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Implementation of Energy Aware Routing Protocol for Mobile Ad Hoc Networks

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Abstract- This paper proposes an Energy Aware Routing Protocol (E-AODV) based on AODV which incorporates local routing of intermediate nodes to increase the lifetime of the network .NS2 (Version 2.34) [1] simulator is used for the simulation of new protocol and AODV protocol for the performance parameters packet delivery ratio and delay. This implementation demonstrates that how small changes in the principle of the AODV protocol can efficiently balance the energy consumption between nodes, which increases the network lifetime and performance. Results obtained using the Network Simulator proves that E-AODV is better than AODV.

Keywords: Ad hoc networks, Routing, Energy Model, AODV, Packet Delivery Ratio.

I. INTRODUCTION

A mobile Ad-Hoc network (MANET) [2] is a self-configuring, infrastructure less network composed of mobile devices connected by wireless link. It is dynamic in nature in terms of movement of mobile nodes. Each mobile node acts as a router and maintains a table to ensure route traffic orderly. It is one of the challenging tasks in MANET. These networks consist of wireless transmitters and receivers with omnidirectional and directional antennas. In infrastructure less and disaster situations there is a need of this kind of networks which are good candidates for" anywhere and at any time". Examples of MANET application consist of disaster recovery and military application. It is not limited to this application only, can be used in any scenario. For an example, an Ad-Hoc network is formed by connecting all machines in a group of people coming for a business meeting at a place when no network services are available. Any message sent by mobile node is consecutively received by all of its neighbouring nodes. If any node wants to send message to a mobile node which is not under the transmission range of the sender node then the intermediate nodes act as router and forward the message. It is not feasible to acquire fixed paths for sending the message because of node mobility. Conventional protocols of wired networks are not suited for ad hoc networks. Hence, there is a need to design new protocols to work in wireless medium [3].

Indeed, when a destination node is out of reach of the source node, the connectivity between the two stations is maintained by the intermediate stations, which means that every node belonging to the chosen route must stay in active mode until the communication is concluded. Therefore, the energy constraint is a critical issue for such a network.

These works was principally interested on the routing layer it leads to numerous routing protocols proposed for Ad-Hoc wireless networks. It is classified into proactive or reactive based on how route information is maintained.As different Ad hoc routing protocols have been developed and implemented and classified into various classes. In fact, routing in these networks is based on a simple and intuitive approach: the retransmission of the packets by each node allows the propagation through the network. The problem lies in the choice of the optimal route. The totality of routing protocols, suggested by the Mobile Ad-hoc Network group (MANET) of the Internet Engineering Task Force (IETF), use the same routing metric which is the shortest path. In other words, the paths are computed based on the minimization of the number of intermediate nodes between the source and the destination.

Thus, some nodes become responsible for outing packets from many source destination pairs. After a short period of time, the energy resources of those nodes get depleted, which leads to node failure. It is therefore significant that the routing protocols designed for ad hoc networks take into account this problem. Indeed, a better choice of routes is one where packets get routed through paths that may be longer but that contain only nodes that have enough energy. For the last decade, many researches had been performed in mobile ad hoc networks (MANETs), especially in routing protocol of Ad hoc on demand Distance Vector (AODV) for the optimization or better performance [4].

This paper aims at specifying an energy aware routing protocol based on this concept, and derives from the most known routing protocol: AODV (Ad-hoc On demand Distance Vector). We show that this extension of AODV, called E-AODV (Energy Aware AODV), increases the network lifetime by simply using energy of each node. The next section of this paper provides a brief description of the AODV routing protocol developed by the IETF. Section 3 draws attention to the Energy Aware Routing Protocol, E-AODV that we have implemented. Simulation results obtained using the Network Simulator NS-2, are presented in section 4. Finally, section 5 summarizes the main results and outlines our future research.

II. AODV ROUTING PROTOCOL

One of the most common and widely used reactive routing protocol for Ad hoc network is AODV [5] .It searches for route when required by source node i.e. on demand. It possesses the characteristic of maintaining the routes in the case of dynamic network where each node is moving. It incurs low processing and memory overhead which in turn minimizes the overall network utilization makes it appropriate for the MANET.

Furthermore, this protocol makes use of sequence number for loop freedom mechanism in each route. The steps to send a packet from sender to destination through AODV [6] are as follows: Firstly, the source node starts route discovery through broadcasting Route Request (RREQ) packet then adjacent nodes will forward RREQ until the packet is reached at the destination or RREQ arrives at the node that has a new fresh route to the destination. This RREQ message contains source and destination node's IP address, sequence number of destination, its current sequence number, hop count and RREQ ID. RREQ ID is monotonically increasing number. It gets incremented after each node initiates new RREQ [7]. Secondly, a Route Reply (RREP) is sent by receiver to the source (originated route). Once the sender-node receives a RREP, it can initialize using this path for data packet transmission. In the case of link failure, Route Error (RERR) is sent back to the source node. It is generated by the node at which link failure is occurred. If source node still wants to communicate with destination, it reinitiates RREQ broadcasting or path finding process or repair broken link.

A. The Energy Model used In NS-2

The NS-2 extension includes an energy model that informs any node about its instantaneous energy level. To use his model, we must define three parameters: the initial energy (*InitialEnergy)*, the transmission power (*txPower)* and reception power (*rxPower)*. These two last values, Multiplied by the duration of transmission or reception of a packet, give respectively the quantity of energy necessary for the transmission or the reception of a packet. For the simulation the default values for these parameters are:

RxPower = 281.8mW (Watt)
TxPower = 281.8mW (Watt)
Initial Energy =100 (Joule)

In our Simulation study, we have assigned to each node an initial energy of 15 joules which will be decreased as the node transmits or receives packets. If the energy level of a node reaches zero, it is seen as a „dead" node, i.e. it is no longer able to take part in communications. It is known that the energy consumption of a node is mainly due to the transmission and the reception of data or controlling packets (such as RREQ, RREP, RERR, HELLO). To measure this amount of energy consumed during the transmission process (noted *txEnergy*), we should multiply the transmission power (*txPower*) by the time needed to transmit a packet:

$$txEnergy = txPower \times (packetsize/bandwidth)$$

And for a received packet:

$$rxEnergy = rxPower \times (packetsize/bandwidth)$$

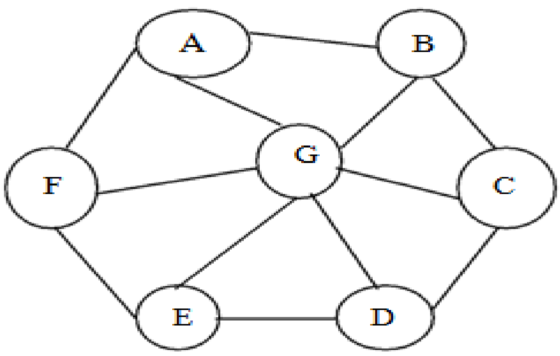

Fig 1: An example ad hoc topology. Node G will participate in all communications between A-D, B-E and C-F.

B. E-AODV: ENERGY AWARE AODV

The ad hoc networks suffer from energy constraint since a mobile station uses a limited capacity battery. Therefore, the performances of such a network become closely related to its effectiveness in terms of energy conservation. The key to achieve these objectives resides in the development of optimized routing protocols as those proposed in [8], [9], [11]. Indeed, the traditional routing is based on the intuitive goal: choosing the shortest ways. This is not always the best choice, since in general, the same nodes will be chosen for several communications as it is the case of node G in figure 1. Consequently, this node will spend its energy resources more quickly than the others and will be the first to die. The problem resides in the fact that the terminal will not be used for its user's applications, but only as a router for the other users. To take this energy constraint into account, a simple approach based on local decisions can be adopted. While searching a route, each node uses local information about its own battery to decide whether to take part or not in the route selection process. Thus, a node whose battery is exhausted can preserve its remaining energy by refusing to relay packets which are not intended to it. This is called a local approach, since the decision of a node is only based on its own state and does not require global information about the entire network, neither about its neighbors. We have chosen to adapt this approach to one of the most known routing protocol, AODV, which was presented in section 2. The principle is to modify both of the route discovery and the route maintenance procedures, in the following way:

1) Route Discovery

When a source node wants to reach a destination node, it starts the route discovery process and broadcasts the route request packets (RREQ), as in AODV. But when an intermediate node receives this request, there is an additional step that it has to do before sending the packet: it must compare its remaining energy with a certain threshold. If it finds that its energy level exceeds the threshold value, it rebroadcasts the request to all its neighbors. In the other case, the node concludes that its remaining energy is not enough anymore to route the others‟ packets. Therefore, the node rejects the RREQ packets and ignores the request. As soon as the destination receives the first RREQ packet, it transmits a RREP towards the source. The treatment of these RREP packets by the source is identical to that of AODV. The example of figure 2 shows the difference between the route established by AODV and the modified AODV. In this network, we can note that with the modified AODV, the route chosen between the end nodes S and D is longer than that built with the original AODV. In fact, with AODV, node 2 must participate in the communication despite its weak battery. The new modifications allow this node to remain alive for a longer time.

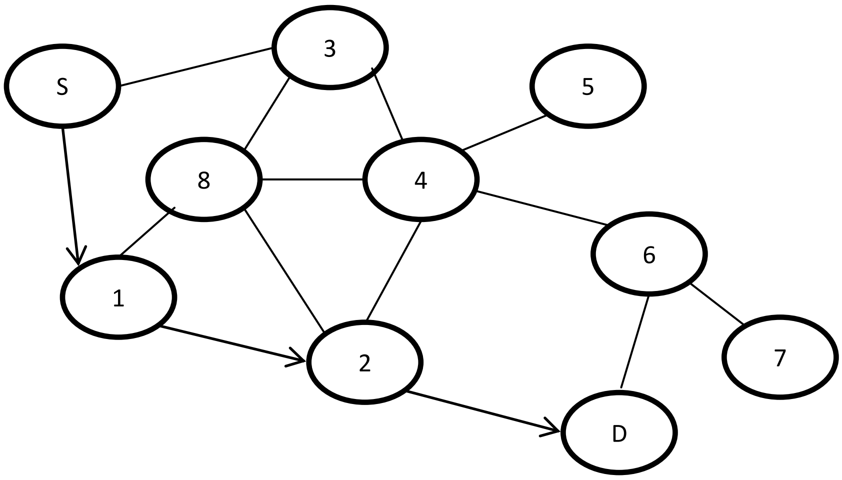

Fig 2: Route Established in AODV

2) Route Maintenance

The maintenance of the route becomes necessary when the energy resources of certain nodes on the road become lower than the fixed threshold. During a communication, each intermediate node supervises the decrease of its energy level. Once the remaining energy reaches the threshold, the node must send a RRER packet to the source in order to launch a new route discovery process. In the same way, the maintenance of the road is made when the connections between two or several nodes on the route are lost because of their movements. In this case, the protocol proceeds just as in AODV: a new RRER packet is returned, and the route is removed from the routing tables.

3) Proposed Algorithm

If A (source) wants to send data to B (destination) then
{
AODV ( ) // finds a route between A and B.
{
For (each node between A and B)
{
Calculate energy of each node with the help of Energy Model & Manage a routing table with one additional parameter node energy.
When any node receives a packet
{
If (Node Energy >Eth)
{
Receive RREQ packet and forward it to next Hop.
Route maintenance is done in which the next hop is selected based on remaining energy of a node.
}
Else
{
Drop RREQ Packet
It sends a RERR to the last node and source need to call AODV () again
}

```
}
}
}
}
```

These modifications lead to a new optimized routing protocol that was called E-AODV (Energy Aware Routing based on AODV).

It allows a node whose battery is used too much to refuse to route the traffic of the other nodes. The route built between any pair of nodes consists only of nodes whose energy level is higher than the threshold. In what follows, we will analyze the results of the implementation of this optimized protocol under NS-2 environment.

III. SIMULATION ENVIRONMENT

The simulation of E-AODV and AODV is done using NS-2 simulator version 2.34.We have considered the following two parameters:

- Packet Delivery Ratio (PDR): is the ratio of the number of packets successfully received by all destinations to the total number of packets injected into the network by all sources. The PDR is therefore a number between 0 and 1.
- End-2-End Delay: End-to-end delay refers to the time taken for a packet to be transmitted across a network from source to destination.

A. Simulation Set Up

The wireless network consists of 10, 15 ,20 numbers of nodes which are distributed randomly in a grid area of 2000m X 2000m with 10 numbers of connections as shown in Table 4.1.

Table 4.1 - Simulation Parameter

Simulator	NS-2.34
Packet Size	512 Bytes
Packet/Session	1000
MAC Protocol	IEEE 802.11
Propagation Model	Two Ray Ground
Number of Node	10. 15. 20
Environment Size	2000 x 2000
Traffic Type	CBR
Mobility	20 m/s

IV. RESULTS

The simulation results are shown in the form of graph that represents

- Packet Delivery ratio and
- Delay as the comparison parameter between the AODV and E-AODV protocol.

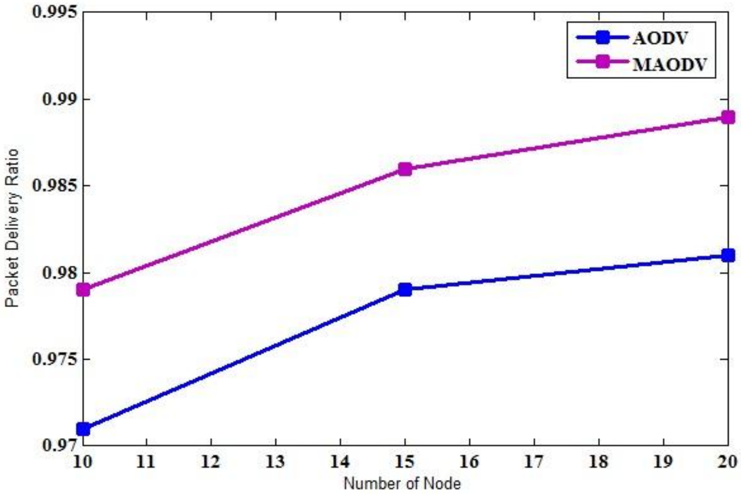

Fig 3. Packet Delivery ratio Versus Number of node

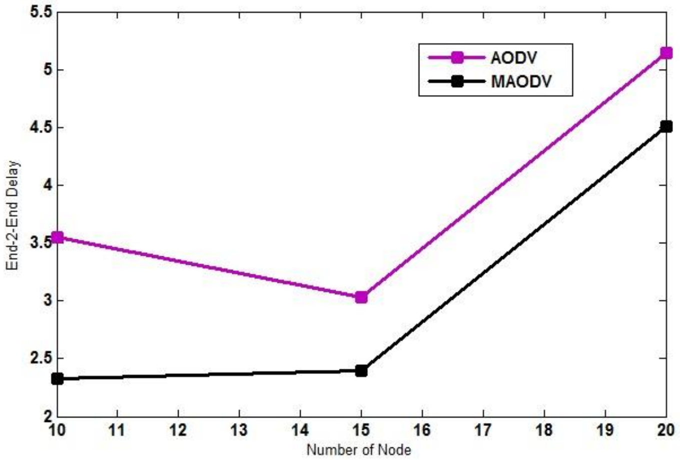

Fig 4. End-2-End Delay Versus Number of nodes

V. CONCLUSION

Here we conclude that E-AODV is better than AODV with CBR traffic model because:

- Increase in the Packet Delivery Ratio for E-AODV in comparison with AODV.
- Reduction in Delay for E-AODV as compared to AODV.

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