

Power aware Multi-path Routing Protocol for MANETS

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Abstract: *Mobile Adhoc Network consists of a large number of mobile nodes that communicate with each other in the absence of any fixed infrastructure. In such an environment each node must work as router to forward the data packets in the network. The principle characteristics of ad hoc network are the dynamic topology and the limited energy of mobile nodes. Nodes in the network are dependent on limited battery power for their operations. The discharge of the battery causes many problems such as the loss of the packets and the re-initialization of route discovery which leads to lot of bandwidth consumption, increase in the delay and decrease in the throughput. In this paper, we propose a new power aware routing protocol for MANETS.*

Keywords- *Ad Hoc; MANET; QoS; AODV.*

I. Introduction

Power consumption is a crucial design concern in Wireless ad hoc networks since wireless nodes are typically battery limited. Power consumption can occur due to receiving the data, transmitting the data traffic, mobility etc. Power failure of mobile node not only affects the node itself but also its ability to forward packets on behalf of others and hence overall network lifetime. It might not be possible to replace/recharge a mobile node that is powered by batteries. To take full advantage of life time of nodes, traffic should be routed in a way that power consumption is minimized. Power Aware Routing is a consideration in a way that it minimizes the energy consumption while routing the traffic, aims at minimizing the total power consumption of all the nodes in the network, minimizing the overhead etc and thus, at maximizing the lifespan of the network using some Power Aware Routing Protocols. Although establishing correct and efficient routes is an important design issue in mobile ad hoc networks (MANETS), a more challenging goal is to provide power efficient routes because mobile nodes operation time is the most critical limiting factor.

Routing in Ad Hoc networks has been a challenging task due to the free movement of nodes and rapidly changing topology. Indeed, it has received tremendous amount of attention from researchers. The protocols may be categorized into two types: reactive or on-demand protocols and proactive or table-driven protocols. Reactive routing protocols are intended to maintain routing information about active routes only. Routes are created when desired by the source node. Route discovery procedure is needed before data transmission, giving rise to high latency. Rapidly changing wireless network topology may break active route and cause subsequent route search. In proactive routing protocol, the nodes continuously maintain complete routing information of the network. This is achieved by flooding network periodically with network status information to find out any possible change in network topology. If any node wants to send any information to another node, the path is known, therefore, latency is low.

In [2], Chen and Heinzelman proposed a Quality of Service (QoS)-aware routing protocol that incorporates an admission control scheme and a feedback scheme to meet the QoS requirements of real-time video or audio transmission. This QoS-aware routing protocol proposes a new method of the approximate bandwidth estimation to react to network traffic.

In [3], Chen et al. presented a congestion-aware routing protocol (CARP), which uses a metric incorporating data-rate, Medium Access Control (MAC) overhead, and buffer delay to combat congestion. These parameters are utilized to select maximum throughput paths, avoiding the most congested links. The CARP route discovery packet is similar to that in Dynamic Source Routing (DSR) [4] where every packet carries the entire route node sequence.

In [5], Zafar et al. proposed a Shortest Multi-paths Source (SMS) routing protocol which is based on DSR and Split Multi-paths Routing (SMR) [6]. This proposed protocol increases the number of selected routes between the source and the destination by requiring. The selected routes have to be partially disjoint. However, these algorithms listed above may result in a rapid depletion of the battery energy in the nodes along the most heavily-used paths in the network. Indeed, routing of packets is a significant power consuming activity since it involves packets forwarding by many intermediate nodes. The general consensus is

that routing protocols should optimize energy consumption for routing. activity given the limited battery power available in wireless nodes.

In [8], Kumar et al. focused on providing power-aware routing protocol. This proposed protocol provides better performance in terms of link failure. Indeed, it finds path between the source and the destination in terms of remaining power of each node. In [9], Sharma and Kush proposed a power-aware routing protocol. This protocol is incorporated with the Ad hoc On-Demand Distance Vector (AODV) protocol [10], which will be discussed in the next section. The proposed protocol allows a mobile node to maintain route to a destination with more stable route selection. It insures fast selection of routes with faster recovery and minimal efforts. In [7], [8] and [9], the authors take into account the aspect of energy of each node when a source discovers a path to a destination, but they do not take into account other aspects such as QoS requirements in terms of delay and bandwidth as in [2] and [5].

The goal of the power aware routing protocol for MANETS is to find an optimal route from a source to a destination in MANET networks. This route is stable in terms of remaining life time of battery. Moreover, it satisfies QoS requirements in terms of bandwidth. On request for data transmission, the source node broadcasts a RREQ packet. This RREQ packet will determine the path from the source node to the destination node.

II. AODV Protocol

AODV is an on-demand routing protocol for mobile ad hoc networks [10]. This protocol uses three types of messages to discover and maintain route: Route Requests (RREQs) and Route Replies (RREPs) messages are used for route discovery. Route Errors (RERRs) messages are used for route maintenance. When a source node needs to communicate with a destination node for which it does not have a route, it broadcasts an RREQ packet across the network. When an intermediate node receives this packet which it does not have seen before, it creates a reverse route to the source. Then, it checks the destination address, if the intermediate node does not have a fresher route to the destination, it increments the hop-count and re-broadcasts the RREQ packet. Otherwise, it generates a RREP packet and sends it to the source node. When the source receives the RREP packet, it saves the route and begins data transmission. When a node detects a link break in an active route, it sends a RERR packet to notify the other nodes about this problem. An active route is used to forward data packets.

The format of RREQ packet for AODV protocol is shown in Figure 1.

Type	Flags	Reserved	Hop-count
RREQ ID			
Destination IP Address			
Destination Sequence Number			
Originator IP Address			
Originator Sequence Number			

Fig 1: RREQ packet format for AODV protocol

Here:

- Type: It represents the type of the packet and it is set to 1
- Flags: It represents a set of flags each flag indicates a state of the packet
- Reserved: It is set to 0 and it is ignored on reception
- Hop Count: Represents the number of hops from the source node to the node handling the request
- RREQ ID: It represents the sequence number uniquely identifying the particular RREQ when taken in conjunction with the source nodes IP address
- Destination IP Address: It represents the IP address of the destination for which a path is desired
- Destination Sequence Number: It represents the latest sequence number received by the source for any path towards the destination,

- Originator IP Address: It represents the IP address of the node which originated the route request,
- Originator Sequence Number: It represents the current sequence number to be used in the route entry pointing towards the source of the route request.

The sequence number ensures loop freedom and allows nodes to determine fresh routes. This latter is a valid entry for the destination which is associated with a sequence number greater than that contained in the RREQ packet. The AODV routing protocol has some shortcomings. It always chooses the shortest path instead of stable path, which results in frequent link failures

III. An Algorithm for Improvement of Link Failure in MANETS

In mobile ad-hoc network all the nodes move from one place to another place very frequently. So the link break between sender to receiver is very frequent. Source node is not able to predict either data can be sent by the source is delivered to the destination or not because of uncertainty of link between source to destination. So we are proposing a power aware routing protocol that provides accurate available power of the node that is used in current path for communication.

The proposed algorithm is an efficient routing algorithm that improves the efficiency of link failure in terms of power as well as bandwidth which improves the quality of services. In this routing protocol, there are some parameters used like TTL, Available Power List and Available Bandwidth List for communication. When RREQ packet is flooded by the source then it contains the following information.

I. Broadcast ID:

The broadcast id is a number stored in packet header which is incremented before a new request is disseminated.

II. Source Address:

Source address is address of source node which is used to send the request between source and intermediate node.

III. Destination Address:

Destination Address is address of destination node which is used to receive the reply from the source or intermediate nodes.

IV. Available Power list:

This field contains the available power of the node which is used in current path for communication.

V. Available Bandwidth List:

This field contains the available Bandwidth of every node which receives RREQ packet, processes it and forwards it to its neighbors.

In this algorithm if S is the source node which wants to communicate with destination D with the help of intermediate nodes. Source node S initiates the RREQ request that packet contains information like TTL, A_Power, A_bandwidth, broadcast id, source address, and destination address. All information is collected by source node before sending the RREQ packet to his neighbors.

When neighbors receive the RREQ packet then first of all they check the TTL value. If TTL is greater than zero they check destination address of RREQ, if destination address is the address of the current node then they consume the packet and calculate average power of the current path. And they also calculate minimum available bandwidth from available bandwidth list. After calculation of these values node sends RREP packet to the source node with average power of current path and minimum available bandwidth.

If destination address is not equal to the current node ID then the current node enters their available power and bandwidth value into the RREQ packet. It also enters the current node ID into visited node list and floods the RREQ packet to its neighbor.

If TTL is not greater than or equal to zero then current node discards the route request packet.

This process is followed by every node which receive the RREQ packet until the RREQ receive the by destination node.

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Algorithm for RREQ & RREP

IF ( TTL > 0)
{
    IF(Node_Id==Destination_Id)
    {
        Consume the RREQ packet;
        Calculate the AVG Power for current path.
        Calculate minimum available bandwidth. ;
        Send RREP to source with AVG power and
            minimum available bandwidth;
    }
    Else IF(Node_Id!=Destination_Id)
    {
        Enter remaining power into A_Power list;
        Enter Node_Id into visited node list;
        Enter available bandwidth into A_Bandwidth list;
        Flood RREQ;
    }
}
Else
{
    Drop the Packet;
}
    
```

Though this protocol provides a stable path in MANETS, its implementation complexity is high

IV. Proposed Protocol

The goal of the proposed protocol is to find an optimal route from a source to a destination in MANET networks. This route is stable in terms of remaining life time of battery. Moreover, it satisfies QoS requirements in terms of bandwidth. On request for data transmission, the source node broadcasts a RREQ packet. This RREQ packet will determine the path from the source node to the destination node. The format of the RREQ packet is shown in Figure 2.

RBW	ML	TTL	seqnum
Source Address			
Destination Address			
Adress 1			
.....			
Address n			

Fig 2: RREQ packet format for SPR protocol

Here:

- RBW: It represents the required bandwidth for data transmission

- ML : It represents the minimum remaining life of the route
- TTL : It represents the time to live
- Seq num: It represents the sequence number that uniquely identifies the RREQ packet
- Source Address: It represents the address of the source node
- Destination Address: It represents the address of the intended destination node,
- Address i: It represents the address of an intermediate node of the route.

When an intermediate node receives an RREQ packet, it compares its own address with the destination address. If it is the destination, it sends back a RREP packet along the reverse route. Otherwise, it checks first the availability of the required bandwidth. If the required bandwidth is not available, it drops the RREQ packet. If there is sufficient bandwidth for data transmission, the intermediate node decrements the time to live (TTL) of the packet. The TTL is the maximum number of hops that a packet can make before reaching its destination. If the TTL becomes zero, the intermediate node drops the RREQ packet and sends an error message to the source node. After that, the node calculates the minimum path life by comparing its own remaining life with the value of the ML Field. This field in the RREQ packet has always to contain the minimum life of all nodes crossed by the path. Before rebroadcasting the RREQ packet, the node adds its address in this packet, and maintains in its routing table some information such as the source address, the destination address, the sequence number and the minimum life of the route.

In this routing protocol, if any intermediate node receives from the same source more than one RREQ packet, it compares the ML fields of these two packets. If the ML field of the new RREQ packet is greater than the previously forwarded RREQ packet, it re-broadcasts this packet.

Otherwise, the RREQ packet is dropped although this RREQ removed can come from the shortest route. After receiving the first RREQ packet, the destination node waits for the reception of other RREQ packets for a predefined time. Then, it compares the ML fields of all received RREQs packets. It chooses who has the greatest ML field value and it removes the other RREQs packets even if the difference between the ML value of the RREQs chosen and the other RREQs removed is small. The path selected by the destination can be the longest path because the SPR protocol does not take into account the end-to-end delay. In order to analyze the functionality, we choose an example of an Ad Hoc networks consisting of eight nodes (see Figure 3).

Assume that N1 is the source node and N8 is the destination node. N1 broadcasts the RREQ packet in order to find a route to N8. Node N8 will receive two RREQs. The first path is (N1 - N3 - N5) having an ML equals to 40 energy units (eu) while the second path is (N1 - N2 - N4 - N6 - N7) having an ML equal to 41 eu. The SPR protocol satisfies QoS requirements in terms of bandwidth, so let us assume in this example that the required bandwidth is available. According to the SPR protocol, N8 will choose the second path (N1 - N2 - N4 - N6 - N7) as it is more stable in terms of remaining battery life although (N1 - N3 - N5) is shorter than this selected route and the difference between their remaining life is very small ($41 - 40 = 1$ eu). So this protocol has serious problem in terms of delay since it does not select the shortest path. Also, in the SPR protocol the destination node selects one route to transmit the data packet. In case there is fault in this route, the process of re-initialization of route discovery is triggered. This leads to lot of bandwidth consumption, increase in the delay and decrease in the throughput. To improve the SPR routing protocol and take into account the end-to-end delay by selecting the shortest routes between the source and the destination nodes, we propose a new routing protocol called PDMRP.

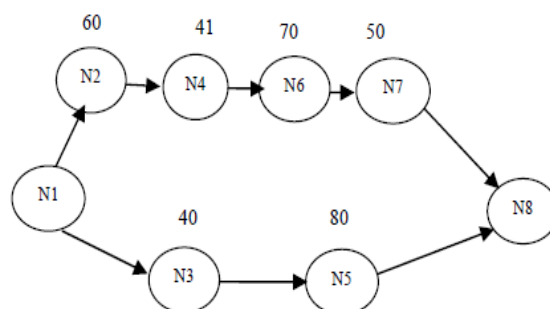


Fig 3: First example of battery life of nodes in network

Here the main advantage is that, this protocol provides a stable path with less complexity

V. Conclusion

The power is a major constraint in ad hoc networks since the nodes operate with limited battery life. Hence, the routing protocols in this type of networks must be developed to consider power aware as a primary objective. Also, the support of QoS requirements in terms of delay and bandwidth becomes a challenge due to the dynamic nature of ad hoc networks. Most of the protocols have concentrated on how to quickly reorganize the ad hoc network during times of mobility and how to find the best route without increasing control overhead. However, since mobile hosts have limited battery resources, ad hoc mobile networks should consume battery power more carefully and efficiently to prolong network operation lifetime.

In this paper, we have proposed power aware routing protocols for MANETS. Here we have compared the performance characteristics of this proposed protocol with AODV routing protocol. The results shows that the proposed protocol significantly outperforms the AODV protocols in terms of throughput, end-to-end delay and loss rate. It also reduces the implementation complexity when compared to link failure improvement algorithm. Further, our proposed protocol performs better in terms of throughput and packet loss as it takes into account the battery life of nodes and therefore chooses a stable path.

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