Energy Saving DSR Protocol for MANET

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Certificate

This is to certify that the work in the thesis entitled *Energy Saving DSR Protocol for MANET* by *Uttam Vyas*, bearing roll number 211cs1057, is a record of an original research work carried out by him under my supervision and guidance in partial fulfillment of the requirements for the award of the degree of *M. TECH* in *Computer Science and Engineering*. Neither this thesis nor any part of it has been submitted for any degree or academic award elsewhere.

Prof Suchismita Chinara

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Abstract

Mobile ad hoc network (MANET) is an infrastructure-less network where the communication capabilities of the network are limited by the battery power of the nodes. Since there is no central infrastructure, It causes various kinds of problems, such as energy efficient routing.

Energy efficient routing is one of the key issues in MANET because all the nodes are battery powered, so failure of one node affect the entire network. If a node runs out of the energy then this may cause partitioning of network. Since each node has limited power, energy become main threats to the network lifetime. Routing must be energy efficient so it will increase the lifetime of the network.

In this work, we have proposed an Energy Saving on demand Dynamic Source Routing (ESDSR) protocol for MANET to minimize energy consumption using variable transmission power and load balancing. The aim of this work is to reduce the energy consumption, for data packet transmission between source and destination, and minimizing the overutilization of the node. We have compared the proposed technique with the existing one and the result shows that the our technique gives better packet delivery ratio, and reduce the energy consumption at each node.

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Chapter 1

Introduction

Mobile devices with wireless network interfaces become an important part of future computing environment consisting of infra-structured and infrastructure-less mobile networks [1]. In wireless local area network based on IEEE 802.11 technology a mobile node always communicates with a fixed base station, and thus a wireless link is limited to one hop between the node and its neighbor base station, where Mobile ad hoc network (MANET) is a multi-hop infrastructure-less network where a node communicates with other nodes directly or indirectly through intermediate nodes. Figure 1.1 shows an example mobile ad hoc network and its communication topology.

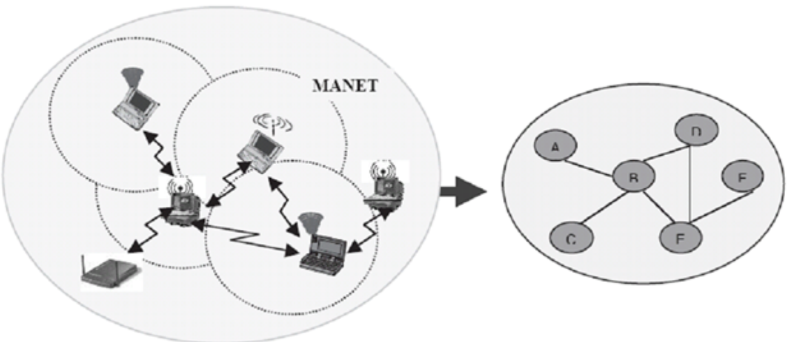

Figure 1.1: Mobile Ad Hoc Network

All nodes in a MANET function as routers participating in some routing protocol which are required for creating and then maintaining the routes. Since MANET are infrastructure-less networks, they are highly used for applications such as military operations, special outdoor events, communications in infrastructure-less regions, emergencies and natural disasters[2]. Routes between the nodes of an ad hoc network may include more than a single hop, hence, we call such networks "multi-hop" wireless ad hoc networks.

Due to the highly dynamic nature routing is the key issues in MANET . Since mobile nodes are powered by batteries with limited capacity, energy efficient routing is one of the most important design criteria for MANET. Failure of a mobile node due to power not only affect the node itself but also its ability to forward packets and it also affect the lifetime of a network.

When a mobile node is actively sends or receives packets it means it is in active mode, and when it is listening to the wireless medium for any possible communication requests from other nodes this mode is known as idle mode. A mobile node consumes its battery energy not only when it is in active mode, but also when it is in idle mode. Thus, energy-efficient routing protocols minimize this battery consumption by minimizing active communication energy required to transmit and receive data packets. We can reduce the active communication energy by adjusting each node's transmission power just enough to reach the receiving node. We can determine the optimal routing path from the transmission power control approach that minimizes the total power required for the transmission of a data packets from source to the destination. A node can switch its mode of operation into sleep/power-down mode when there is no data to transmit or receive and save the energy. However, it requires a fully designed routing protocol to guarantee data delivery even if most of the nodes sleep and do not forward packets for other nodes. Another important approach is load distribution approach to optimizing active communication energy. While the primary focus of the above two approaches is to reduce energy consumption of every single nodes, the main goal of the load distribution method is to avoiding over-utilized nodes when selecting a routing path and balance the energy usage

among all the nodes and to maximize the network lifetime[3].
Each approach has its own advantage or disadvantage so it is not clear that any particular algorithm is best for all scenarios. However, we can combine the existing methods to offer a more energy-efficient routing mechanism.

1.1 Characteristics and Advantages of MANET

In general MANET is having the same characteristics of wireless network, and additional Characteristics those are is specific to the Ad Hoc Networking:

(i) Wirelees:
Each node communicate through wireless media and share the same media (radio, infra-red, etc.).

(ii) Ad-hoc-based:
MANET is a collection of nodes which is dynamically formed a temporary network in an arbitrary manner as need arises.

(iii) Infrastructure-less and Autonomous:
MANET does not depend on centralized administration or any established infrastructure. Each node in MANET acts as a router, and generates independent data.

(iv) Multi-hop routing:
Routes between the nodes of an ad hoc network may include more than a single hop, hence, we call such networks "multi-hop" wireless ad hoc networks.

(v) Mobility:
while communicating with other nodes each node is free to move. Topology of an ad hoc network is dynamic in nature due to constant movement of the nodes, causing the communication patterns among nodes to change frequently.

Advantages are

(i) Accessibility:
Regardless of geographic position MANET provides access to information and services.

(ii) Deployment:
The networks can be set up easily at any place and time.

(iii) Infrastructure-less:
MANET is a infrastructure-less network. This allows people and devices to interwork in areas with no supporting infrastructure.

(iv) Dynamic:
MANET can freely and dynamically self-organize into arbitrary and temporary network topologies.

1.2 MANET Applications

Ad hoc networks can be set up anywhere at any time Because they are flexible, infrastructure-less, including administration or pre-configuration, because of these simplicity people realizes the commercial potential that mobile ad hoc networking can bring[4].
This section describes some of the applications of ad hoc networks. The lack of infrastructure and self-configuring nature make them highly appealing for many applications. The lack of infrastructure is good for low-cost commercial systems, since it require a large investment to get the network up and running. Lack of infrastructure is also good for military systems, where communication networks must be configured as quickly as possible, often in remote areas. Other advantages include low maintenance cost and ease of network reconfiguration.

- Search and Rescue Operations
- Sensor Network

- Military Networking
- Personal Area Network

1.3 Design Issues and Challenges

Ad hoc wireless networks have the traditional problems of wireless communications, such as power control, bandwidth optimization, and enhancing the quality of transmission, while, in addition, multi-hop nature, their mobility, and the lack of infrastructure causes a number of complexities and design constraints.

(i) Quality of Service:
For the successful communication of nodes in the network Quality of Service (QoS) guarantee is very much essential. The different QoS metrics includes packet loss, throughput, jitter, delay, and error rate.

(ii) Network Security:
Mobile networks are more vulnerable to security threats than fixed-wired networks. Mobile networks are more vulnerable to security threats because it uses open and shared broadcast wireless channels means nodes with inadequate physical protection. In addition, because a mobile ad hoc network is a infrastructure-less network, since there is no centralized security control MANET mainly relies on individual security solution from each mobile node.

(iii) Robustness and Reliability:
MANET is multi-hop network, so network connectivity is obtained by forwarding and routing among multiple nodes. Although MANET comes with the advantage of infrastructure-less, it also causes design challenges. Due to various types of failed links, a node may fail to forward the packet, like overload or acting selfishly. Unreliable links misbehaving nodes and can have a severe impact on overall performance of the network. Such types of misbehaviors cannot be find and isolated quickly because of the lack of

centralized monitoring and management mechanisms. This increases the design complexity significantly.

(iv) Energy Constrained Operation:
Each node in MANET is battery powered which cannot be recharged. So if a node runs out of the energy then this may cause partitioning of network. Since each node has limited power, energy becomes main threats to the network lifetime. Additional energy is required to forward packets because each node is acting as both a router and an end system at the same time [5].

(v) Limited Link Bandwidth and Quality:
Since the mobile nodes communicate to each other via wireless links it cause bandwidth-constrained, error-prone, variable capacity, since wireless links have significantly lower capacity than wired links and, hence, it causes network congestion.

(vi) Dynamic Topology:
The dynamically nature of ad hoc network causes to the formation of an unpredicted topology. This topology change causes dropping of packets, partitioning of the network and frequent changes in route.

(vii) Infrastructure- less network:
The key aspect of an ad hoc network is its lack of infrastructure, and most design issues and challenges come from this characteristic. Also, it brings added difficulty in fault detection and correction because of lack of centralized mechanism.

1.4 Problem Statement

For a given pair of node (source and destination), the routing algorithm should select a path in such a way that it minimizes the consumption of energy and maximize the life time of network. We have to select nodes for a route in such a way that it will maximize network lifetime, so a node will be selected in a route if it is minimizing energy consumption and maximize the network lifetime.

1.5 Organization of thesis

In this section we provides the overview of the thesis

Chapter 2 provides the literature review, which has been carried out to save energy and maximize the network lifetime in MANET by different -different approaches such as Transmission power control approach, Load distribution approach, and sleep/power-down mode.

Chapter 3 provide the introduction of traditional DSR and proposed ESDSR. It also provides flow graph, algorithm and an example of ESDSR.

Chapter 4 provides the Implementation and simulation result of traditional DSR and ESDSR.

Chapter 5 Provides the conclusion and future work.

Chapter 2

LITERATURE REVIEW

2.1 INTRODUCTION

As we discussed briefly in the previous chapters about the MANET routing protocols. So power consumption of a mobile node is one of the most important factor to be noticed. So In this section we have made a detailed literature review about the power control approach in MANET and different energy efficient routing protocols that already exist.

2.2 Power Control in AD-HOC Networks

Power control is one of the key issues of MANET which deals with the performance of the system. The selection of optimal transmission power level is good for network and it always increase the performance[6]. The main aim of power control is to increase the battery life, reducing the interference and latency.
The amount of power required to send a packet can be minimized by the equation given below:

$$Min \sum_{i \epsilon path} P(n, n+1)$$

Where P (n, n+1) denotes the amount of power required for sending a packet between node n and node n+1 [7]. Link cost between the nodes calculated separately in both the cases first when the transmission power is fixed and second when transmission power varies dynamically, variation in terms of distance which changes between pair of nodes.For fixed energy case the cost for a node to send and recieve a packet is:

$$Cost = m \times size + b$$

where m denotes the cost which depends on the size of packet and b is fixed cost for acquiring the channel [8].

2.2.1 Introduction

The transmission power of a node must be selected in such a way that it is optimal by optimal means minimum transmission power sufficient enough to connect and communicate with the desired destination. This optimal transmission power level minimizes interference improves both bandwidth and energy consumption. However, MANET is infrastructure-less so there is no such thing like base stations which make centralized decisions about power control settings, so in ad-hoc networks power control decision needs to be managed in a distributed fashion [9].

2.2.2 Importance Of Power Control

We can see from the figure 2.1 that there are two transmission simultaneously occurring between node N2-N1 and N4-N1. We can see from the fig. that that node N2 can connect to node N1 at 30mW and 1mW. If the node N2 transmit at 30mW then this cause interference between the two transmissions occur at N1 -N2 and N3-N4, . So by the power control scheme we can select an optimal power level at which both the transmissions can occur without any interference.

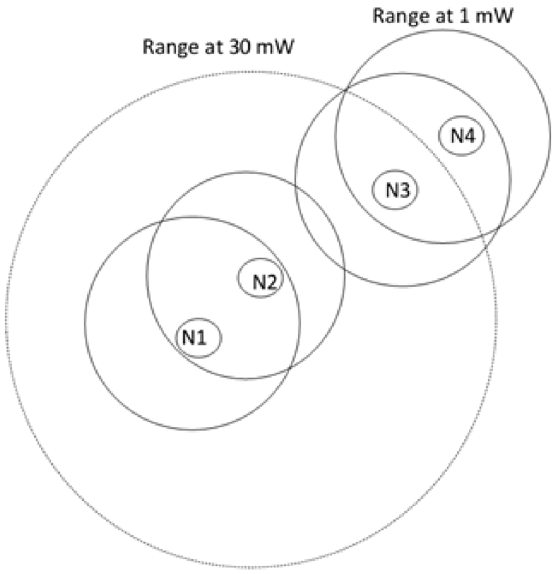

Figure 2.1: The need of power control

2.2.3 Power Control in the Layered Hierarchy

Since Power control is not limited to a single layer. It affects multiple layers. In the

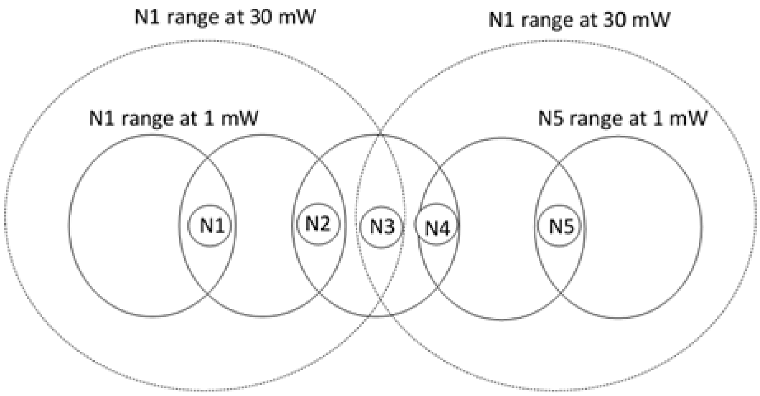

Figure 2.2: Power Control in Network Layer

figure 2.2 the routes between the two nodes are different for different power level. Suppose if the power level is set at 1mW for all the nodes then the route will be N1-N2-N3 from node N1 to N3.However if the power level is set at 30mW for all the nodes, then the route will be N1-N3 since both are reachable at same power level. So the selection of a power level affects the route and hence it will also affect the network layer [9].

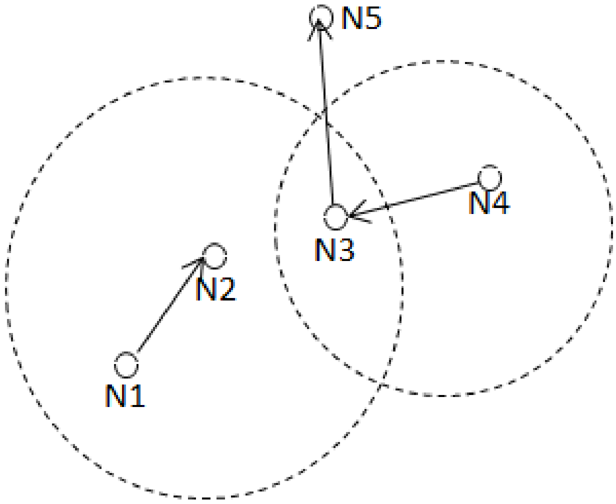

Figure 2.3: Power Control in transport layer

We can see from figure 2.3 that if node N1 chooses to transmit to node N2 at a higher power level then it will cause interference between the transmission of node N3 and N4. This interference causes loss of a large number of packets sent from N3 to N4. Also it will affect the transmission of data packets between nodes N4 and N5 that uses node N3 to relay the packets. Hence power control also affects the transport layer [9].

2.3 Energy Efficient MANET routing protocol

A routing protocol establish an efficient and correct route between source and destination. But finding only the efficient and correct route is not only our requirement since each node has limited power, we have to find the route in such a way it would remain for long time so the nodes can use this route for communication. To achieve a longer network life time, we should minimize the energy consumption of a node in both active and ideal mode. Approaches that are used to minimize the energy are:

(i) Transmission power control approach

(ii) Load distribution approach.

(iii) sleep/power-down mode

2.3.1 Transmission Power Control Approach

Increasing or decreasing the transmit power level has its own advantages or disadvantages. If the transmission power level is higher means signal power at the receiver end is higher, and it decreases the hop count to reach destination[15]. It causes higher signal to noise ratio and hence the error in the link is reduced. It is advisable to use a high transmission power if the signals in a network keep on dying, so that the signals which are received at the destination end are not weak. However, high transmission power also causes few disadvantages. The battery consumption of the device will be high. It also increases the Interference[10].
There has been plenty of research is going on topology control of a MANET via transmission power control approach, and the main objective is to use minimal power and maintain a connected topology. All the transmission power control approach based energy efficient routing protocol find the best route which minimize the total transmission power. Energy efficient routing protocols based on transmission power control find the best route that minimizes the total transmission power between a source-destination pair.

Common Power (COMPOW) protocol

Common power (COMPOW) is based on power aware approach[11]. In this approach every node maintains a routing table at each power levels that is available on the wireless card. Routing tables at different power level is built by exchanging hello messages at each power level P_i, so the routing table RT_i correspondence to the routing table at i_{th} power level.Thus, the number of entries in routing table RT_i of node u directly depends on the number of nodes that are reachable from u at power level P_i. So clearly, number of entries in routing table RT_{max} (RT_{max} is the routing table at maximum power level) gives the information about total number of nodes that can be reach at P_{max}. So P_i is the optimal power level which is defined as the minimum power level i , such that the number of entries in the routing table RT_{max} equals the number of entries in RT_i. Once we find the optimal power level i, table RT_i is declared as the master routing table, which is later can used to route packets between nodes.

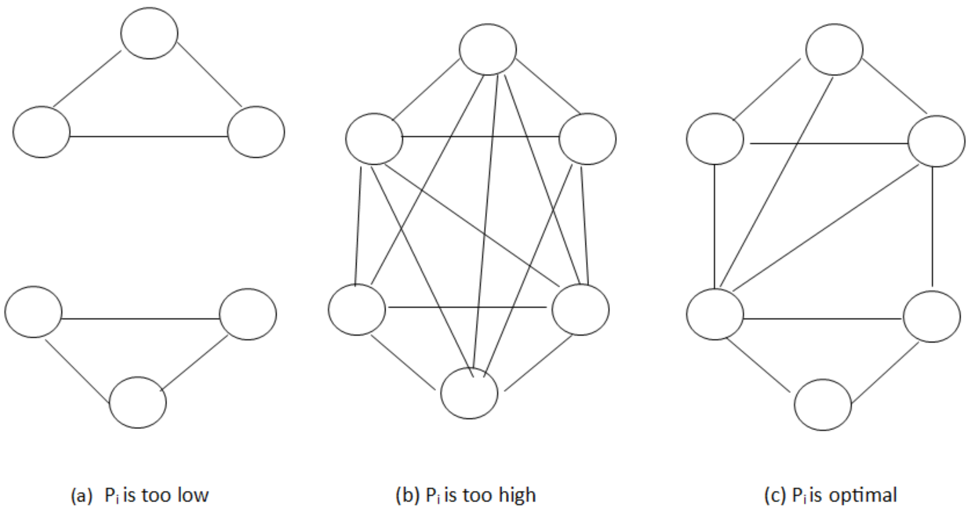

Figure 2.4: Proper selection of the common transmission power level in COMPOW.

Flow Augmentation Routing (FAR) Protocol

The FAR protocol finds a path whose sum of link cost is minimum for a given source destination pair[12]. The cost for link (i,j) is determined by this formula $e_{i,j}^{x1} \times E_i^{x2} \times R_i^{-x3}$where e_{ij} is the required energy for a unit flow transmission and R_i and E_i are the residual and initial energy at the node i, and x1, x2, and x3 are weighting factors. A link which requires less transmission energy according to the formula is preferred. Also, if a transmitting node has high remaining energy then it can also prefer because it will provide better energy balance. Since unit flow transmission cost (e_{ij}) and initial energy (E_i) are constant for a link (i, j), and the remaining energy (R_i) will continue to decrease as communication moves on so x1,x2,and x3 are the deciding factor while calculating link cost. So the optimal solution which is determined at one moment may not be optimal after some time because of corresponding links costs and the remaining energy (R_i) have changed. Because of this reason, FAR solves this problem in an iterative fashion: first discover the optimal route between the pair of nodes for the first time step, update nodes link costs, residual energy and discover another route for the next time step.

Online Max-Min Routing (OMM) Protocol

Main goal of this protocol is to maximizing the minimal residual power (max-min) while minimizing power consumption (min-power)[13]. For the given set of nodes with link costs, OMM protocol finds the optimal route between given source-destination node by using the single-source shortest-path algorithm (Dijkstra's algorithm). This optimal min-power path will consumes the minimal power (P_{min}) but it may not be the max-min path. In order to discover max-min path OMM protocol discover multiple min-power route which are close to optimal value (less than ZP_{min}) and it select the best path or the path which will maximize the minimal residual power (max-min) .

An example of OMM algorithm is shown in figure 2.5. From the figure we can understand that S-B-D, S-A-D, and S-C-D these are the paths from source S to destination D. In which the path S-B-D required minimal ($P_{min=18}$) energy. Other two paths S-A-D (path cost=22) and S-C-D (path cost=31) have cost less than the threshold value ZP_{min} which is 36 here, so we can consider these two path also. To discover a max-min path we have to compare remaining energy of all the nodes which participate in routing. Here the remaining energy of node c is 30 which is maximum but if we choose the path S-C-D then it will drop to 9. So by comparing

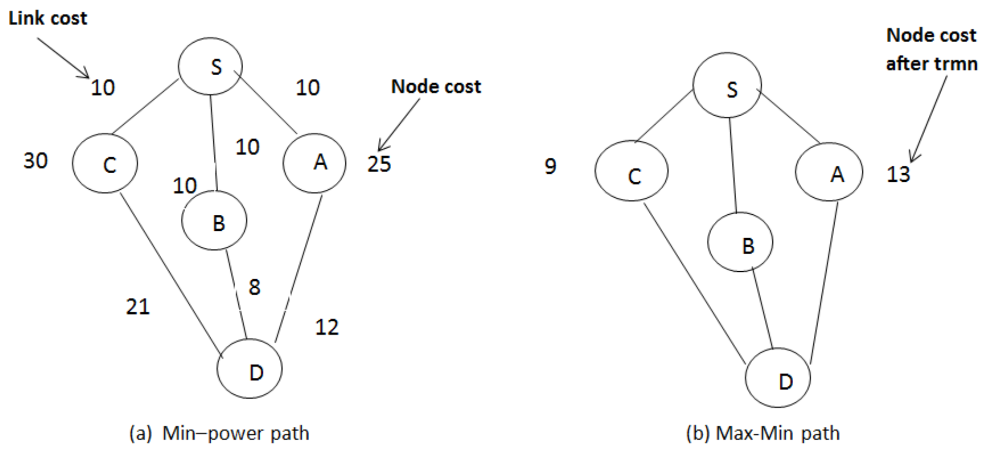

Figure 2.5: Min-power path and max-min path in the OMM protocol.

the remaining energy of nodes A,B, and C we can clearly see from the figure that the remaining energy of node A is maximum so we choose the path S-A-D.

Power aware Localized Routing (PLR) Protocol

Each node in the network provided with local information, so the routing algorithm which required global information such as power level, data generation rate and other information may not be the practical [14]. So PLR is based on local information only here the source node only knows the location of destination node or its neighbor node. A source node may not be able to find an optimal path with these information's only but it can choose its next hop in such a way that the total transmission power can be minimize. As we know that there is a super-linear relationship between transmission power and the distance so direct communication required more energy than the indirect communication so it's better if we use indirect communication. In the example node A want to communicate to destination D, here either it can directly communicate or it can communicate indirectly via 1,2,3. In order to discover an optimal path node A first compare the power requirement to each distance it knows and based on this comparison it will select the route.

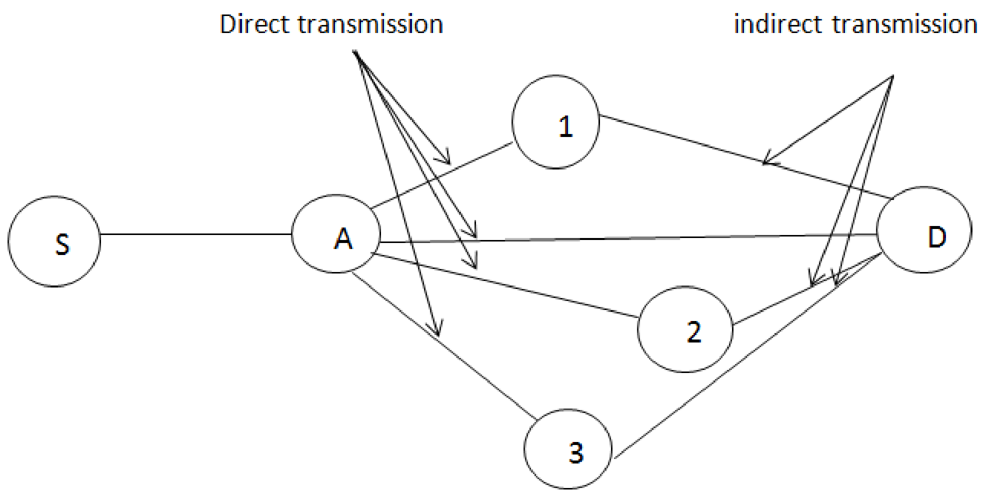

Figure 2.6: Selection of the next hop node in the PLR protocol.

2.3.2 Load Distribution Approach

Load distribution approach doesn't always try to minimize the energy consumption, Its main goal is to balance the energy consumption by selecting the nodes which are underutilize. This may cause longer routes but we are using underutilize nodes which are energy rich. By using the underutilize nodes it ensure the longer network lifetime of the network. Conditional Max-Min Battery Capacity Routing (CMMBCR) protocol and Localized Energy-Aware Routing (LEAR) these two protocols are based on load distribution approach.

Localized Energy Aware Routing (LEAR) Protocol

The LEAR routing protocol is same as DSR but it modifies the route discovery process to balance the energy consumption. Normally in DSR protocol whenever a node receive a route request, it adds its header and again broadcast it. So an intermediate node always forwards the messages if it is selected in a route[16]. However, in LEAR protocol before forwarding the route request a node checks its remaining energy (E_r) if its higher then threshold (THr) value then only it will participate in forwarding packet else it will drop the route request packet. Hence, all the nodes which are selected in route are energy rich.

Conditional Max-Min Battery Capacity Routing (CMMBCR) Protocol

Conditional Max-Min Battery Capacity Routing (CMMBCR) Protocol is same as LEAR, it also uses the concept of a threshold to increase the lifetime of the network. First it found multiple routes, and if all the nodes in all routes between source and destination are energy rich means their remaining battery energy is more than threshold then the min-power route is selected. And if some of the nodes in all possible routes have lower remaining energy than threshold then max-min route is selected [17].

2.3.3 Sleep/Power-Down Mode Approach

This approach focus on the time when the node is not communicating means when a node in inactive mode. So the idea is to put the node in sleep mode or power off mode when it is not communicating with any other node to save energy. If all the nodes are in power off or sleep mode, it is not possible to deliver packet to destinations. One way to overcome this problem is to elect a node as master, and this master node will communicate instead of its neighboring node while they are sleeping. After some time period each slave node wake up and communicate with master node to check whether it has any data to receive if not then it again sleep. This master slave architecture is followed by two protocols first one is SPAN protocol [18] and the second one is Geographic Adaptive Fidelity (GAF) protocol [19].

SPAN Protocol

SPAN uses distributed master eligibility rule to select master node. According to the rule if two nodes in the network cannot reach each other directly or via master node then it should be declared as master node. This rule does not concentrate on minimizing the master node but the main goal of this rule is to maintain the connectivity with energy saving. This may be possible that the master node also overloaded. To overcome this problem each master check after some time period that whether it should withdraw as master or not and gives a chance to its neighbor nodes to become master. The nodes which are not master also need to check after some time interval that whether they are eligible to a become a master or not according to rule.

GAF (Geographic Adaptive Fidelity) Protocol

As its name says each node in the GAF protocol has location information to locate itself to a virtual grid so the entire network area is divided into virtual grids, and master node in each grid is selected on the basis of remaining energy so the node with highest remaining energy is selected as master in each virtual grid.

Chapter 3

Energy Saving DSR Protocol for MANET

3.1 Motivation

Energy efficient routing is a key technique to minimize the energy consumption of the network. There are many existing energy efficient routing protocol as we already discussed. But each one of these protocol has its own advantages and disadvantages. After studying this existing protocol which we are described above, we decided to design an energy efficient routing protocol which reduces the total energy consumption as well as maximize the life time of the network. So we proposed a new energy saving dynamic source routing protocol which is based on the DSR protocol.

3.2 Selected Protocol: Dynamic Source Routing

The Dynamic Source Routing protocol (DSR) [20] is designed specifically for use in multi-hop mobile ad hoc networks it's very simple and efficient routing protocol. Here sender itself knows the complete route of nodes to the destination. One advantage of using DSR is that no need of sending periodic router updates and advertisements. DSR uses source routing algorithm each data packet in DSR consists total routing information from source to destination. Each node in DSR maintains a cache which has route information from source to destination. DSR includes two phases: Route discovery and Route maintenance.

(i) Route Discovery

Route discovery phase is launched whenever a node wants to communicate or contact to destination node which isn't in the transmission range of source node, therefore source node must obtain a route to the destination node by Route discovery mechanism. Before initiating route discovery mechanism sender node must check for route in its route cache if no route is found in its route cache then it proceeds as follow:

- First source node creates a route request packets containing the address of sender node as well as the address of destination node then it broadcast this RREQ to all its neighbors.
- After receiving this request these neighbor nodes consults its route cache to find a route to the destination otherwise these neighbor nodes first add their address to the header and then broadcast the route request to their neighbors, and this goes on until route request reach the destination node. If a node already process a particular route request then it ignore the new received RREQ by checking its sequence number.

(ii) Route Reply

When the destination node receives the route request this procedure is executed by a node:

- Destination node adds this new route to its route cache for future use.
- Destination node adds its address to the header of DSR packets.

– And destination node replies with route reply (RREP) which is unicast along the path contained in the header.

(iii) Route Maintenance

After forwarding the packet, sender node also confirm that whether the packet is correctly received or not, since ad hoc networks are highly dynamic in nature so it may happen that the topology of the network is changed because of the node mobility so there may be some situation where sender node doesn't receive the acknowledgement of packet. In this case sender node resends the packet until it reaches to a predefined value of attempts. Whenever this resend value reaches to the predefined value sender node consider this link as broken then first it deletes all the routes containing this link from its route cache and after that sender node generates a route error (RERR) message to inform the intermediate node as well as source node about the link failure. Intermediate node also delete all the route containing this route and this process continues until the route error packet reach to the source node which launch a new route request or find a new route.

(iv) Route Cache

The route cache is used to store frequently used routes in order to avoid unnecessary new route discovery mechanism which takes lot of network resources. So whenever a new route is discovered we saved this route in the route cache for future use, a node can also update its route cache from route request and route error message.

3.3 Proposed method

Energy Saving Dynamic Source Routing (ESDSR) protocol is based on Transmission power adjustment approach and Load balancing approach. To reduce the transmission power we are using transmission power control approach in which a node will transmit data using optimal power instead of transmitting at full power[21], by optimal transmission power means the transmission power which is sufficient enough to connect to the required node. For load balancing we are avoiding the nodes whose remaining energy is less than threshold (TH_r) value and we are selecting the nodes whose remaining energy is higher than threshold. This energy saving Dynamic Source Routing (ESDSR) protocol designed by making changes to the minimum-hop fixed-transmit power version of DSR.

3.4 Energy Saving Dynamic Source Routing (ESDSR) protocol

step 1:

In the route discovery phase source node creates a route request packet (RREQ) containing a unique number to identify the request, address of both source node and destination, a route record containing the addresses of each intermediate node through which RREQ is forwarded and it also contain one more field 'thr' (threshold).The RREQ packet format will be as

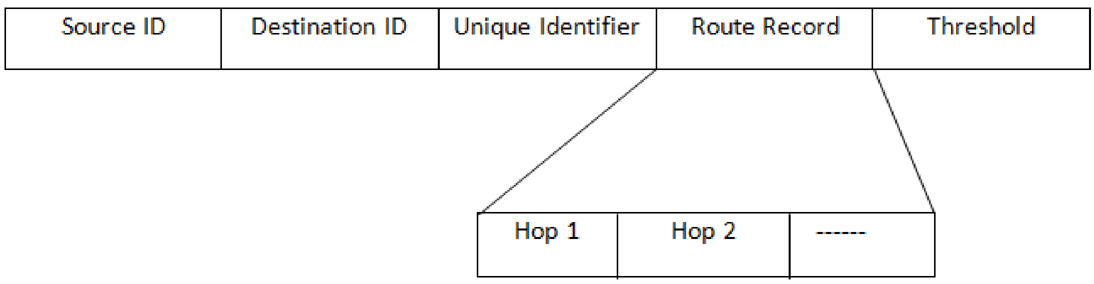

Figure 3.1: RREQ packet format

step 2:

When a node receives a RREQ message first it will compere its remaining energy (R_i) with threshold (TH_r) value and based on the result of this comparison it will take one of the following decisions.

case 1: If the remaining energy (R_i) of the node is less than the threshold (TH_r) value then it will not participate in routing and it won't participate in relaying packet.

case 2: If the remaining energy (R_i) of the node is greater than the threshold (TH_r) value then it will broadcast the RREQ packets to all the neighbors. In this case ESDSR is same as DSR.

step 3:
It may happen that remaining energy of all the nodes receiving RREQ is less than the threshold (TH_r) value, In this case sender node won't receive any route reply (RREP). However, sender node wait for some fixed amount of time and after that it will resend the RREQ with lower value of th_r.
step 4: When the destination node receives the route request, it replies with a route reply (RREP). When a node send RREP it will adds it's coordinate to the RREP packet , so when the next node receive this RREP it knows the location of the successor node in the route to destination by this location information a node can determine the optimal transmission power required to communicate with its successor node in the route to the destination.The RREP packet format will be as

Source ID	Destination ID	Unique Identifier	Route Record	Final Path Table	Location Information

Figure 3.2: RREP packet format

3.4.1 A flow chart for sender to send the data packet

The flow graph for sender to send the data packet is shown in figure 3.3

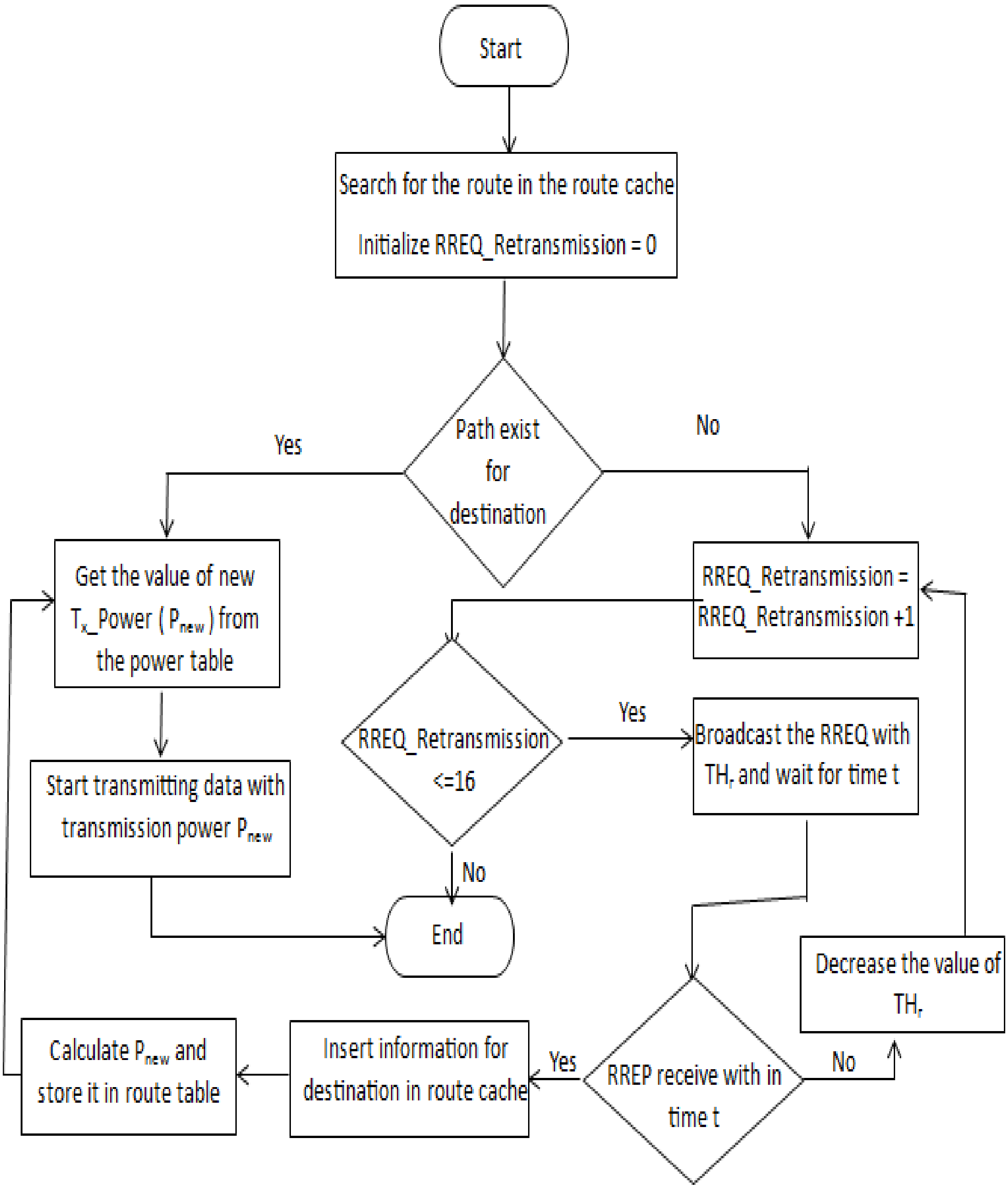

Figure 3.3: A flow chart for sender to send the data packet

Alogorithm 1 Algorithm for sender to send the data packet

Procedure TransmitData(SourceAddr,DestAddr,Message)

$Initialize : RREQRetransmission = 0$

$PathExist = SearchRouteCache(DestinationAddr)$

If $PathExist = TRUE$ **then**

$TxPower = GetTxPower(DestinationAddr, NextHopAddr)$

$StartTransmittingData(Message, NextHopAddr, TxPower)$

else

$InsertDatatoBuffer(Message)$

$InitiateRREQ(SourceAddr, DestinationAddr, Threshold)$

$StartTimer(RequestPeriod, DestinationAddr)$

end if

end procedure

Procedure SearchRouteCache(DestinationAddr)

$for\ j = 1\ to\ NumberofEntries\ \ do$

if $RouteCache[DestinationAddr] = DestinationAddr$ **then**

$Exist = TRUE$

$j = NumberofEntries + 1$

        else

            $j = j + 1$

            $Exist = FALSE$

        end if

    end for

    return $Exist$

end procedure

Procedure InitiateRREQ(SourceAddr,DestinationAddr,Threshold)

    if $RREQRetransmission \leq 16$ **then**

        $RREQRetransmission = RREQRetransmission + 1$

        $TransmitRREQ(SourceAddr, DestinationAddr, Threshold)$

    end if

end procedure

Procedure StartTimer(RequestPeriod)

    $\triangle t = RequestPeriod + CurrentTime$

    $wait(\triangle t)$

    $TimerExpire(DestinationAddr)$

end procedure

Procedure TimerExpire(DestinationAddr)

$PathExist = SearchRouteCache(DestnationAddr)$

if $PathExist = TRUE$ **then**

; $RREQRetransmission = 0$

else if $RREQRetransmission \geq 16$ **then**

$Threshold = Threshold \setminus 2$

$InitiateRREQ(SourceAddr, DestinationAddr, threshold)$

else if $InitiateRREQ(SourceAddr, DestinationAddr, threshold)$

$RequestPeriod = RequestPeriod \times 2$

else if $threshold < MinimumEnergy$

$DeleteMessageFromBuffer(DestinationAddr)$

end if

end procedure

Procedure ReceiveRREP(DestinationAddr)

$InsertInRouteCache(destinationAddr, NextHopAddr)$

$Txpower = CalculateNewTxPower(NextHopAddrAddr, Coordinates)$

$InsertInPowerTable(destinationAddr, NextHopAddr, TxPower)$

$StartTransmittingData(Message, NextHopAddr, TxPower)$

end procedure

3.4.2 A flow chart for Intermediate node to handle packet

The flow graph for intermediate node to handle the packet is shown in figure 3.4

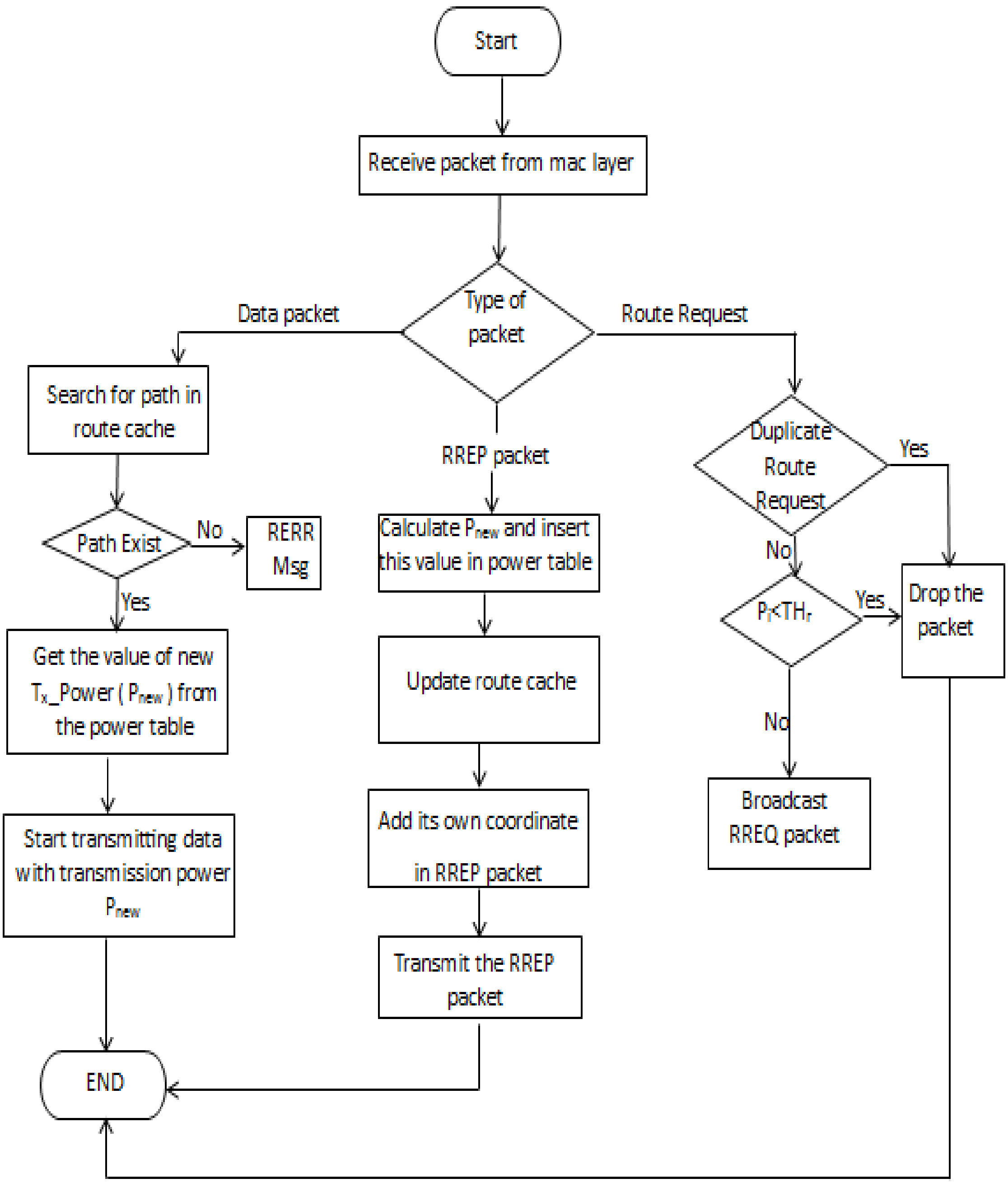

Figure 3.4: A flow chart for Intermediate node to handle packet

Alogorithm 1 Algorithm for Intermediate node to handle the packet

```
Procedure ReceivePacket(Message)
    TypeofPacket = Type(Message)
    if TypeofPacket = RREQ then
      DuplicatePacket = SearchSeenTable(sourceAddr, RREQID)
     if DuplicatePacket = TRUE then
        Discard the packet
    else
        InsertSeenTable(SourceAddr, RREQID)
        if RemainingEnergy < Threshold then
          Discard the packet
        else
          BroadcastRREQ(SourceAddr, DestinationAddr)
        end if
     end if
    else if TypeofPacket = RREP then
      CalculateNewTxPower(NextHopAddrAddr, Coordinates)
      InsertInPowerTable(destinationAddr, NextHopAddr, TxPower)
      Update coordinate and reply time in RREP packet
```

$TransmitRREP(Message)$

else if $TypeofPacket = DATA$ **then**

$PathExist = SearchRouteCache(DestinationAddr)$

if $PathExist = TRUE$ **then**

$TxPower = GetTxPower(DestinationAddr, NextHopAddr)$

$StartTransmittingData(Message, NextHopAddr, TxPower)$

else

Discard the packet

$TransmitRERR()$

end if

end if

end procedure

3.4.3 A flow chart for Destination node to handle packet

The flow graph for Destination node to handle the packet is shown in figure 3.5

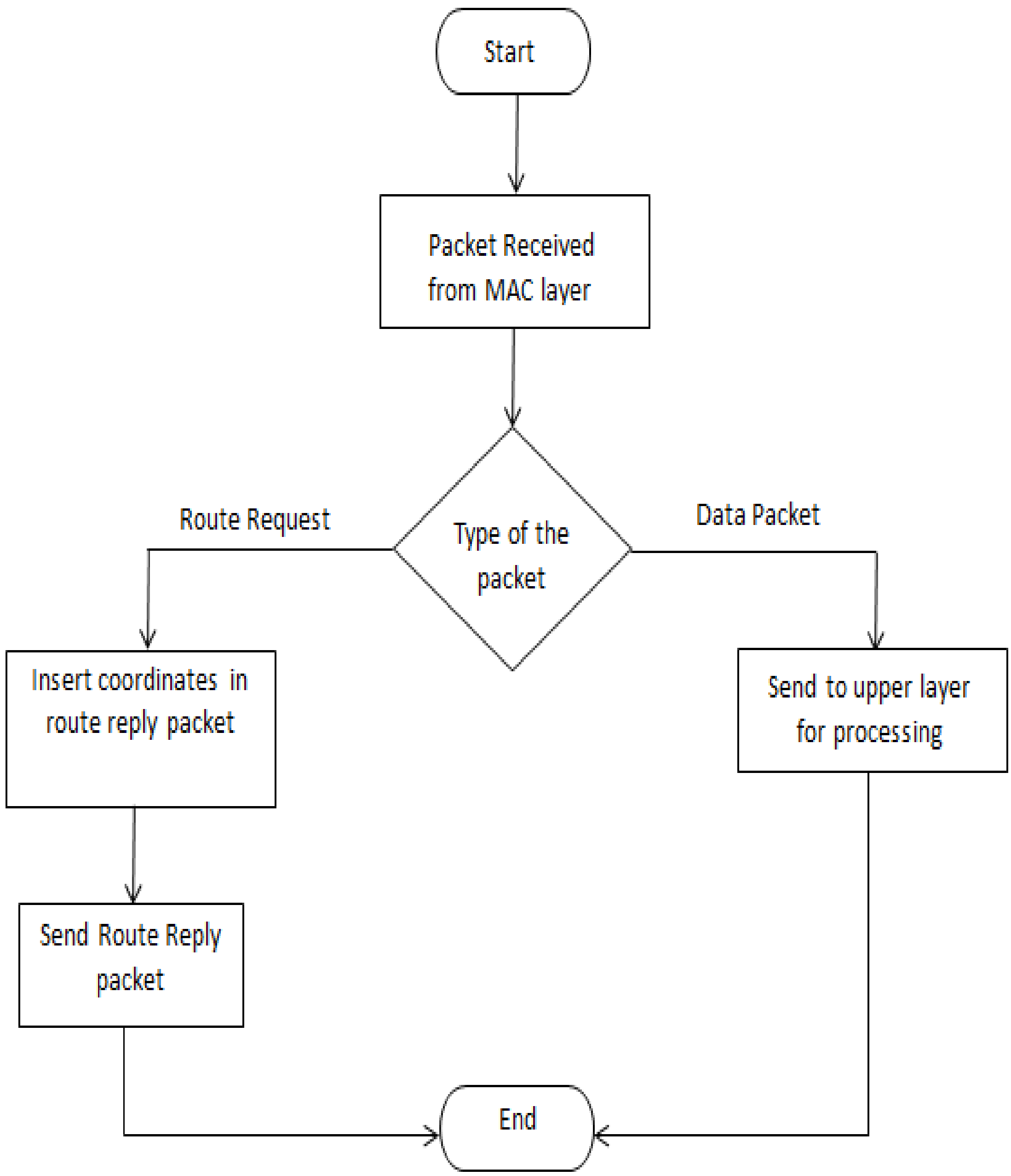

Figure 3.5: A flow chart for Destination node to handle packet

Alogorithm 1 Algorithm for Destination node to handle the packet

1. **Procedure** ReceivePacket(Message)
2. $TypeofPacket = Type(Message)$
3. **if** $TypeofPacket = RREQ$ **then**
4. $Create\ a\ RREP\ packet\ for\ source\ add\ its\ coordinate\ and\ reply\ time$
5. $InitiateRREP(SourceAddr, DestinationAddr)$
6. **else if** $TypeofPacket = DATA$ **then**
7. $SendtoUpperLayer(Message)$
8. **end if**
9. **end procedure**

3.4.4 An example of ESDSR

Fig 3.6 shows the network topology where node S is the source node and node D is the destination node. From the figure we can understand that there are basically three possible paths from node S to node D, but in order to find the energy efficient path we will discover route from node S to D using ESDSR algorithm.

(i) Route Discovery

Figure 3.7 shows that initially node S will broadcast a RREQ to all the nodes which are in the range of node S, here the neighbor nodes are 1, 2 and 4. On receiving RREQ these neighbor nodes (1, 2, and 4) will consults its route cache to find a route to the destination otherwise these neighbor nodes first compare their remaining energy (R_i) with the Threshold value (TH_r). If the

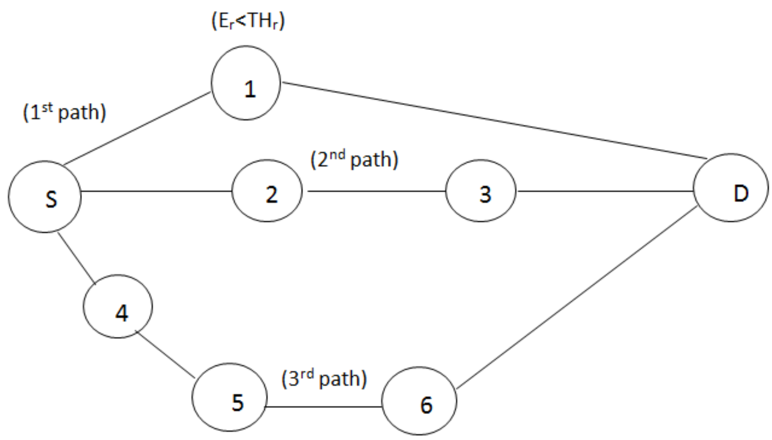

Figure 3.6: Topology of a Network

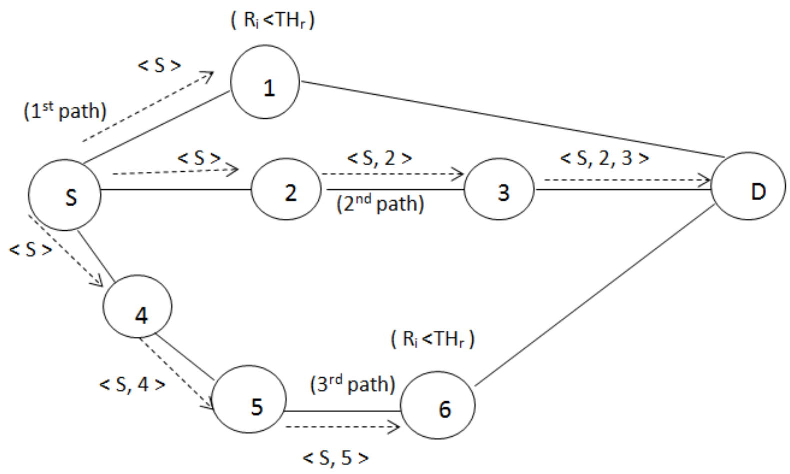

Figure 3.7: Route Discovery by ESDSR Protocol

value of R_i is less than TH_r then the node will drop the RREQ and won't participate in routing or forwarding packet. In the figure 3.7 the remaining energy R_i value of node 1 and 6 are less than THr so it will drop the RREQ packet. If the value of R_i is greater than TH_r then it will add its address to the header and then broadcast the route request totheir neighbors, and this goes on until route request reach the destination node. If a node already process a particular route request then it ignore the new received RREQ by checking its sequence number. Here in this example Ri of node 2 and 4 are higher than TH_r so they will rebroadcast the RREQ packet. In this way RREQ will travel in the network and reach to destination.

(ii) Route Reply

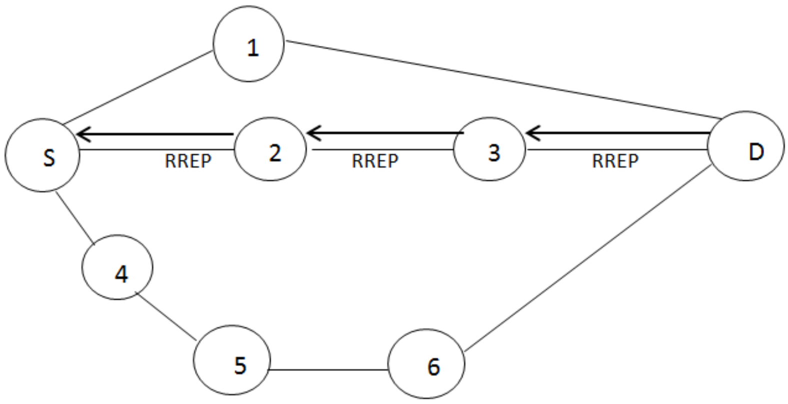

Figure 3.8: Route Reply by ESDER Protocol

When a RREQ reaches to its destination node, destination node will reply with RREP packet. When a node send a RREP packet it adds it's coordinate to the RREP packet So when the next node receive this RREP it knows the location of its successor node in the route to destination by this location information a node can determine the optimal transmission power required to communicate with its successor node in the route to the destination. The calculated power P_{new} is stored in a power table at each node and this is the minimum power required for successful communication to the next node in the route. In this figure node D replies with RREP packet along with its coordinate so when node 3 receives the RREP from node D it know the location of node D, from this location information node 3 will calculate the new power P_{new} which is the minimum power required to communicate with node D, and store this new power P_{new} in the power table. After calculating the new power P_{new} node 3 will forward the RREP packet along with its coordinate. In this way RREP will reach to node S, and now node S knows the route to D along with the minimum power required for communication.

(iii) Threshold value adjustment by a node

It may be possible that the remaining energy of all the neighbor nodes (1, 2, and 4) is less than threshold value (TH_r) in this case node S won't receive any RREP. However, node S will wait for some fix duration of time and after that it will resend the RREQ , node S will resend the RREQ packet to a predefined limit and look for RREP packet. If it won't receive any RREP packet then it will lower down the value of TH_r and resend the RREQ packet, and this process will continue until the source node finds a path to the destination node D. so here in this example the path which is discover by ESDSR algorithm will be S-2-3-D.

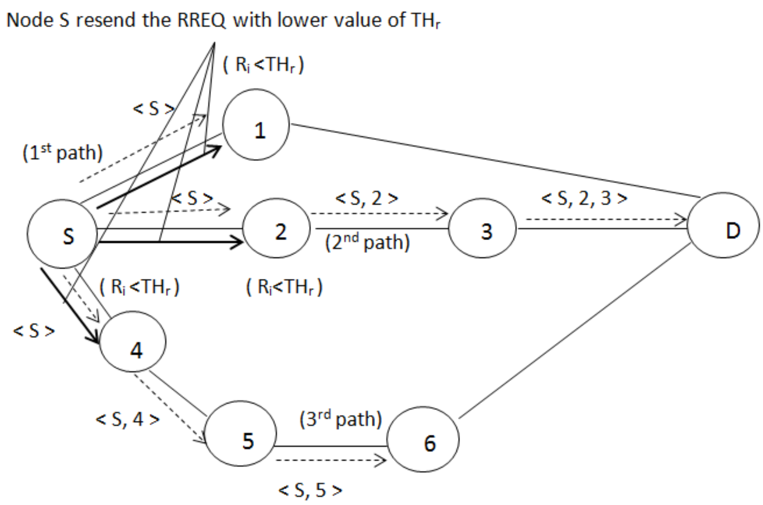

Figure 3.9: Threshold value adjustment by a node

Chapter 4

Simulation and Results

We have implemented proposed ESDSR on Qualnet 4.5 and Matlab. We have simulated the same scenario using both DSR and proposed ESDSR and observed changes in transmission range, packet delivery ratio, energy consumption by each node, and average energy consumption. From the simulation results it's clear that our proposed method ESDSR is more efficient than the existing DSR. We setup scenario with a size of 1500m × 1500m and place 50 nodes in it. The node placement strategy is random.

Table 4.1: Simulation Parameter

Topology size	1500 × 1500
Number of nodes	50
Traffic type	CBR
Packet size	512 bytes
Transmission range	$150 - 400m$
Full Battery Capacity	300 mAhr
Energy Supply Voltage	6.5 volt

4.1 Simulation Result

- **Transmission Power versus Distance**

  Figure 4.1 shows the relationship between transmission power and distance. In case of DSR protocol it is constant but in case of ESDSR protocol transmission power depends on distance. So from the fig. we can clearly see that if the distance is less, transmission power used is also less.

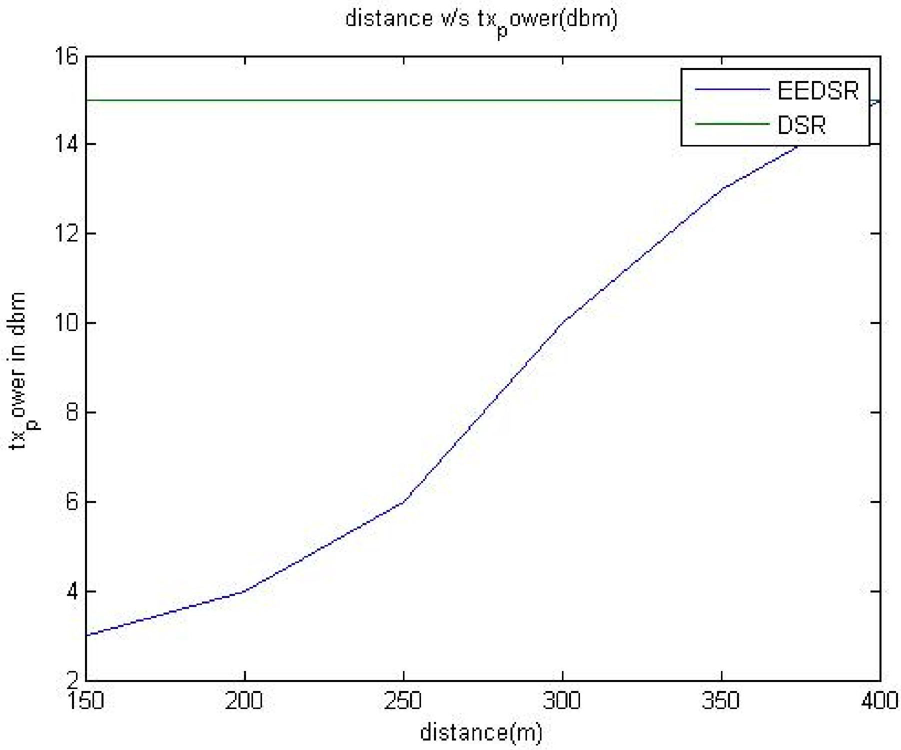

Figure 4.1: Transmission Power versus Distance

- **Energy Consumption at each Node**

  Figure 4.2 shows the energy consumption of each node in case of DSR as well as ESDSR. From the fig we can understand that the energy consumption in the case of case of ESDSR protocol is less than the DSR protocol and for load balancing ESDER protocol is using underutilized node (11, 26, 33 and 41).

Here in this scenario there are 50 nodes where node 1 is source node and node 50 is destination node and we are sending 250 packets from node 1 to 50.

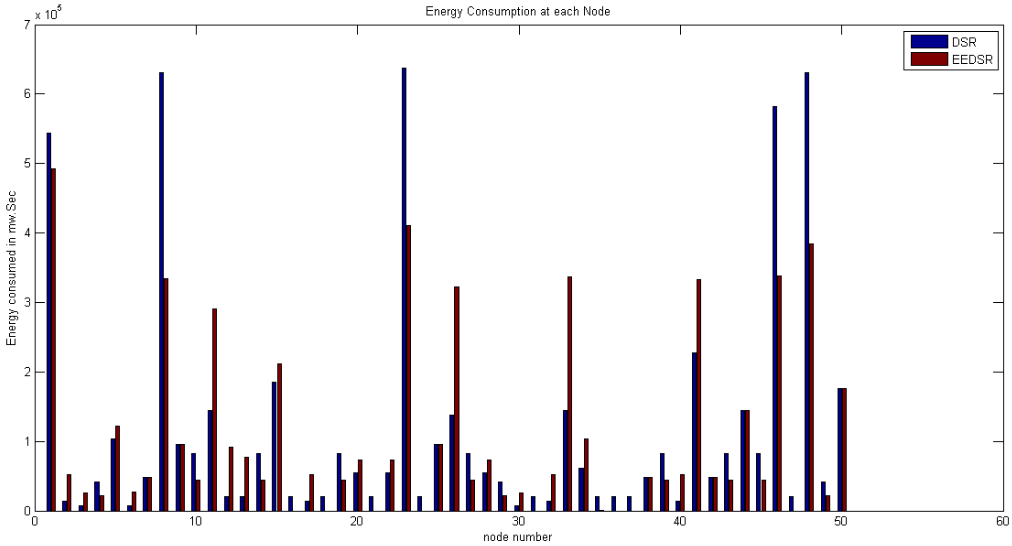

Figure 4.2: Energy Consumption at each Node

- **Average Energy consumption**

  Average energy consumption can be defined as the ratio of total energy consumed by all the nodes in the network by the number of nodes in the network. The figure 4.3 shows the graph of average energy consumption vs. number of nodes and the nodes in ESDSR will consume less energy than the nodes in DSR. The blue line shows the average energy consumption of ESDSR and red line shows the average energy consumption of DSR on different number of nodes. We compare the values of average energy consumption by sending 200 packets from randomly chosen source to destination on different number of nodes.

- **Packet Delivery Ratio(PDR)**

  Packet Delivery ratio is the ratio of number of data packets successfully delivered to the destination by the number of packet transmitted. The figure

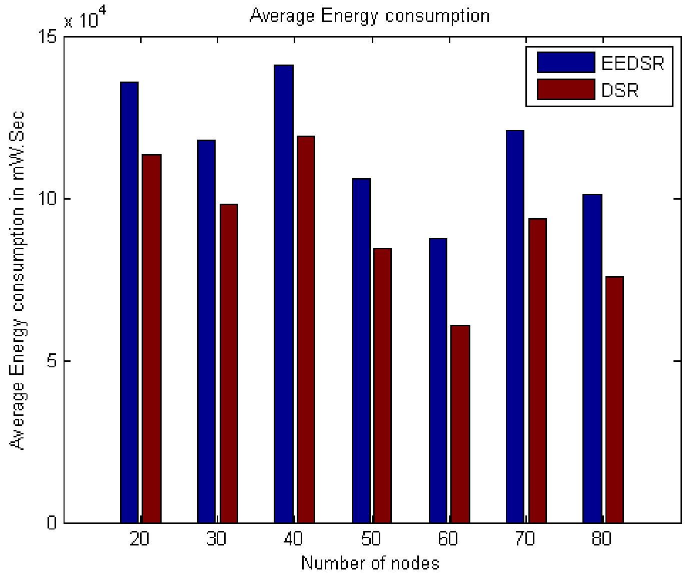

Figure 4.3: Average Energy consumption

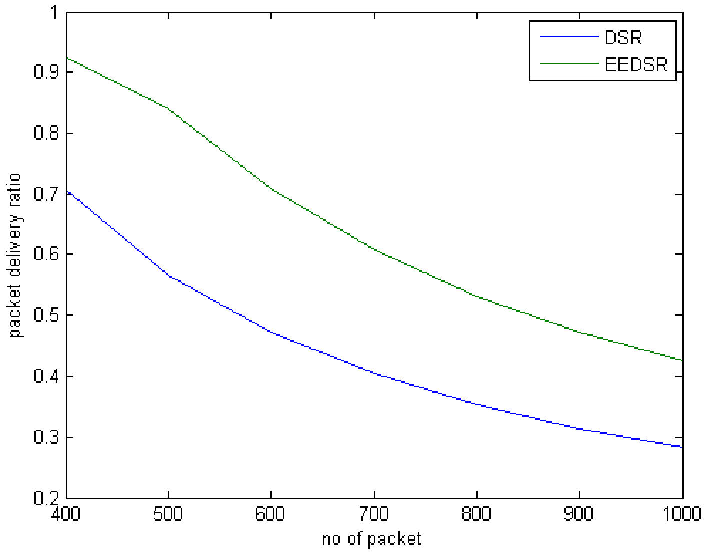

Figure 4.4: Packet Delivery Ratio

shows the better performance of ESDSR as compare to DSR. ESDSR provides considerable improvement of PDR.

Chapter 5

Conclusion and Future Work

5.1 Conclusion

In this thesis, we have evaluated the energy efficiency of the existing well known MANETs routing protocols. Routing protocol are not only used to find efficient and correct route but also it should keep network alive as long as possible means it should use nodes energy in such a way that the lifetime of network increases. To accomplish this goal we are minimizing the active communication cost of a node. Load distribution and Transmission power control these are the two approaches we are using to minimize active communication cost.

In this thesis, we have studied and analyzed DSR algorithm and proposed algorithm ESDSR to save energy which leads to higher network lifetime. The simulation results of ESDER show that the performance of ESDSR is much better than DSR according to energy consumption at each node, average energy consumption, and packet delivery ratio, average energy consumption. From the simulation results we can conclude that ESDSR works better than DSR by giving more network lifetimes or by consuming less energy as compare to DSR.

5.2 Future Work

The future work includes studying the energy efficiency of routing protocols from quality of service provisioning.The different QoS metrics includes packet loss, throughput, jitter, delay, and error rate. In future this work can be extended by including the amount of energy consumed by mobility models by varying number of sources, transmission range, node density, traffic load, and the network size.

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