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A Review on Energy Efficient AODV Routing Protocols

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Abstract - Mobile Ad Hoc Network is a comprehensive concept in itself. Collection of multi-hop wireless nodes those are arbitrary and dynamically located in a fashion to establish communication with no centralized infrastructure. Ad hoc is characterized as random, on-demand and multi-hop topologies that alter swiftly by the period of time. The power source of a mobile node is the battery. The battery has limited capacity and is an insufficient source of energy. The battery is also hard to change and recharge. Therefore, in MANETs, it is important to purpose some protocols so that the network is energy efficient, no packet delays and consumes less energy compared to traditional AODV. In this paper, a review of different algorithms and protocols based on in what ways energy efficient routing is done in AODV.

Keywords - ***MANET, Routing Protocols, AODV, Energy Efficiency, Network life maximization.***

I. Introduction

MANETs are ad hoc, that means on- demand. MANET is an infrastructure less network that works on multi-hop wireless mobile nodes. Mobile nodes are interconnected to each other to maintain a communication without any centralization. Because of their infrastructure less property, it is easy to deploy a MANET in any area, very quickly and it is also easy to remove or add any node at any point of time without hampering the connection in any way. MANET became very popular because of their simple setup. Be it a disaster-prone area, remote area or scantily populated area, MANET provides stable communications. Infrastructures need organization and management but MANET saves both time and cost of a user. Following are some characteristics of MANET:

- Easy to deploy
- Infrastructure less

- Flexible
- Dynamic network topology
- Lack of centralized control
- Mobility
- Route updates are frequent

Because of all these characteristics, MANET has various applications in different fields. Following are some listed applications of MANET:

- Military tactical operations
- Disaster relief operations
- Commercial use
- Search and rescue operations

Besides these characteristics and applications, MANET has some challenges that it faces. Energy efficiency, battery constraints, security, quality of service, limited power supply, unicast and multicast routing, network overhead are some challenges faced by MANET. In this review paper, some purposed methods to overcome one of the major challenges of MANET i.e. Energy Efficiency are discussed. It is necessary to have an energy efficient network for more network life and no delays in data packets.

II. ROUTING PROTOCOLS

The existing routing protocols of MANET are Proactive, Reactive and Hybrid.

A. Proactive

It is also known as the table-driven routing protocol. In this protocol, topology information keeps on constantly updating for all the nodes of the network. If there is a change in the network, routing table of the node is updated and also the information is passed on to the neighboring nodes. Now as the paths are known between a pair of nodes, there are no initial delays. Types of Proactive routing protocols are DSDV (Destination- Sequenced Distance Vector), OLSR (Optimized Linked State Routing) etc. [1].

B. Reactive

It is also known as the on-demand routing protocol. In this protocol, if a node wishes to initiate a communication with another node that has no direct path, the protocol issues a route discovery throughout the network. This goes on until feasible path is not found. There is an initial delay in the protocol in finding a feasible path. Types of Reactive routing protocols are AODV (Ad hoc On-demand Distance Vector), DSR (Dynamic Source Routing) etc. [1].

C. Hybrid

The combination of positive aspects of both proactive and reactive approaches is a hybrid routing protocol. The most used protocol is ZRP (Zone Routing Protocol). It divides the entire network into zones. The communication within the zones is carried out by Proactive and communication between the zones is carried out by Reactive.

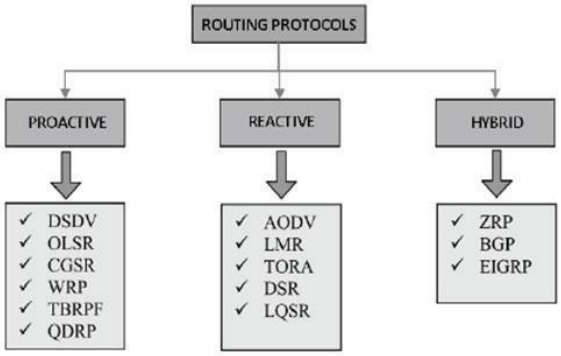

Figure 1: Classification of MANET routing protocols

III. Ad Hoc On-Demand Distance Vector

Ad hoc On-demand Distance Vector routing protocol falls under the reactive protocol. It is an extension of DSR protocol. In DSR, as a node finds out the path to a destination node, the data packet is sent to the destination. The data packet consists of data and also the path to a destination. As for now, if the path to a destination is small it is easy to send the data packet but, if network size is large, the bandwidth will be wasted.

AODV broadcasts a route discovery mechanism which includes two data packets known as, RREQ (Route Request) and RREP (Route Reply). AODV maintains the route in a table. Time is also associated with the table. Destination sequence number is used for the prevention of routing loops and avoidance of old and broken routes.

A. Route discovery

Two counters are maintained by every node, sequence number and broadcast id, which increments whenever the source issues a new RREQ. The source broadcasts RREQ data packet for the searching of a route. The data packet includes:

<source_addr, source_seq#, broadcast_id, dest_addr, dest_seq#, hop_count>

Once RREQ is received by the destination node, it unicasts RREP to the source node by using a reverse route. This data packet includes:

<source_addr, dest_addr, dest_seq#, hop_count, lifetime> Intermediate node discards duplicate packet and sends RREP if it has an active route with a higher sequence number.

B. Route Maintenance

If destination or intermediate node moves outside of an active communication path, the node up-streams a RERR message listing the unreachable destinations. And if there is any requirement of new route discovery process, as soon as the source node receives a RERR message, the source node initiates the route discovery process again.

IV. Background and Review

It has been seen that for an efficient network, transmission of data mustn't simply use the shortest path, however additionally the one that consumes the least power. Energy is consumed by a node for sending data, receiving data and even once it's inactive. This wastage of energy has to be optimized for effective routing. This will be done as follows [2]:

- Optimizing the transmission power: This reduces the transmission energy, by not exhausting low energy nodes.
- Load distribution: This methodology regulates the trail by exhausting energy-rich nodes, as a result reducing the energy consumption of nodes as low-energy nodes consume a lot of power.
- Sleep or Power-down mode: This makes energy consumption minimum throughout inactive periods. Now further, we will study various ways in with a MANET can be made energy efficient which are purposed in a literature.

The authors in [2] presented Bee Ad Hoc (Energy Efficient Bee Inspired Routing Algorithm). As we notice, many of the best solutions we obtained are inspired by nature. Bee ad hoc is exhibited on the disciplined work principles of bees. In bee ad hoc, reactive routing is done. When the control packets are flooded in the network, which is multi-hop, it is observed that sending control packets through multi-paths, less energy is consumed. In bee ad hoc, four agents come into play as follows:

(1) Packers: residing within the nodes and are responsible for storing and receiving of data from the transport layer.

(2) Scouts: principle job is to discover newest paths from source to destination.

(3) Forages: are deployed as the scouts return to their respective node and data packets are delivered. Simultaneously, the path is assessed.

(4) Swans: launched when a node exceeds its threshold value.

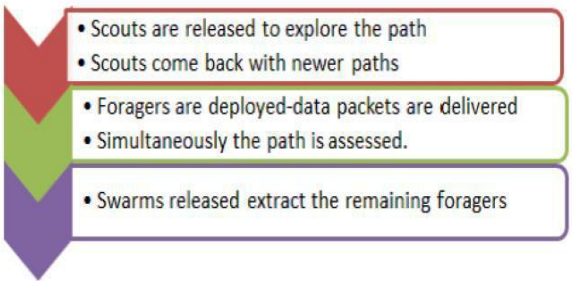

Figure 2: Workflow in Bee Ad Hoc Routing protocol

The authors in [3] presented MEP-AODV. Multipath Energy- Efficient Probability Routing Protocol, an extension of AODV. In MEP-AODV, for balancing the energy consumption, the battery power remaining in nodes except for the source and the destination nodes are taken into count. Whenever an intermediate node receives an RREQ, it cross-checks its remaining battery power and decides whether to relay or to drop the RREQ by using a probability function which is given as:

$$b_i = \frac{c_i}{e_i} \tag{1}$$

$$p_i = \begin{cases} 1 & b_i \geq r_1 \\ 1 - \dfrac{r_1 - b_i}{r_1 - r_2} & r_2 \leq b_i < r_1 \\ 0 & b_i < r_2 \end{cases} \tag{2}$$

Where c_i is present as residual battery energy of node *i* and e_i is the complete battery energy of node *i*. b_i is the residual energy ration of c_i. r_1 and r_2 are predefined thresholds and the values are $1 > r_1 > r_2 > 0$. The probability of RREQ rebroadcasting is represented by p_i. When b_i is more than r_1, it means that node *i* has necessary residual battery energy and beyond doubt relays the RREQ. When b_i is between r_1 and r_2, the probability relaying the RREQ only depends on b_i. When the node has very low battery energy and needs to be protected, this is when b_i is less than r_2. Thus, this RREQ will be discarded.

The authors in [4] proposed an algorithm for finding an optimum path in AODV. The energy- efficient routing protocol in MANET selects an optimum path by using residue energy in the node as routing metric instead of multi-hop metric. The energy model here calculates the residue energy of node by subtracting the energy consumed by a node for various routing decisions and for all packets sent, received and dropped while transporting from the source to

its destination. It isn't necessary that the path which is selected would be the path consuming minimum energy but would have maximum residue energy of the node. The energy consumed at the node is calculated as follows:

$$Ec_i = E_s(n_i)\, E_r(n_i) + E_f(n_i) + E_d(n_i) \quad (3)$$

Where, Ec_i represents the energy consumed at node *i* and E_s, E_r, E_f, E_d represent the energy consumed while sending, receiving, forwarding and dropping at node *i*, respectively. Now to obtain the residual energy following equation is used:

$$Eresidual = Einitial - Eci \quad (4)$$

The protocol used here favors the path which has maximum lifetime and thus increases the total lifetime of the network. For energy efficient routing protocol, the function is as follows:

$$\text{Max } E_k(t) = \text{Min } E_i(t)\ i \in k \quad (5)$$

Where E_k (t) is the residual energy of path and E_i (t) is the residual energy of node i which is in path k. To avoid paths that are congested by power/ traffic and the paths which are lightly loaded, this approach follows load balancing approach. This helps energy efficient routing protocol accomplish less variance in the energy levels of different nodes which are in the network and thus maximizes the lifetime of the network.

The authors of [5] evaluated the performance of proposed energy efficient cross-layer design to AODV, which is named as Cross-Layer Energy Efficient AODV (CLEE-AODV). CLEE-AODV exhibits lower energy consumption per node than AODV. The throughput of CLEE-AODV is higher since it preemptively selects the alternative communication path with better energy reserve to transmit the data packets.

The authors of [6] proposed MEL-AODV (Maximum Energy Level- AODV). An energy efficient routing protocol algorithm to increase the network lifetime and to achieve efficient utilization of node power based on remaining energy in each node. The purposed algorithm selects the path which has maximum energy and low cost. For keeping the energy consumption of the nodes to be effectively balanced and the average survival time of the nodes in a network, the routing protocol chooses the link with higher energy for data transmission.

In [7, 8] author analyzed flood attack in MANET which degrades the overall performance of the network. It also keep, node busy in transferring flood request packets, which results, in energy drain

The authors of [9] proposed the routing protocol for Energy Efficient AODV (EE-AODV). To save the energy in mobile devices, EE-AODV has enhanced the data packet's handling process. EE-AODV sets an energy level as minimum energy. An intermediate node should have the minimum energy. If the energy of an intermediate node is less than the minimum energy, then a node is discarded as the intermediate node, until and unless if there is no alternative path. Nodes involved in the data packet transmission, losses their energy every

time a data packet is received or delivered. Total energy consumed during transmission of a packet is given as:

$$ET=TP \times TT \quad (6)$$

Where TP is defined as the transmit power of a packet and Is defined as the transmit time of a packet. Now, the remaining energy of a node will be:

$$Enew=Ecurr - ET \quad (7)$$

Where E_{new} is the remaining energy and E_{curr} is the current energy of a node.

So the total energy consumed during receiving a packet will be given as:

$$ER= RP \times RT \quad (8)$$

Where ER is the energy, RP is the receiving power of a packet and RT is the receiving time of a packet. Hence the remaining energy will be:

$$Enew= Ecurr - ER \quad (9)$$

With the help of these equations, energy of a node at any point of time can be calculated [10].

The author of [11] proposed ERA-AODV. Energy in the network is normally spent mostly during the broadcasting and data forwarding. When the destination is not found in the routing table, the source node forwards the RREQ packet to the neighbors to find a path to the destination node. The proposed work aims at minimizing the energy consumption. According to this concept, the nodes in a mobile ad hoc network and source node has the information of coordinates of the destination node and are equipped with GPS. While forwarding the RREQ packet, the node will forward the information about location coordinates of the destination node to the neighbor nodes. Upon receiving the destination coordinates, nodes can make a choice as to if they are located in quadrant towards destination or not. A node will never forward the RREQ packet if that particular node is located outside the quadrant. Another thing the proposed scheme takes into account is the transmission range of the node. It is known that a node would consume more energy if any node forwards the data over a longer distance. Therefore, in the proposed scheme, a node would transmit the packet over a lesser distance if that node has less energy remaining. The transmission range would be adjusted according to remaining energy of the nodes. When the destination node receives the RREQ packet, the destination node will sort out the paths according to the highest remaining energy, least hop count, least delay, bandwidth and least speed of the intermediate nodes. The destination will reply to source node via the best-optimized path. And through the same path, the source node will send the data to the destination.

Table 1: Comparison of different protocols

S. NO.	PROTOCOL	DESCRIPTION
1.	Bee Ad Hoc	Sends control packets through multi-paths which consume less energy.
2.	MEP- AODV	For balancing the energy consumption, the battery power remaining in nodes except for the source and the destination nodes are taken into count.
3.	Energy Efficient AODV	Selects an optimum path by using residue energy in the node as routing metric instead of multi-hop metric
4.	CLEE- AODV	Preemptively selects the alternative communication path with better energy reserve to transmit the data packets.
5.	MEL- AODV	chooses the link with higher energy for datatransmission by selecting the path which has maximum energy and low Cost.
6.	EE- AODV	sets an energy level as minimum Energy. An intermediate node should have The minimum energy.
7.	ERA- AODV	According to this concept, the nodes in a mobile ad hoc network and source node has

		the information of coordinates of the destination node and are equipped with GPS

V. Conclusion

In designing a wireless ad hoc network, the greater challenge is the limited accessibility of energy. To overcome such challenge, there exists a number of routing protocols and algorithms. In this paper, we reviewed different research papers on energy efficient routing for AODV to determine the route with maximum network lifetime, reduced delay and maximum energy. Choosing a better protocol is very necessary. Also, whether it performs best for a particular type of network is also checked and verified. Thus, this paper gives an overview of a number of purposed algorithms and protocols that can be used for AODV to make it more energy efficient.

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