Energy Efficiency in AODV : A Literature Review

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Abstract

To establish path between nodes in a mobile adhoc network, an efficient routing protocol is required to discover routes. Due to dynamic topology of Ad Hoc Network, power is one of the important design criteria for adhoc networks. Mobile nodes have limited battery power. Power failure of a mobile node not only affects the node itself but also decreases network performance due to link failure. Much research efforts have been devoted to develop energy aware routing protocols. In this paper we propose an energy efficient routing algorithm that takes care about stability of network. A new route discovery process proposed in this paper that takes into account the distance between nodes and node battery power to improve energy efficiency in AODV. This will maximize the network lifetime by minimizing the power consumption and decrease the routing overhead. We will implement our proposed algorithm in AODV and performance will evaluate against the original AODV, finally we will study it through NS-2 simulator.

Keywords: Ad-hoc Network, AODV, Energy Efficiency, Link Failure, NS-2 Simulator, Routing, Stable Path.

1. Introduction

The networks are classified mainly in two types based on connectivity, wired and wireless networks. A wireless network provides have capability of bending easily without breaking over standard wired networks. With the help of wireless networks, the users can retrieve information and get services even when they move from one place to another.

There are two types of wireless networks:

(a). Infrastructure based Network: In Infrastructure based (or infrastructure less) wireless networks[7], the mobile node can move in range of a base station. If node goes out of the range of a base station it gets into the range of another base station while communicating, the base stations are fixed as shown in the figure 1,

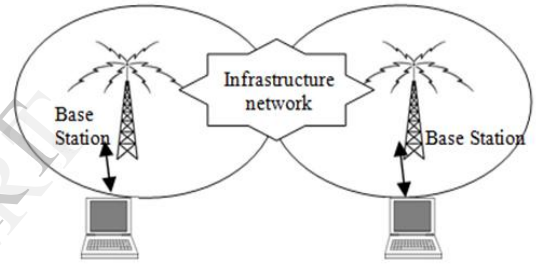

Figure 1: Infrastructure Based Network

(b). Infrastructure Less Network: In Infrastructure Less (Ad Hoc wireless network), there are no fixed base stations and all the nodes in the network act as hosts and routers [7]. The mobile node can roam while communicating in the Ad Hoc network dynamically establishes routing among them to form their own network 'on the fly'. Ad hoc network can be shown as in figure2.

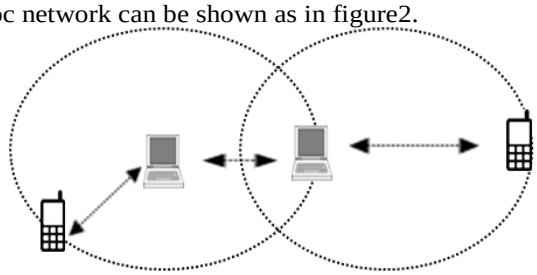

Figure 2: Ad hoc Network

Mobile Ad Hoc Networks are self-configuring self-organizing, multi hop and infrastructure less networks [2]. Mobile nodes are connected by wireless links. These networks are suitable for virtual classrooms, rescue operations, battle field etc. in remote areas. Each node serves as an intermediate node to transmit data packets between a pair of nodes. The topology of ad hoc network

depends on the node mobility so this can change rapidly. Routing is the main challenge in ad hoc networks. MANETs uses dynamic topology i.e. suddenly and rapidly change due to nodes move out. Link failure of these nodes may result in loss the connection among communicating nodes that causes unnecessary power depletion.

The MANETs performance is highly dependent on routing protocols. Routing protocol is responsible for path establishment from source to destination for packet transmission within the range. These packets are transmitted through number of intermediate nodes if there is not any direct link from source to destination. For successful delivery of packets to its destination depends on the battery power of each node. Energy efficient based routing protocol is required for stable network. A stable network consists stable nodes in the network which being used by transmitting nodes. The natures of ad hoc networks are mobility, infrastructure less, energy constraint so link failure occurs frequently [1].

Many researchers worked on the different areas in MANET, some of them are [3]:

- Limited Wireless Communication Range
- Energy Conserving
- Dynamic Topology
- Battery Power Constraints
- Limited Power Supply
- Security

When a node wants to establish a connection to its destination for send data packets, is starts route discovery process for finding the path from source to destination. Due to limited battery power and mobility nature of nodes, a node may exhaust its power without giving any prior information to neighbor nodes. This degrades the performance of routing protocol as well as network. In MANETs, two main reasons that cause link breakages are: (a) Nodes Mobility, (b) Node Energy.

This paper is organized as follows: Introduction is presented in current section. Section 2 presents overview of routing protocols then general discussions on energy efficiency. Section 3 provides the related work, researches in energy efficient routing and need for energy efficiency. Section 4 presents the proposed work and Section 5 presents conclusion and future enhancement.

2. Overview of Routing Protocols

Routing protocols in the MANET are responsible for finding a valid path between nodes and also establish and maintain them [4]. MANET routings are classified in three categories as shown in figure 3, [3][5]:

- Proactive (Table Driven),
- Reactive (On Demand) and
- Hybrid

Proactive or Table Driven Routing Protocols:

Proactive protocols maintain accurate, current routing information from each node to every other node in the network. Each node maintains one or more tables to store routing information. If network topology change these routing protocols respond by propagating updates information whole network. This type of routing is called source routing [6]. The areas in which they differ are the number of necessary routing tables and changes in network structure are broadcast. These types of routing protocol examples are: GSR, WRP, ZRP, STAR etc.

Reactive or On Demand Routing Protocols:

Another approach from table-driven routing is source-initiated on-demand routing. On demand routing creates routes only when required by the sending node. When a source node requires a route to its destination, then source node starts route discovery process within the network. Once a route is found or all possible route have been examined then this process is completed. After this, the route established, it is maintained by a route maintenance procedure until either the destination becomes inaccessible along every path from the source or until the route is no longer valid [6]. On demand routing protocols are: AODV, DSR, etc. The study has been concentrated on AODV reactive routing protocols because of proposed scheme is suitable for this work.

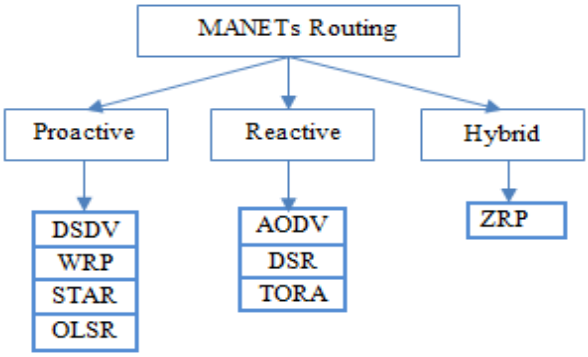

Figure 3: MANET Routing Protocols

Ad hoc On Demand Vector routing protocol is a reactive routing protocol designed by Charles E. Perkins and Elizabeth M. Royer. It maintains the established path as long as they are needed by the sources to its destination. It uses sequence numbers to ensure the freshness of routes. Route discovery and route maintenance are main features of AODV described below:

(1) Route Discovery Process:

The route discovery process is initiated whenever a source node needs a route to a destination. Route discovery process floods route request (RREQ) packets targeting the destination and waiting for a route reply (RREP) packet as shown in figure 4 [8]. When an intermediate node receives a RREQ packet it first sets up a reverse path to the source node using the previous hop of the RREQ as the next hop on the reverse path as shown in figure 5.

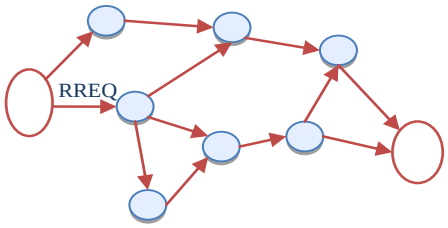

Figure 4: AODV Route Request

If a valid route is available to the destination, then intermediate node generates a RREP, else the RREQ is re-broadcast. Duplicate copies are discarded of the RREQ packet received at any node. When the destination node receives a RREQ packet, it also generates a RREP. The RREP is unicast routed back to the source via the reverse path. As the RREP proceeds towards the source, a forward path setup to the destination is established.

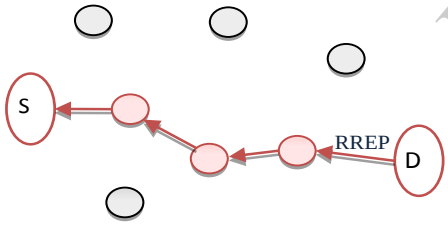

Figure 5: AODV Route Reply

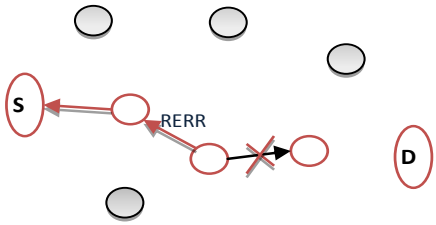

Figure 6: AODV Route Error

(2) Route Maintenance Process:

When a link failure occurs, route maintenance is done using route error (RERR) packets. When a link failure is detected, a Route Error Packet is sent back via separately maintained predecessor links to all sources using that failed link as shown in figure 6. Routes are formatted by the RERR along its way. When a source node receives a RERR, it starts a fresh route discovery if the route is still needed. Unused routes in the routing table are expired using a Time-To-Live technique [8].

Characteristics of AODV [7]:

- Able to Unicast, Broadcast, and Multicast communication.
- On-demand (Source-Initiated) route establishment with small delay.
- Link breakages can efficiently repair.
- Loop-free routes through use of sequence numbers.
- Track accuracy of information.
- Only keeps track of next hop
- Periodic HELLO messages used to track neighbors.

Since, nodes in an ad hoc network are limited battery capacity; power management is an important issue. Battery power is a precious one resource that should be used efficiently in order to avoid the early termination of nodes. Power management deals with the process of managing resources by means of controlling the battery discharge, adjusting the transmission power, and scheduling of power sources so as to increase the life time of nodes in the ad hoc networks. The main reasons for power management in ad hoc networks are the following [10]:

Limited Energy Reserve: Ad hoc networks have very limited power resources where fixed infrastructure is impossible. Energy management is necessary for reducing the gap between power consumption requirements and power availability. Difficulties in Replacing Batteries: It is very difficult to replace or recharge batteries in that situation

Lack of Central Coordination: The lack of central coordination needs some of the intermediate node to act as relay nodes (router). If the proportion of relay traffic is heavy, it may lead to a faster depletion of battery power.

Battery Constraints: Battery increases the size of the mobile nodes. If we reduce the size of mobile battery, it will results in less energy capacity. So energy management techniques are necessary if reducing the size of battery,

Optimal Transmission Power: Selection of transmission power determines the reachability of the nodes. If transmission power increases, the battery charge also will increase. For effectively utilization of the battery power, it is necessary to select an optimum transmission power.

Channel Utilization: Power control is required to maintain the required SIR ratio at receiver node and to increase the channel reusability.

Different methods to reduce power consumption are as follows [9]:

- at the mobile device,
- by controlling transmission of packet
- using optimized power routing protocols

3. Related Work

Many researches have been addressed power conservation and efficiency issues at different layers of the network protocol stack. However, most such researched have been targeted the network layer. We will discuss some of the Power Aware Routing protocols which were implemented at the network layer.

RupaliMahajanet. al. proposed an Energy Efficient Routing Protocols for Mobile Ad-Hoc Networks [11]. In this paper, the authors proposed an energy efficient route discovery process for AODV based on ERS. In this approach energy saving of the nodes is done by avoiding the redundant rebroadcasting of the RREQ packets. The relaying status of the node is decided based on the broadcasting of its RREQ packets by its neighbors. Thus it helps in reducing routing overhead incurred during the route discovery process. Simulations are performed by using Global Mobile Simulator.

Maher Heniet. al. proposed Power Control in Reactive Routing Protocol for Mobile Ad Hoc Network [12]. The purposed work minimize the regular period of HELLO messages generated by the AODV protocol used for the search, development and maintenance of routes. This information is useful to have an idea about battery power levels of nodes. After storing this information, the nodes select the shortest and safest path in terms of energy.

ShayestehTabatabaei et.al.proposed Power-Efficient Reliable Routing Protocol to Increase Throughput in Ad Hoc Networks [13]. In PEAODV, authors used a new cost function to select the optimum path that considering the minimum residual energy of the nodes in route, and the route stability in accordance with the rate mobility of node and available bandwidth and radio frequency.

R.Rajeshkannaet. al. proposed an Energy Efficient Enhanced AODV Routing Protocol for maximize the lifetime of Mobile Ad hoc Networks [14]. The authors used energy optimal routes to reduce the energy consumption of nodes. Authors used HELLO massages of AODV to calculate the difference between transmitting power and receiving power and which gives the value of propagation loss. Low battery alert mechanism to overcome the overuse of the firstly established route.

Yonghui Chen et. al. proposed an Energy Efficient Routing Protocol Based on energy of node and Stability of Topology [15]. During route discovery, the source node not only takes the residual energy of the intermediate nodes and hops, but also considered the influence of motivation of those nodes imposed on the topology of network. Simulation results show that the proposed protocol achieves better network service performance compared to current protocols.

T. Poongkuzhali et.al. proposed An Optimized Power Reactive Routing based on AODV Protocol for Mobile Ad-hoc Network[16]. Authors used a technique called Optimized Power Reactive Routing (OPRR). An OPRR Protocol described the concept of cognitive function and AODV protocol. Authors ensured that the data packet is transferred in the shortest path and also in reliable mode. It will improve the data transmission with an energy efficient manner. It gives the performances of PAR protocol which has POWER field in RREQ message along with relative mobility field.

Why Need Energy Efficiency

Nodes are independent to other nodes and can move frequently in MANETs. This mobility of nodes degrades the overall performance of the network. A single link breakage in network leads a route to become as an invalid route for further transmission of data packets. Then route discovery process starts again and causes more control packet flooding throughout the network. This process of route re-discovery consumes the battery energy at mobile nodes also drops a lot of data packets. Thus, overhead increases and efficiency of also decreases in the network. Choosing a shortest path always increases link breaks probability [17].

4. Proposed Work

We proposed a new technique to overcome these previously defined problems facing in MANETs. To improve the energy efficiency in AODV we firstly find out the stable route between source to destination for sending and receiving data packets. When network is highly mobile many data packets get lost because of collision. Our main aim is to implement a stable AODV to achieve high performance in the highly mobile environment. For this, we tried to measure distance between nodes in a periodic manner so that we can find out the most stable neighbor of node. If every node can store the knowledge about stable neighbor, the stable path from source node to destination node can be easily discovered. Here we can also add an information

field that tells about current energy status of node and a destination field that tells about the distance between two nodes, so high battery power and more stable node must be selected.

When a source begins a RREQ packet it simply broadcasts the RREQ to all its neighbors. We will include distance and battery status field in AODV RREQ packet. Every node appends its own co-ordinates in the packet and forward to its neighbor and neighbor calculates the distance between them by using own coordinates. At the same time every node stores their battery status also in the packet. Finally, RREQ reaches to destination node, it also do the same. Based on the statistics such as distance between nodes and battery power, destination node decides more stable route. It just sends back the reply packet through this most stable path. In this, a short distance node and a node which have sufficient power will be selected to establish a path. This will reduce the routing overhead.

As shown in figure 7, source node is S and the destination node is D. Suppose the transmission range of each node is 200 meters. In original AODV a path with minimum hop count were selected, then the path will be S A B C D. If node A goes out of transmission range, the path will be break and the route discovery process will be useless. Our proposed work chooses the path from S E F G H D with minimum distance and considers battery power also. Hence improves route lifetime.

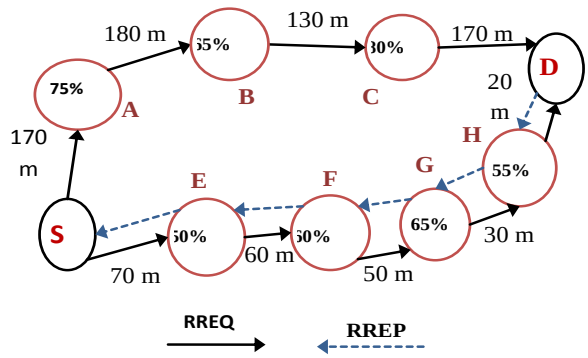

Fig.7: Selection of Route, Based on Energy and Distance

Parameter Used

(a) Packet Delivery Ratio (PDR):
The packet delivery ratio is defined as the ratio of number of data packets received at the destinations over the number of data packets sent by the sources as given in equation (i). This performance metric is used to determine the efficiency and accuracy of MANET's routing protocols.

$$\text{Packet Delivery Ratio} = \frac{\text{Total Data Packets Received}}{\text{Total Data Packets Sent}} \text{X } 100$$

(b) Average End-to-End Delay:
The average end to end delay defined as the time taken in delivery of data packets from the source node to the destination node. To calculate the average end-to-end delay, add delay of each successful data packet delivery and divide that sum by the number of successfully received data packets as shown in equation (ii). This metric is useful in delay sensitive applications such as voice and video transmission.

$$\text{Average End to End Delay} = \frac{\sum(\text{Received Time} - \text{Sent Time})}{\text{Total Data Packet Received}}$$

(c) Throughput:
A throughput of the network is the average rate at which message is successfully delivered between a receiver and sender. It is also referred to as the ratio of the sum of data packet received from its sender to the time the last packet reaches its destination. Network Throughput can be measured as packets per second, bits per second (bps), or packet per time slot. It is required that the throughput must be at high-level in a network. Some factors affects the MANET's throughput are Non-reliable Communication, Dynamic Topology, Limited Energy Reserved and Limited Bandwidth.

(d) Routing Overhead:
Routing overhead is defined as the number of routing control packets, including Route Request and Route Reply. The overhead will increase when high mobility, less battery power in the network. In this proposed work the algorithm will reduce the route discovery process as we will reduce the route failure. So the frequent route discovery process will be avoided which results reduce the node's computational and routing overhead involved in route discovery process.

(e) Energy Consumption:
This is the ratio of the average energy consumption in each node to initial energy. The energy consumption is calculated for the entire network.

5. Conclusion

A frequent change in network, link breakage is a critical problem. This is due to mobility of nodes and energy constrained. Hence degrade the overall performance of network. Our proposed work based on AODV protocol. We used distance between nodes and battery status of every node. This helps to find out the best route in the network to utilize the available node energy. Here we will find out the more stable neighbor of nodes with high battery power status. This will enhance the performance, reduce the routing overhead of AODV routing protocol. Using this technique we will improve the energy efficiency of AODV.

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