY FRACTION[PDF]:

This is the ratio of the data packets delivered to the destination to those generated by the traffic source.

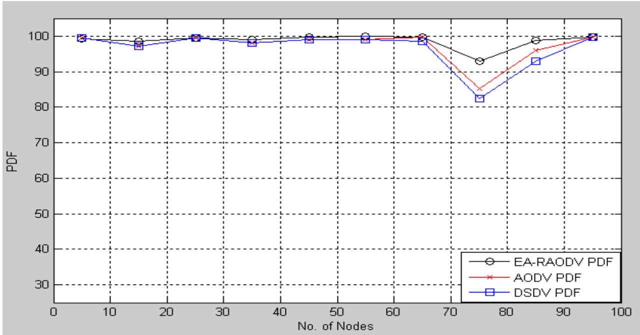

Fig.6: packet delivery fraction for EA-RAODV, AODV, DSDV

See fig.6, AODV produces more PDF when comparing to DSDV protocol because AODV can send and receive more number of packets.

E. NORMALIZED ROUTING LOAD[NRL]:

This will be the ratio between the number of routing packets and the number of received packets. The Normalized Routing load must be low.

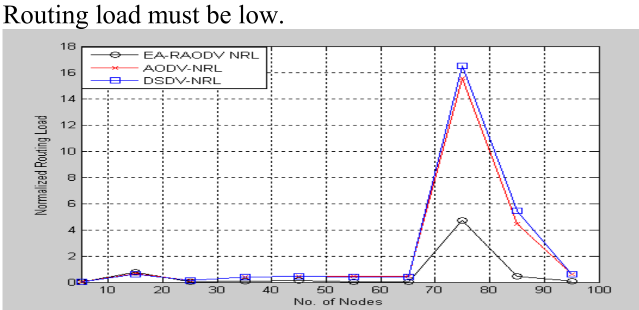

Fig.7: Normalized Load for EA-RAODV, AODV, DSDV

See fig.7, Shows that DSDV is producing more amount of traffic when comparing to AODV so the Normalized Routing Load will be high in DSDV protocol.

F. ROUTING OVERLOAD:

Routing overhead is the number of routing packets transmitted per data packet delivered to the destination.

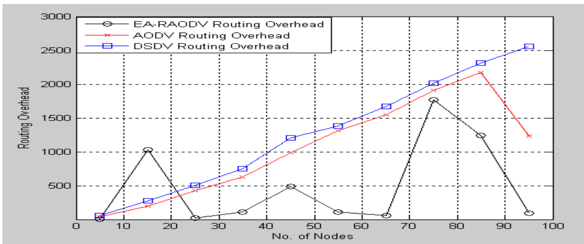

Fig.8: routing overload for EA-RAODV, AODV, DSDV

See fig.8, DSDV producing more number of routing packets when the number of nodes increases, compared to DSDV protocol, AODV is not producing that number of routing overhead.

G. THROUGHPUT:

Throughput is the average rate of successful message delivery over the communication channel.

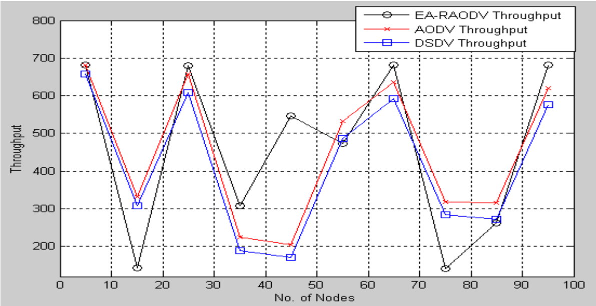

Fig.9: throughput for EA-RAODV, AODV, DSDV

See fig.9, AODV is providing high throughput when compared to DSDV protocol. The average rate of successful message delivery is high for AODV protocol.

CONCLUSION:

In this paper, we have analysis of ad-hoc routing protocols. From them RAODV is chosen for additional enhancement. The importance of energy conservation in ad hoc routing protocols is explained. The routing process has been done based on the metric of the remaining energy in energy aware RAODV. The modified RAODV performs routing based on both hop count and minimum remaining energy and the various energy-aware parameters are analyzed in NS2 2.34 for EA-RAODV, AODV and DSDV protocol by increasing the density of nodes. It is concluded that, EA-RAODV performs well in Packet Delivery Fraction (PDF) but in some situations due to link breakage the PDF is low. EA-RAODV can send more number of packets compared to AODV and DSDV by increasing the number of nodes. Based on energy consumption DSDV performs low in state compared with AODV and EA-RAODV, Since EA-RAODV requires less energy for transmission of packets. As the remaining energy of nodes are calculated in EA-RAODV. It is advantages not to use the nodes with minimum remaining energy in order to avoid decayed nodes in the network.

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