A MODIFIED ENERGY EFFICIENT AD HOC ON DEMAND THREE PATH ROUTING PROTOCOL

Thesis

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By

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In this world, we come in contact with so many other people. Among these people, there are some good ones who help or support us. Acknowledgement for those might be just a trifle thing written on a piece of paper. However, we can say that it gives us a great opportunity to memorise and express our heartily feelings to those, whom we love, respect, revere and share our secrets. Now, here I get a great chance to express my token of thanks to people who in a way helped and supported me to complete this work.

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Pantnagar — *Pradeep Kumar*

August, 2015 — ***(Author)***

CERTIFICATE

This is to certify that the thesis entitled **"A Modified Energy Efficient Ad Hoc on Demand Three Path Routing Protocol"** submitted in partial fulfillment of the requirements for the degree of **Master of Technology** with major in **Computer Engineering** of the College of Post-Graduate Studies, G. B. Pant University of Agriculture and Technology, Pantnagar, is a record of bona fide research carried out by Mr. **Pradeep Kumar,** Id. No. **45636** under my supervision and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation and source of literature have been duly acknowledged.

Pantnagar
August, 2015

(RAJEEV SINGH)
Chairman
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CERTIFICATE

We, the undersigned, members of the Advisory Committee of Mr. **Pradeep Kumar,** Id. No. **45636,** a candidate for the degree of **Master of Technology in Computer Engineering** with major in **Computer Engineering,** agree that the thesis entitled **"A Modified Energy Efficient Ad Hoc on Demand Three Path Routing Protocol",** may be submitted in partial fulfillment of the requirements for the degree.

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LIST OF ABBREVIATIONS

MANET	Mobile Ad hoc Network
AODV	Ad hoc On Demand Distance Vector
e.g.	For example
Et al.	And others
Etc.	Et cetera
QoS	Quality of service
OLSR	Optimized Link State Routing
FSR	Fish-eye State Routing
i.e.	That is
DSDV	Destination-Sequenced Distance Vector
CGSR	Cluster-head Gateway Switch Routing Protocol
DSR	Dynamic Source Routing Protocol
TORA	Temporally Ordered Routing algorithm
ABR	Association Based Routing
SSA	Signal Stability-Based Adaptive Routing
LAR	Location-Aided Routing(LAR)
ZRP	Zone Routing Protocol
WARP	Wireless Ad hoc Routing Protocol
RREQ	Route Request
RREP	Route Reply
RERR	Route Error
EEAODV	Energy Efficiency AODV
ESAODV	Energy Saving AODV
OPRR	Optimized Power Reactive Routing
PCRR	Power Control in Reactive Routing
PEAODV	Power Efficient AODV
EEEAODV	Energy Efficient Enhanced AODV
GloMoSim	Global Mobile Simulation
ESR	Expending Ring Search
EDAODV	Energy and Delay AODV

EDDSR	Energy and Delay DSR
EMRP	Energy Aware Multipath Routing
AOMDV	Ad hoc On-demand Multipath Distance Vector
PAAOMDV	Power Aware AOMDV
MSR	Multipath Source Routing
TTL	Time To Live
MAC	Medium access control
NS	Network Simulator
DCF	Distributed Coordination Function
ARP	Address Resolution Protocol
ANC	Active Neighbor Count
EEAOTP	Energy Efficient Ad hoc On demand Three path
NRE	Node Residual Energy
CBR	Constant Bit Rate
NAM	Network Animator

INTRODUCTION

This chapter gives an introduction of the mobile ad-hoc network (MANET) along with shedding light on its various applications which have made them indispensable in today's world of technology and scientific research. The first section of the chapter describes MANET and clarifies the concept of MANET with examples. The second and third sections describe classification of wireless network and routing protocol respectively. Section fourth presents the motivation behind the project and section five deals with the problem formulation. Section sixth and seventh furnishes the objective and plan of the proposed work respectably. Finally, section eighth presents outline of thesis.

1.1 Introduction to Mobile ad-hoc network (MANET)

Mobile ad hoc network (MANET) represents special case in wireless networks (Figure 1.1). In this network, group of mobile nodes communicate and no centralized control is required for node communication.

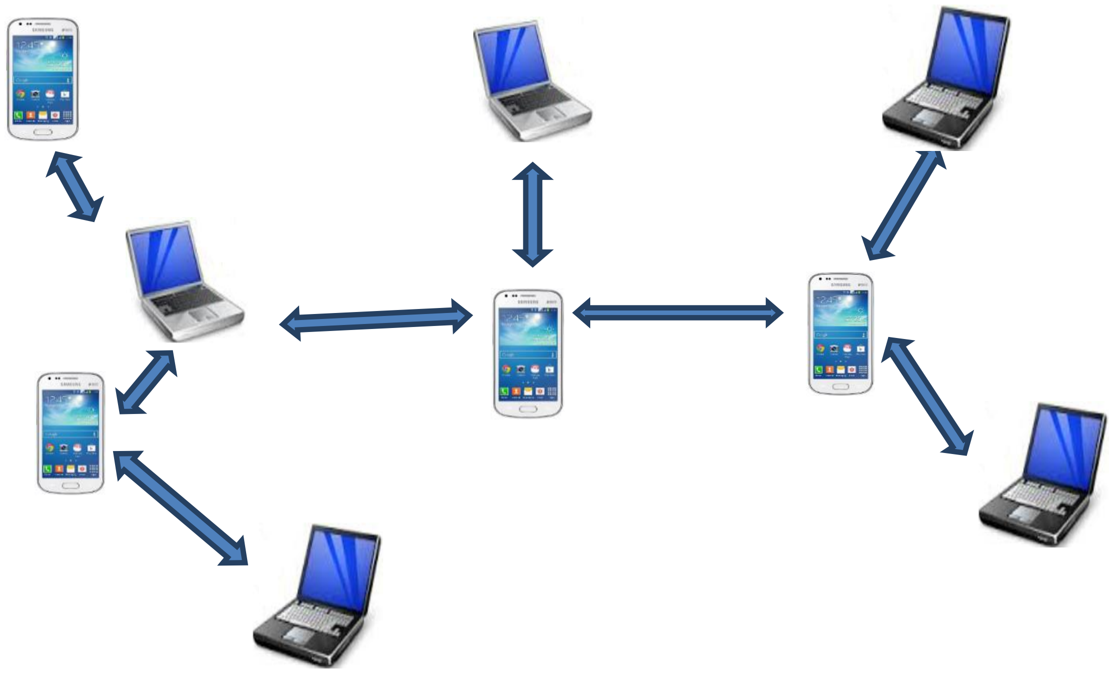

Figure 1.1: Mobile Ad-hoc Networks (MANETs)

MANET is different from conventional network as each participating node performs the role of both host and router. It is a self-organising and self-configurable network with distinguished features like dynamic topology, restricted energy capacity, unbalanced links and lack of supporting infrastructure.

Figure 1.1 shows an example of distributed wireless network termed as MANET where different nodes are communicating utilising radio waves. In this network each node communicates to other lying in its radio range. The nodes in-between act as forwarding routers and forward the packet to sink node. The information in MANET is represented in form of packets that are communicated to their peer via intermediate nodes. The intermediate nodes use store and forward methodology for communicating the packets to the destination. In MANET nodes usually enjoy mobility due to which routing information require constant updates and needs to be sent to other nodes. A large volume of such updates may result in choking of the network. Such updates should be minimized.

1.1.1 Characteristics of MANETs

There are many characteristics of MANETs as follows:

- All the nodes are mobile.
- Multi-hop routing (data are traverse from source to destination using several intermediate nodes)
- A single node acts as host and router.
- Scalability
- The capacity of wireless links is variable.
- Dynamic network topology.

1.1.2 Advantages of MANETs

The advantages of MANETs are summarised as follows:

- Setting up a MANET requires very less amount of time and can be established in any area.
- Network set up is very fast and is cheaper for the large area coverage.
- It provides effective group communication.
- At the time of disaster, a MANET is easier to establish than their wired counterpart. The places where wired network is affected by the disaster, MANET can be implemented.

1.1.3 Disadvantages of MANETs

These are summarised as follows:

- Scarcity of resources.
- Lack of security and centralized authorization.

- Problem in detection of malicious nodes due to the dynamic network topology.
- Secured wired protocols are not as such applicable for ad hoc network.

1.1.4 Applications of MANET

Some of the MANET applications can be listed as follows:

- Sharing in conferences/workshop.
- Mine site operations (coal mining, archaeology etc.)
- Urgent Business meetings.
- Military and police operations.
- Disaster relief operations.

1.1.5 Design Issues/Challenges

MANET raises some issues while designing the network topology. Some of the major considerations include:

- Power consumption, battery life and spatial reusability
- Symmetric (bi-directional) and asymmetric (unidirectional) links
- Quality of Service (QoS)
- Mobility pattern of nodes

The limited availability of the energy resources is most concerning challenge of the MANET design. In this network, each mobile node has fixed amount of battery power and its replacement is not possible during the entire network life time. A node forwards data packets on behalf of others nodes hence its failure affects both node itself and the entire network lifetime. The battery power is consumed during listening on the medium, receiving and sending the data packets. Therefore energy-efficient mobile ad hoc routing protocols should reduce energy during active communication and during ideal periods while listening to the wireless medium.

1.2 Classification of wireless network

A wireless network is two types:

(i) Infrastructure based network (Figure 1.2(a)) (**Mishra and Chinara (2012)**)

(ii) Infrastructure less network (Figure 1.2(b)) (**Mishra and Chinara (2012)**)

1.2.1 Infrastructure Wireless Networks:

Infrastructure Wireless Networks allows all the wireless node communication through third fixed party that is called a Base Station (Figure 1.2(a)).

Figure 1.2(a): Infrastructure network with base station

Both the nodes i.e., the source node and the destination nodes should lie within the transmission range of the Base Station in an infrastructure wireless communication. In this source node first notifies the base station for communication with the destination node. The base node acts as router for forwarding the packets to the destination node.

1.2.2 Infrastructure less Wireless Networks

No base station is required for communication in the Infrastructure less wireless networks (Figure 1.2(b)) i.e., a particular group of mobile nodes or terminals can directly communicate with each other. In infrastructure-less network mobile nodes forms an autonomous system and can dynamically exchange information without using any centralized administration. The intermediate mobile hosts sometimes act as normal hosts and sometimes as forwarding routers.

Figure 1.2(b): An infrastructure-less Network

1.3 Routing Definitions

Routing: In a multi-hop network, the data packets need to be sent from source to destination nodes through consisting of intermediate nodes. A process for finding the best path from source to destination is known as routing. The data packets are sent through the selected path known as forwarding.

Energy efficient routing: The process for finding the path between source and destination node in such way minimum energy is consumed during the data transmission is called energy efficient routing.

Multi path routing: A routing process in which multiple paths are selected for forwarded the data between source and destination node. Selected paths are generally sorted based on some parameters.

Energy consumption: It is an amount of energy consumed by the nodes in a network while participating in network activities and its own use such as transmitting, receiving, hearing etc.

Energy constraints: The constraint in network operation due to the limited energy in each particular network nodes is called energy constraint.

Available battery power: The amount of battery power left in individual node after participated in network process for some period of time.

Node Lifetime: The time periods in which nodes have sufficient energy to participate in useful network activities. Lifetime may be expected by using Mathematical calculations involving the present remaining energy of the node and the rate at which energy is drained from the node due to network activities. This calculated lifetime is called expected lifetime of the node.

Route discovery: The process of new route is creating from source to destination when they want to communicate to each other.

Route maintenance: Processes undertaken when an active route is found to be broken during communication time between the nodes.

Threshold: A predefined value which is compared to the current available battery power of node to determine whether the node has sufficient energy to continue participating in the network activities.

Source node: The node which transmits the data in the network is known as source node.

Destination node: The node which received the data packets in the network is known as destination node.

Unicast: A data communication technique where data is transmitted from one source node to one destination node.

Multicast: A data communication technique where data is transmitted to two or more nodes as destination.

Broadcast: A data communication technique where data is transmitted to all the nodes as destinations which are connected to the source node.

Network traffic: Network traffic is the data transmitted through the network.

Shortest path: The path selected from source to destination should be minimum time for transmission of data packets.

Hop count: A parameter evaluated by counting the number of hops (intermediate nodes) participating in a path to reach the destination node.

Cost function: Cost function is a mapping between an event or mapping to a real number which quantitatively represents the cost associated with the event. The goal is to minimize the cost as much as possible.

Energy history: The record of the energy state of a particular node in the network at specific interval of time.

Energy drain rate/Energy discharge rate: It represents energy consumption rate of the node.

1.3.1 Routing Protocols for MANETs

Three categories of classification exist for MANET routing protocols: (1) Table-driven routing protocols, (2) On-demand routing protocols and (3) Hybrid routing protocols. These are shown in Figure 1.3 along with some examples.

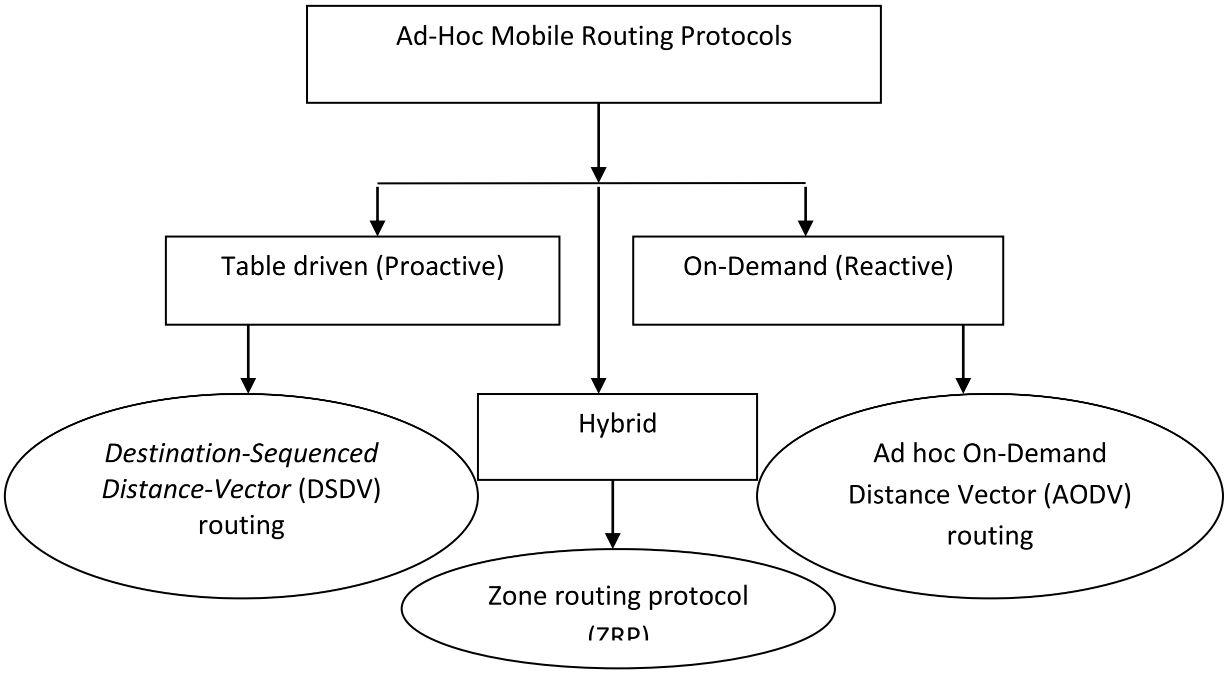

Figure 1.3: MANET Routing Protocol classification (**Bhatt and Upadhyay (2013))**

1.3.1.1 Proactive Protocols or Table Driven routing protocols

Table Driven routing protocols utilize routing table updates and hence are also known as table driven routing protocols. Each node maintains the routing information of all other nodes in the network even before it is needed thus justifying the term proactive. Upon change in the network topology the routing information also gets changed. The proactive routing protocols are not suitable for larger networks, because they need to maintain node routing information for each and every node in the routing table for each node. This causes more overhead in the routing table leading to consumption of more bandwidth and energy.

Examples:

- Optimized Link State Routing (OLSR)
- Fish-eye State Routing (FSR)
- Destination-Sequenced Distance Vector (DSDV)
- Cluster-head Gateway Switch Routing Protocol (CGSR)

1.3.1.2 Reactive Protocols or On-Demand routing protocols

In reactive Protocols, route discovery is initiated whenever data transmission is required. As the route is established when required, these protocols are termed as on-demand routing protocols for establishing the connection for transmitting and receiving the data packets, the flooding of the route request data packets is done throughout the network. Thus, initial delay during data transmission occurs in on-demand routing process.

Examples:

- Ad hoc On Demand Distance Vector (AODV)
- Dynamic Source Routing Protocol (DSR)
- Temporally Ordered Routing algorithm (TORA)
- Associativity Based Routing (ABR)
- Signal Stability-Based Adaptive Routing (SSA)
- Location-Aided Routing Protocol (LAR)

1.3.1.3 Hybrid routing protocols

Proactive and reactive routing protocols have some advantages and disadvantages. Hybrid routing protocol is combination of both proactive and reactive routing protocol to overcome the disadvantage these protocols. It includes the benefits of both protocols. For example facilitating ad hoc on demand distance vector (AODV) protocol with some proactive features by refreshing routes of active destinations at some interval would definitely reduce the overhead and delay. Thus revive interval can improve the performance of the network and nodes. These protocols can fit in the facility for other protocols without compromising with their benefits.

Examples:

- Zone Routing Protocol (ZRP)
- Wireless Ad hoc Routing Protocol (WARP)

1.3.2 Properties of Ad hoc Routing Protocols

There are many Ad hoc Routing protocols as follows:

I. **Distributed operation:** Each node should independently function without control of a centralized controlling node and can enter or leave the network as and when required.

II. **Loop free:** Loop routes waste of bandwidth or CPU consumption. Hence, routing protocol assure loop freeness in routes.

III. **Demand based operation:** This means the protocol should respond only when needed and should not periodically broadcast information and hence avoid network resource wastage.

IV. **Unidirectional link support:** Utilization of unidirectional as compared to the bi-directional links improves the routing performance.

V. **Power conservation:** The nodes in the Ad-Hoc network supports standby mode during ideal time.

VI. **Multiple routing:** In presence of another valid stored route, the routing discovery procedure initiation is controlled thus reducing the discontinuation in transmission.

VII. **Quality of services support:** Quality of service is necessary for real time traffic support.

1.3.3 Problems in Ad hoc routing protocols

I. **Asymmetric links:** the symmetric links which are always static are generally used in wired networks. But this is not used in the ad hoc networks because each node is mobile and regularly changing its location in the networks.

II. **Routing overhead:** In wireless ad hoc networks the nodes keep on changing their positions due to which unnecessary routing overhead is caused.

III. **Interference:** This is the main problem in mobile ad hoc network node might overhear transmission of other nodes. Also, transmission of one node might interfere with that of other due to shared wireless medium.

IV. **Dynamic Topology:** The topology of MANET is not constant i.e. keeps on changing. The mobile node might move or medium characteristic might change. Routing tables and algorithms must adopt such changes dynamically. In a fixed wired network a routing update usually gets generated every 30 second which might be very low for ad hoc network.

1.3.4 Ad hoc On-Demand Distance Vector (AODV) Routing protocol

The AODV routing protocol is an enhancement of DSDV routing protocol. It falls in the category of reactive protocols which means routes are created on-demand and only required. This minimizes the network level broadcast. The route is entry checked in table when source node needs to transmit data. AODV is a single path, loop- free and distance vector protocol based on hop-by-hop routing method. The three main components of AODV include:

1. Route discovery
2. Route maintenance
3. HELLO – For link status monitoring

Route discovery: The route discovery procedure is initiated whenever route to destination is required. For this routing table is checked for existing path to destination. If route exist, packets are forwarded through it else a new route discovery process is started. Route discovery is initiated by sending a Route Request (RREQ) data packet which contains the following fields: Source node’s current sequence number, Source node’s IP address, Destination sequence number, Broadcast ID number, Destination IP address.

Broadcasting is done through flooding and waits for a route reply (RREP) packet. An Intermediate node receiving a RREQ packet set a reverse route entry to the source in its route table. Reverse route entry consists of following fields: Source IP address, Source seq. number, IP address of node number of hops to source node from which RREQ was received. When the destination node receives a RREQ packet, it also generates a RREP packet. The RREP is routed back to the source via the reverse path. When this RREP reaches to source, a forward route to the destination node is created.

Route maintenance: AODV uses error messages for route maintenance when a node upon detecting a broken route to the next hop route error (RERR) message is generated and sends to related nodes RERR contains a list of unreachable destinations. A new route discovery process may be initiated later for detecting another route.

HELLO – For link status monitoring: Hello messages are used with the intention to identify and monitor the link status (Fig. 1.4) these are sent regularly at fixed interval to all neighbour nodes. If any node do not hear Hello packet from its neighbour it understands that the link break has occurred.

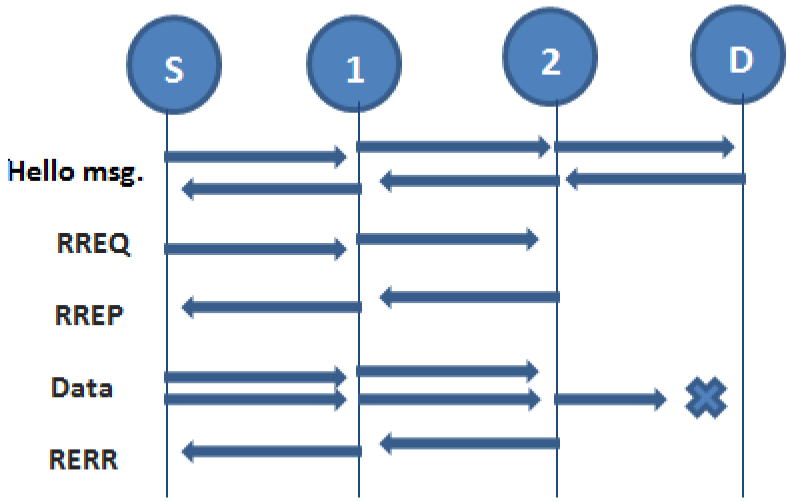

Figure 1.4 AODV protocol messaging

Timers associated with the routes are updated as data transmits from the source to destination. If a particular route is not used for some specific period of time then node removes invalid route from its routing table.

For on-going transmission when a link break is detected, a Route Error (RERR) message is sent to the source as per reserve path. As the RERR is forwarded toward the source, each intermediate node invalidates routes to the unreachable destinations. When the source upon receiving the RERR, source invalidates the route and re-initiates route discovery following are the fields of each route table entry in AODV:

- Destination IP Address
- Destination Sequence Number
- Valid Destination Sequence Number flag
- Other state and routing flags (such as valid, invalid, repairable, being repaired)
- Network Interface
- Hop Count (number of nodes between source and destination)
- Next Hop
- List of Precursors
- Lifetime (expiration or deletion time of the route)

The sequence numbers are used in AODV for avoiding routing loops. Even when a node is no longer reachable due to link failure the sequence numbers play important role when a link breaks or is deactivated. When a destination becomes unreachable the route is invalidated by using the sequence number and marking the route table entry state as invalid.

1.3.5 Characteristics of AODV

- Possibility of Unicast, Broadcast, and Multicast mode communication.
- Small delay due to on-demand routing.
- Path breakages are efficient maintained.
- Use of sequence numbers ensures loop freeness.
- Accuracy of information is tracked via Sequence number.
- Only keeps track of next hop for a route instead of the entire route.
- Hello message generated at periodic intervals for tracking neighbours.

1.3.6 Advantages and Disadvantages

The main advantage of AODV is that route is established when needed and Sequence number is used to find the persisted route to destination. It reduces the delay in connection setup. The Hello message is used to supporting the routes maintenance between the nodes.

One of the disadvantages of this protocol is that intermediate nodes can lead to inconsistent routes if the source sequence number is too old and the intermediate nodes have a higher source sequence number.

1.4 Motivation

Wireless technology is gaining popularity mainly due to low cost use, establishment and high mobility. These wireless networks namely LAN, cellular network and ad hoc network are frequently used for data communication. Cellular network involve WAN technologies and hence are costly. WLANs use infrastructure for communication and hence required setup and establishment cost. Ad hoc network on the contrary are easy to use, establish and involve low cost. Thus ad hoc networks are gaining special attention of the researchers.

The motivation behind this work is to make an energy efficient algorithm for MANET. In the proposed work a modified multipath routing protocol is implemented based on AODV routing protocol so that the resultant modified energy efficient multipath is improved.

1.5 Problem formulation

Topology of MANET is highly dynamic. This is because of node mobility due to which the on-going communication gets interrupted. In the shared medium overhearing other nodes may result in energy loss. Energy loss may even result due to packet loss, congestion, mobility of nodes, traffic and network size, receiving of data, transmitting the data. All nodes have limited battery power and cannot be recharged every time and place. Therefore, it is important to realize the consumption problem in MANET routing protocols due to traffic and link failure in routing protocols requires special attention.

1.6 Objective

The objective of the proposed work includes:

1. To study the existing routing protocols in MANET.
2. To improve:- a). Energy efficiency, b) Network throughput and, c) Delay in Energy Efficient AODV (EE-AODV).

1.7 Plan of proposed work

Energy plays a very crucial role in MANET because in MANET, nodes are mobile and therefore, nodes cannot be recharged at any random place or time. After studying various papers related to the formulation of energy efficient routing protocols in MANET, this work concentrates upon making energy efficient protocol and improving the performance parameters like reducing delay and increasing throughput of existing on-demand routing protocols. The two popular on-demand routing protocols are dynamic source routing (DSR) protocol and ad-hoc on demand distance vector routing (AODV) protocol were considered. Among them, the AODV routing protocol is selected to implement the proposed scheme because of the following advantages: 1) AODV does not create necessary traffic and refreshes information quickly. 2) AODV performs better in highly mobility and lord scenarios. 3) AODV more scalable.

1.7.1 Proposed work

This thesis is an extension of EE-AODV routing protocol to three paths AODV routing protocol based on minimum threshold energy. Threshold level of energy is considered at individual node level. Depending on the threshold level proposed protocol selects nodes having energy higher than minimum threshold condition. If any node reaches less than minimum threshold level then that node informs source to choose a new path for the remaining communication. The nodes with more energy than the minimum threshold energy are only considered in the new path. Thus, the proposed protocol saves the node from getting dead completely such that low energy alive node which can be used in future for some crucial communication. Best three paths are chosen which have maximum energy from all the discovered paths and data is sent simultaneously from source to destination over these selected paths on the basis of remaining energy. 50% data is sent by higher energy path and remaining 50% of data is sent by the remaining two paths i.e. the remaining two paths contain 30% and 20% data with respect to their energy level.

1.8 Thesis Outline

This thesis is organized as follows. The first chapter describes the background, problem statement and objectives of the study. The second chapter discusses some related works on the problem of energy efficient AODV routing protocol. Chapter three provides detailed information of the methodology and tools used in this study. In chapter four obtained results are presented and comparative analysis of the applied methods is discussed. In chapter five a general summary and conclusion of this study is described.

REVIEW OF LITERATURE

In this Chapter a review of the various research works in the field of AODV routing protocol in mobile ad-hoc network (MANET) is presented, which proved helpful in the development of the proposed work.

Ad hoc On-Demand Distance Vector (AODV) is a routing protocol for mobile ad hoc networks (MANETs). It is developed by University of California, Nokia Research Centre,University of Cincinnati and Santa Barbara by S. Das, E. Belding-Royer and C. Perkins in 2001.

2.1 Review related to energy efficient single path AODV routing protocol

S. Tang et al. (2004) In this work Authors proposed energy saving AODV routing protocol (ES-AODV) to improve AODV routing protocol for reducing the energy consumption. ES-AODV protocol calculates excess energy of nodes and each node participates in route evaluates its weight which is directly inverse proportion with its energy and it always uses local repair to minimizes the energy of the source node for route re-establishment. To adjust the emission power of node dynamically the power controlled method was used and it selects the route which has minimum hop count for transmitting the data packets from source to destination. So that it can improve the life time of nodes and the energy consumption of nodes in the network.

Yonghui Chen et al. (2010) proposed an Energy Efficient Routing Protocol by using the concept of energy of node and stability of topology in network. In this protocol at the time of route discovery, the source node takes the energy of hops and left over energy of the intermediate nodes. When the results were simulated, the proposed protocol performs better than AODV protocol.

T. Poongkuzhali et.al. (2011) proposed an Optimized Power Reactive Routing (OPRR) protocol. The protocol is based on AODV and it is for Mobile Ad-hoc Network. Optimized Power Reactive Routing (OPRR) technique is used by the author. This Protocol describes the concept of AODV protocol and cognitive function of the protocol. The data packets are transferred from the shortest path in a reliable mode, which improves the data transmission.

Maher Heniet al. (2012) proposed Power Control in Reactive Routing (PCRR) Protocol for MANET. The proposed work minimize the regular period of HELLO messages generated by the AODV protocol used for the search, development and maintenance of routes. These ideas reduce the overhead of network and are useful for battery power levels of nodes. This proposed protocol also focuses on the shortest and safe path in terms of energy.

Shayesteh Tabatabaei et. al. (2012) proposed Power- Efficient AODV (PEAODV) routing protocol for the enhancement of throughput in MANET. In PEAODV, to select the optimum path, authors uses a new cost function and the left over energy of the nodes in path, and the path stability in accordance with rate mobility of node and along with available bandwidth and radio frequency.

Kanna and Saradha (2013) proposed an Energy Efficient Enhanced AODV (EEEAODV) routing protocol. It maximizes the lifetime of Ad hoc Networks. Optimal energy routes are used by the authors to reduce the energy consumption of nodes. HELLO messages of AODV are used by the author to calculate the difference between receiving power and transmitting power. It gives the value of propagation loss.

Rupali Mahajan et al. (2013) The author proposed an energy efficient route discovery process for AODV based on ERS (expending ring search) and showed the simulation results using Global Mobile Simulator (GloMoSim). In this work, the redundant re-broadcasting of the RREQ packets is avoided and hence the node energy is saved. The broadcasting of the RREQ packets by the neighbours, decides the relaying status of the node. Thus, during the route discovery process it reduces the overhead in network.

2.2 Review related to energy efficient multipath AODV routing protocol

Lee and Gerla (2001) proposed Dynamic Load-Aware Routing (DLAR) in Ad-Hoc Networks. Authors extend multipath dynamic MANET on-demand (DYMO). By selecting the alternative routes from source to sink, it reduces the traffic and reduces consumption of battery power of route. Due to of multipath extension, there are several routes for data transmission between source and destination and hence any alternative path can be obtained when current route is breaks. It reducing the delay but requires large memory for saving larger routing tables.

Meng Li et al. (2005) proposed a cross-layer optimized energy aware multipath routing protocol (EMRP) in MANET. It uses the energy aware multipath routing protocol. By sharing the information among the network layer, the MAC sub-layer and the physical layer, EMRP utilizes the network resources for example, bandwidth of link and energy of node. It is a cross-layer design and hence, EMRP utilizes the information from the physical layer and the MAC layers to select better routes.

Jin-Man Kim and Jong-Wook Jang (2006) proposed an enhanced AODV routing protocol. The goal of this work is to increase the networks lifetime in MANET. Authors used Energy Mean Value (EMV) algorithm for maximizing the network lifetime. This algorithm only considers node energy.

Yumei Liu et al. (2008) proposed multipath routing protocol for mobile ad hoc networks, called MMRE-AOMDV. It is extension of the ad hoc on-demand multipath distance vector (AOMDV) routing protocol. This protocol compares minimum residual energy of each route then; it arranges multi-routes in descending nodal energy form and selecting route which has higher residual energy. This route is used to forward remain data packets. This improves the battery power consumption of each node and hence increase lifetime of whole network.

Vinay Rishiwal et al. (2009) proposed power-aware routing protocol. This protocol minimizes the power consumption and maximizes the network lifetime while route establishment process between source and destination. This algorithm maintains less congested and energy efficient path between source and destination and hence transfer the data efficiently. This algorithm uses the different paths for different type communication. Thus, it improves the network lifetime.

Dhurandher et al. (2009) proposed an energy efficient ad hoc on demand routing(EEAODR) protocol for mobile ad hoc network. EEAODR is an improvisation on AODV protocol that calculates the routing path by considering power level of all the nodes. This protocol is proposed to increase the life time of the network. EEAODR makes use of the alternate paths to increase the network life. Here different paths are used depending on the optimality function of the routing path. A node in the network loses energy in transmitting, receiving, processing as well as when it is in idle state. The amount of energy that a node spends in any transaction depends on the nature and size of packets, and the distance between source and destination. The path having minimum cost is select for effective data transmission.

Shalini Puri et al. (2009) proposed a modified Ad hoc On-demand Multipath Distance Vector (AOMDV) routing protocol. When link failure occurs this protocol utilizes it as alternate path. In the modified AOMDV protocol both hop count value and queue length are together used for selection of route between source and destination that avoids congestion. When queue length exceeds its maximum value then alternative path is used for load balancing. If routes are already congested, intermediate nodes avoided broadcast of route request packets. The proposed protocol avoids congestion, balance the load and link failure and enhances packet delivery ratio and throughput and reduces the packets loss.

Tekaya, M. et al. (2010) Author proposed a new protocol LB-AOMDV (Load Balancing-AOMDV) to improve the performance of network. It is based on concept of load balancing and use of multiple paths for data transmission. It gives the solution for enhance the capacity of network and control the congestion of network.

Santhiet S. et al.(2011) proposed a power aware multipath routing protocol by modifying Ad-hoc On Demand Multipath Distance Vector protocol (AOMDV). In this, authors concern Energy consumption problem in wireless mobile network. By reducing the requirement of power for establishing the connection between source and sink, the lifetime of network can be improved. Authors avoid major problem of the loop formation and reduces congestion in the network.

Rajaram and sugesh (2011) proposed a Power aware ad hoc on demand multipath distance vector (PAAOMDV) scheme for power efficient routing protocol. In this protocol all nodes keeps an Energy Reservation Table (ERT) but not route cache as existing AODV protocols. ERT contain the following entries i.e. Request id, Source id Destination id and amount of energy reserved, route and last operation time. The basic operations of PAAOMDV include maintenance of route and transmitting the data packets. When route is created, source starts transmitting the data packets to the sink.

Frikha M. et al. (2011) proposed a new mechanism of energy constrained routing protocol based on AODV (ECBAODV) which is based on local decision of the nodes and used the concept of saving the energy of nodes having very less energy by using the concept of threshold energy. In on-demand ad hoc algorithms, when source or destination made a final decision for finding the path then all nodes participate in the route discovery process.

Nawel Bendimerad al et. (2011) proposed the multipath routing technique for wireless networks. The objectives of this work reduce the energy consumption of nodes and network stability during link failure. In this protocol multiple paths served many purpose (i) For reliable data delivery using alternate route (when the current path fails a source selects the alternative path) (ii) By using several paths at the same time for load balancing.

Seema Verma et al. (2012) proposed optimized energy aware routing (OEAR) for energy efficient routing protocol. In this protocol energy of the node considered while selecting the route during route discovery process and also takes into account the number of packets buffered in the node. The protocol worked in on-demand manner and selects the most stable path out of all possible paths between source and sink.

Annapurna P. Patil et al. (2013) utilized difference cost matric in AODV for proposing a novel energy efficient routing protocol. For evaluation of average energy consumed, network lifetime, packet delivery ratio, convergence time and throughput, performance metrics are used. In this protocol Energy conserved by toggling between two parameters: - 1) remaining energy capacity, 2) the transmission power.

Palav V. N. et al. (2014) proposed a modified AODV routing protocol and termed it as Energy Efficient Ad-hoc On Demand Vector Routing protocol (EE-AODV). They define the threshold energy level of each node and the nodes that satisfy the threshold level are only considered in paths. EE-AODV uses energy efficient algorithm that have two phases: energy survival phase and energy saving phase. In EE-AODV packets are forwarded from source to destination through the path which has a high energy which leads to improving the performance of network by increasing network lifetime.

MATERIALS AND METHODS

This chapter elaborates various techniques and tools that have been employed in the development of the proposed EEAOTP routing protocol. First section presents materials and the software tools that have been used for the realization of the proposed approach. Section two focuses on the comprehensive outline of the various techniques used for proposed approach. Section three presents the proposed algorithm and some pseudo code of proposed protocol.

3.1 Tools Used

The following sub section describes the software used for evaluating the proposed system.

3.1.1 Software Used

NS2 is the main software that is used in formalizing the proposed work. Linux is used as a platform and basic utilities of this platform are also used.

3.1.1.1 Simulator Choice

We studied and compared NS-2, OPNET and GloMoSim, the simulation software and among them NS-2 simulator was chosen for the simulation purpose.

3.1.1.2 Comparison among Ns-2, GloMoSim and OPNET simulators

Table 3.1: Comparison of Ns-2, GloMoSim and OPNET

	Free	**Open Source**	**Programming Language**
NS-2	Yes	Yes	C++, TCL
GloMoSim	Limited	Yes	Parsec
OPNET Modeller	No	No	C

Table 3.1 compare the three simulation software's. Among these NS-2 is chosen because of the following advantages.

1. NS-2 is freely downloadable, open source and most widely used for MANET simulators. It runs on Linux platform and hence is easy to build and modify.

2. Several communities and researchers have provided the extension to NS2 and such extensions are easy to implement and merge with NS2.
3. The recent MANET work is mainly published in NS2 which make NS2 platform use indispensable in simulations.

3.2 Proposed System

In the EEAODV, route discovery process finds multiple paths using RREQs. It takes into account the threshold energy of each intermediate node for choosing the paths and these all paths are save in source route table. The data packets are send by shortest path, if that path is failed then alternative path is selected for continuously sending the data packets. Here, in the proposed EEAOTP, route discovery process finds multiple paths using RREQs. It also takes threshold energy of each intermediate node for finding the multiple paths but it selected the best three paths which have higher energy and data packets are send all three path simultaneously in the percentage of 50-30-20 respectively. If one path breaks, data packets are sending by remain two paths in the percentage of 60-40 respectively. If two paths break then all the data are send on remain single path to maximize the lifetime of lifetime of the network.

3.2.1 Operation of proposed EEAOTP

The EEAOTP protocol has been implemented based on AODV protocol. The AODV protocol is considered in the class of on-demand routing protocol in which routing process takes place hop by hop and each node has a route table in which received packet's information are saved. As discussed earlier in the introduction, the proposed EEAOTP tries to determine all possible paths from source to destination in order to send data packets simultaneously. Concisely, the proposed EEAOTP counts the number of active neighbours for each path, and finally it chooses three paths for sending information in which each path has higher energy. In these top three paths, the number of packets will be divided with the percentage of 50-30-20 respectively and send the packets in all the selected top 3 paths simultaneously. Here, active neighbours of a node are defined as nodes that have previously received the RREQ. In this protocol, there is no possibility that source and destination choose another path to exchange information. So if one link fails, it split the packets in the ratio of 60-40 and if two paths fail, all the packets will be sent through one path.

The Energy Efficient Ad hoc On-demand Three Path (EEAOTP) routing protocol is reactive routing protocol similar to AODV in MANET. So in EEAOTP, three paths are find based on energy level by broadcasting a route request (RREQ) to discover a route in a reactive manner. In EEAOTP the difference is that a field for the number of paths with energy is used in the route table. Each intermediate node sets up a temporary reverse link in the process of a route discovery. This link points to the node that forwarded the route request. Hence, the route reply (RREP) message can find its way back to the originator when a route is discovered. When intermediate nodes receive the route reply, they can also set up corresponding forward routing entries and the destination sequence number is used in the RREQ packet and RREP packet to prevent old routing information being used as a reply to the newest request. A higher sequence number denotes a more recent route request and route maintenance in EEAOTP is similar to AODV but there are three paths. Advantage of EEAOTP is that it is a loop-free protocol due to the destination sequence numbers associated with routes. EEAOTP is called reactive protocol which sends the packets to the destination in a fast manner with three paths having high energy. The packets are split in the ratio of 50-30-20 to avoid the packet losses. This protocol avoids the Bellman-Ford count to infinity problem.

3.2.2 Experimental materials

In AODV implementations, routes discovered are kept in the route table cached at the intermediate nodes. Upon receiving a RREQ packet the intermediate node update cache entry and returns a RREP packet. However, in the proposed EEAOTP, intermediate nodes don’t need to maintain Route Cache table. Therefore, more RREQ packets will reach to destination node. In the EEAOTP protocol, each node must keep the received RREQ specifications in the route table which is called Route_seen, in order to reply to the neighbour questions properly for monitoring the link. Also, to count the active neighbours with high energy in each path, in the Route_seen table, every node has a field named "total high energy neighbours after sending RREQ (Total_ANC)" and Also has the ActiveNeighborCount field name is added to the headers of RREQ and RREP to make next nodes of the path aware of the number of neighbouring nodes in traversed nodes.

Whenever source realizes that it does not have valid route to destination, it initiate a route discovery process. Route discovery involves sending RREQ packet to the neighbour node with high energy. The RREQ packet has ActiveNeighborCount field with initial value as zero. The neighbour nodes of the source upon receiving RREQ packet places the path information into the routing table. They mark themselves as route creator in the table. Before resending the RREQ the neighbour verifies that their neighbours have not seen this packet earlier. For those neighbours who have seen RREQ previously, ActiveNeighborCount field value in RREQ packet is increased. This interaction between neighbours is facilitated by Hello packets that are periodically exchange between nodes. Neighbouring nodes search the specification of RREQ in Route_Seen before answering Hello packets. If the time expires and reply is received, the node that has broadcasted the RREQ packet continues with the route discovery. It is possible for a node to receive multiple RREQ packet, In such a case the discovery of only the new possible neighbours is initiated i.e., only new neighbours need to consider the query important while previous one remains non-reactive to these queries. Nodes keep the address and details of RREQ packet and requesting node in Route_Seen table. For the first time, it sends a hello packet is returned after recording a query's specifications. The ActiveNeighborCount field of RREQ packet counts the exact number of routes with respect the energy level and this information is utilized at source node. The source node calculates the energy level of each node via Energy_Table that contains energy level of all the nodes. Accordingly energy level of each path is updated. Finally, it finds the top three paths which are having high energy. Source can choose those RREPs from received ones that have the lowest ActiveNeighborCount with highest energy and send information simultaneously through these three paths. For this purpose, the source node sets a clock after receiving the first RREP packet and waits for receiving the rest of RREP packet. After the timer expires, it selects paths with less ActiveNeighborCount.

3.2.3 Method for Obtaining Node Energy

AODV protocol records the only neighbours node ID in the routing table during the discovery process. EE-AOTP enhances the routing table structure by adding nodes residual energy along with node ID of neighbours. EE-AOTP appends the NRE (node residual energy) field to indicate the nodes residual energy into the Hello packet. Based upon the information received from neighbour via Hello message, the neighbour node's residual energy, data is updated.

3.2.4 Residual Energy Calculation

The residual energy is the remaining energy at every node which is the energy left after the packet transmission. The residual energy R_E can be calculated by using the following Eqn. (3.1). (**Aye and Aung (2014)**)

$$R_E = E_I - E_C(t) \qquad \text{........ (3.1)}$$

Where E_I is the initial energy of a node and $E_C(t)$ is energy consumed by a node after time t. Total energy consumption T_{EC} of node is defined as the following equation

$$T_{EC} = E_I - R_E \qquad \text{........ (3.2)}$$

3.2.5 Optimization of Routing Updates:

Routing update optimization mainly has two aspects: the setting of node energy threshold and the selecting of the next hop. Because of the difference of nodes energy consumption, nodes energy threshold T were set. T is the minimum critical value of nodes that is 40% of initial value of node. When the intermediate node received the RREQ packet, the node will compare NRE with T. The routing process is carried out according to the following steps:

Step 1: NRE <T, the intermediate node will send routing update message to the source node and according to the energy level of paths, the source node will choose backup route for data transmission.

Step 2: NRE >T, intermediate nodes transmit and receive information from its neighbour nodes normally.

3.2.6 Total Energy of a path

This is the sum of energies of the all the nodes which participate in route between Source and Destination.

3.2.7 Residual Battery Power of a Node

This parameter indicates the power left in a node.

3.2.8 Route Discovery Process

Two fields are added in format of the Route Request and Route Reply packets. The Route Error packet format is remaining same. Similar to traditional multipath protocol, sequence numbers are used to ensure the freshness of the routes avoiding routing loops in the network.

3.2.8.1 Route Requests

When source node want to communicate with the specific node and not have a valid route in its routing table then it generates one Route Request (RREQ) packet and broadcasts it. When a node receives the RREQ packet, it creates or updates a reverse route which is needed in case the node receives an eventual RREP back to the node which originated the RREQ (identified by the Source IP Address). After updating its reverse route it rebroadcast RREQ packets to its neighbours. This process will continue till RREQ packet reach to the destination node.

3.2.8.2 Route Replies

When a destination node determines that it can reply to the RREQ, it creates a RREP packet and unicasts the RREP to the source node. If the node receives another RREP packet after it forwards the first RREP towards the source node, it will forward the later RREP only if it has a greater sequence number. Once all the necessary updates are completed, intermediate node forwards the RREP to the source node. After transmitting the RREQ, the subscribing node waits until the route discovery period is over before selecting routes. During this period, it keeps track of the best three routes.

3.2.9 Route Selection Criteria

The destination node waits for a certain time T_{wait} till all route requests are reached to the destination. The destination node compares the destination sequence number, ActiveNeighborcount, E_{min} and E_{sum} of a route in the RREQ packet received in the routing table and then selects the top three route with maximum energy and minimum number of ActiveNeighborcount.

3.2.10 Algorithm/process of EEAOTP

Step1: Find the initial energy of each node and define the threshold energy level of nodes.

Step2: Find the residual energy of each node and maintain energy of each node in a table.

Step3: If energy of a node is within threshold, enter node into routing table.

Step4: If energy of a node is not within threshold, don’t allow the node into routing table.

Step5: Find the multiple paths from source to destination.

Step6: Select the three paths which are having higher energy level.

Step7: Send the data packets from source to destination by using those three paths simultaneously in the ratio of 50-30-20 with respect of energy level of paths.

Step8: If one path is broken, data is sent on remaining two paths 60% and 40% with respect to energy level of paths.

Step9: If two selected paths are broken then all the data is sent on the remaining single path.

3.3.11 Methodology diagram

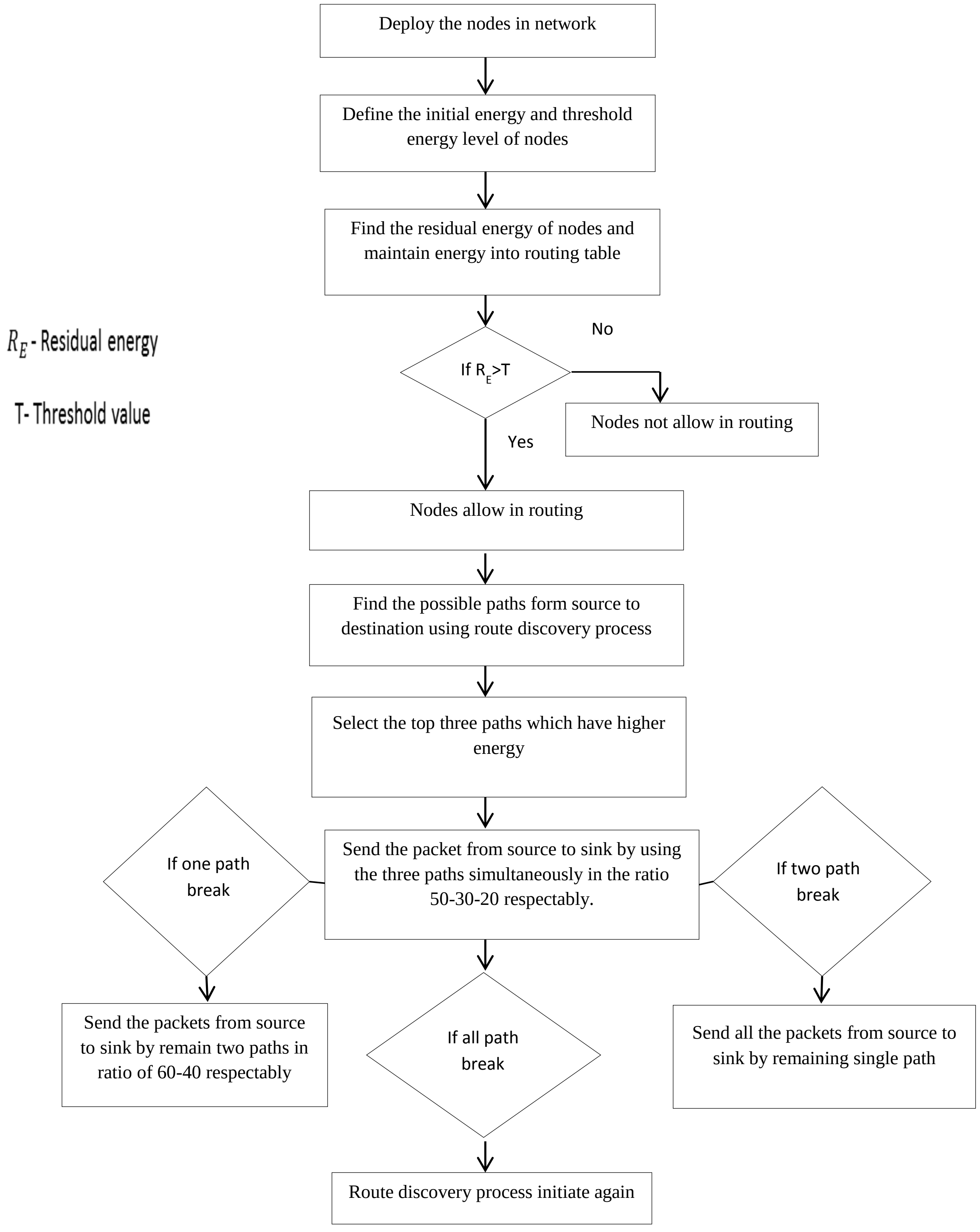

Figure 3.1: Methodology diagram

3.3.12 Experimental Methodology

The energy saving routing approach which is adopted in EEAOTP has enhanced the RREQ handling process. EEAOTP considers node's remaining energy as a routing metric. The RREQ process for EEAOTP to achieve higher energy efficiency is as below:

1. The route discovery process is initiated whenever a source node wants to communicate with another node and it does not have any valid routing information in its table.
2. Every node maintains two separate fields: a node sequence number and a broadcast id. We assume that intermediate nodes receive one RREQ and discard other RREQ using these fields.
3. However we allow destination nodes to accept more than one route request. Meanwhile intermediate nodes obtain current node energy information and add to E_{sum} field. This process is continued until destination node receive RREQ packet.
4. Upon receiving first RREQ packet, destination node will update in its routing table. If there are better energy route received, destination node will continue updating its route table.
5. All routes that satisfy an energy condition are added to unicast RREP. Then destination node unicast RREP to the source node reversely after getting route information with satisfying condition.
6. After receiving RREP, source node selects top three paths which have higher energy and then sends data through these higher energy routes.
7. Packets will be split in the ratio of 50-30-20 and taking the top three paths.
8. If one path fails, it sends the packets in two paths with the ratio of 60-40.
9. If two paths got link failure, it will send all the packets in a single path.
10. When a node sends and receives data packet, the network interface of the node decrements the available energy according to Eqn. 3.6 and Eqn.3.8, where

    Energy in transmit mode (Etx) = txPower × txtime …… (3.5)

    Energy Remaining (Enode) = current energy – Etx …… (3.6)

    Energy in receive mode (Ercv) = rcvPower × rcvtime … ... (3.7)

    Energy Remaining (Enode) = current energy - Ercv …… (3.8)

    Where, txPower is transmission power, txtime is transmission power
    recPower is receiving power and rectime is receiving time.
11. The same process will be finding the Top Three paths based in the Energy level when route discovery process initiate again.

RESULTS AND DISCUSSION

This chapter presents the results that have been obtained using proposed approach and shows the comparison with other approaches. This chapter is divided into two sections. In first section, the simulation environment is described and in second section result analysis is included.

4. 1 Performance evaluation

Network simulator (NS2.34) a discrete event driven simulator is used as described in chapter 3 for simulating EEAOTP experimental network.

4.1.1 Simulation Environment

All the three routing protocols i.e EEAOTP, EEAODV and AODV use the network simulator (NS) version 2.34 over Cygwin as a platform for simulation. An area of 1000 × 1000m is considered for simulation, the time duration for the simulation is taken as 10 seconds. The Random Waypoint mobility model is used. Each individual node function as per the IEEE standard 802.11 along with exhibiting distributed coordinated functionality at the MAC layer. The node has transmission coverage area of 250m and its data transmission rate is taken as 2Mbps. Source node transmits following constant bit rate with 512bytes UDP packages per second. The received power and transmitting power of node were considered as 395mw and 660mw respectively. These were in accordance to the energy consumption model of Wave LAN PC/Card**. (Yang T. et. al.(2005))**

Initial energy of each node during simulation was taken as 100 joules. A total of 6 traffic connections were considered. NS2 has inbuilt energy mode for tracking the residual energy of the node. The same model was considered in our simulations. The trace generated after simulation was saved in a file an later AWK script was used to plot the graph from the stored trace data. The graphs for residual energy, no. of nodes, PDR. Delay etc. for the network were plotted.

For visualizing the node topology and connection statistics the default Network animator (NAM) tool was used. NAM showed packet transmissions and routing table broadcasts with great details and resolution (Figure 4.1 and 4.2). The simulation parameters considered during simulation along with their values are as shown in table 4.1.

Table 4.1: Simulation parameters with specific values

Parameter	Value
Simulator	NS-2.34
Channel Type	Wireless Channel
Propagation Model	Two Ray Ground
Mobility Model	Random Waypoint
Dimension of Simulated Area	1000×1000m
Queue Type	Drop Tail
Antenna	Omnidirectional
Initial Energy	100J
Simulation Time	10s
Radio Range	250m
Bandwidth	2Mbps
Packet Size	512Byte
MAC Layer	IEEE 802.11
Traffic Size	CBR (Constant Bit Rate)

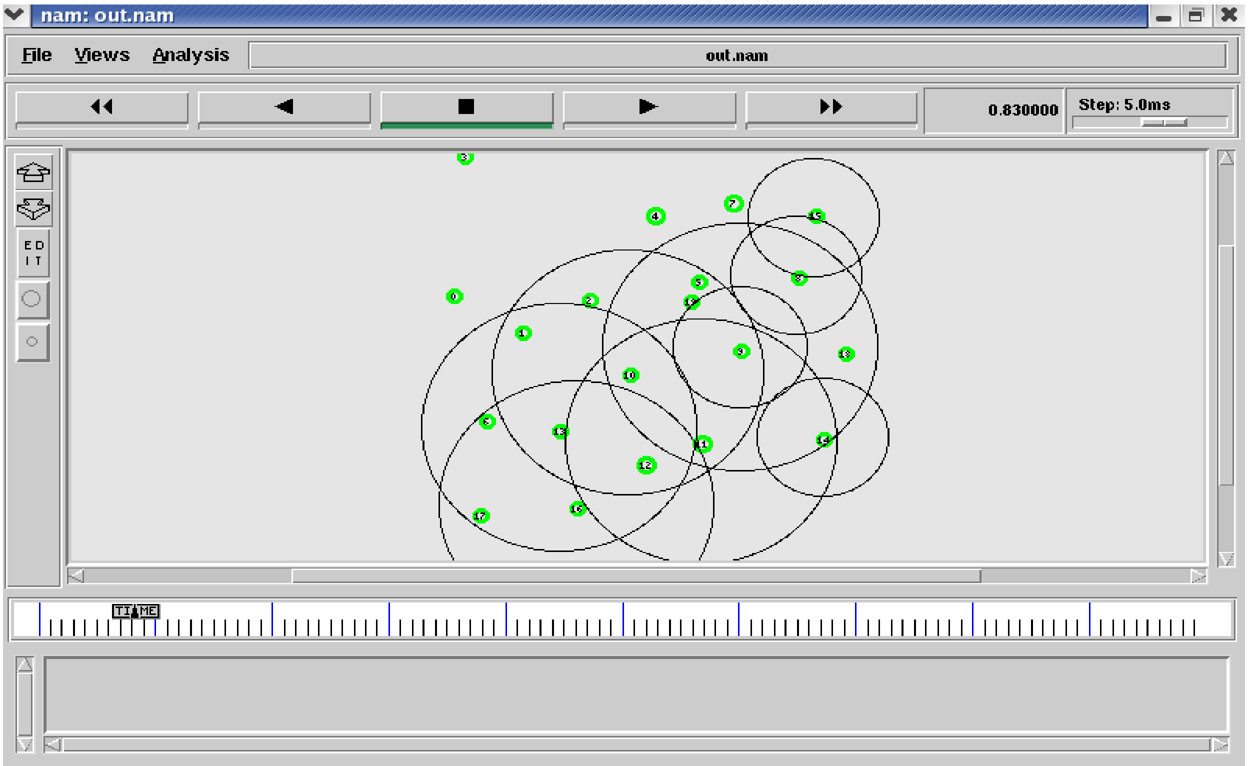

Figure 4.1: A screenshot of 20 nodes EEAOTP NAM-Network Simulator

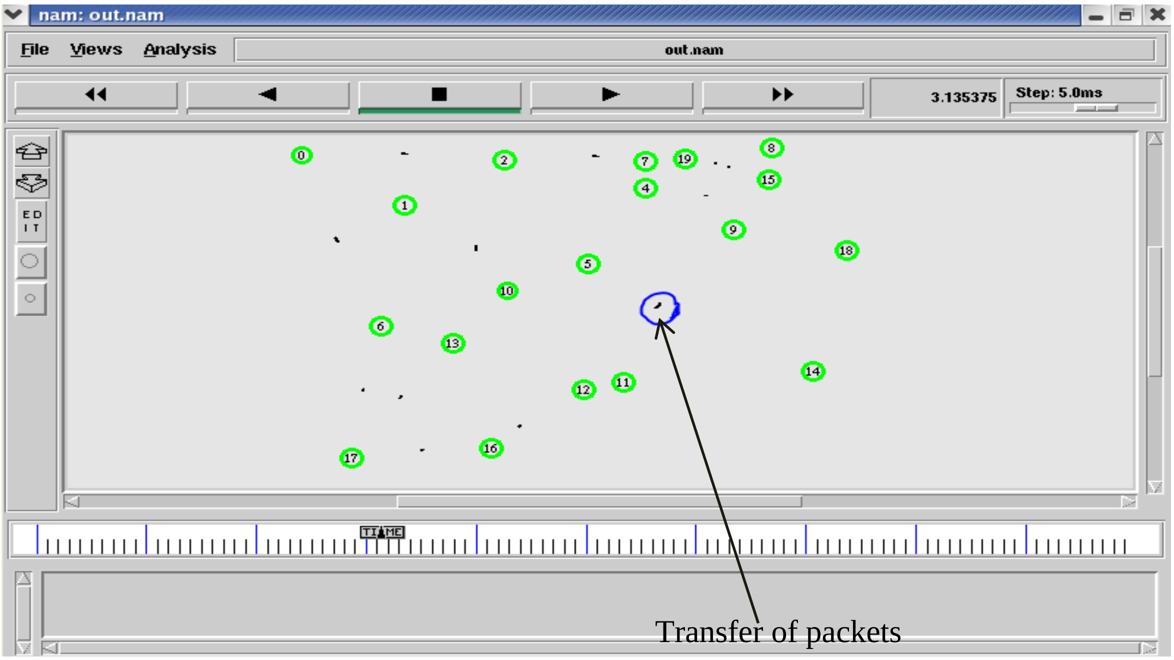

Figure 4.2: A screenshot of 20 nodes during packets transfer EEAOTP NAM-Network Simulator

4.2 Performance Results

The AODV, EEAODV and proposed EEAOTP on various parameters were simulated and the graphs obtained by AWK script are shown for the comparison purpose. Following performance metrics are evaluated.

1. **Packet delivery ratio-** PDR represents the ratio between the number of packets sent and the number of packets received.
2. **End to end delay-** Time taken by a packet to finally reach the destination node.
3. **Throughput-** Measured in bits per second (bps) for successful packet delivery.
4. **Energy consumption**-Energy consumption refers to the average amount of energy spent while transmitting data packets from source to sink.
5. **Packet loss –** Refer to no. of packets that were lost during communication.

4.2.1 Packet delivery ratio (PDR)

The simulation is conducted with 10 to 100 nodes for comparing performance of AODV, EEAODV and EEAOTP protocols and the result is shown in Figure 4.3. The x-axis represents number of nodes and y-axis represents packet delivery ratio (PDR) in percent (%).The EEAODV shows high PDR than AODV and EEAODV during the data transfer between source and sink pair because EEAOTP consider top three path having high energy and send data packet simultaneously in ratio of 50-30-20 respectively. So EEAOTP reduce the congestion or traffic on paths, link failure problem and the possibility of restarting the route discovery process. Since the AODV is having less PDR it shows the packet losses are quite high in AODV. This is an important drawback in AODV.

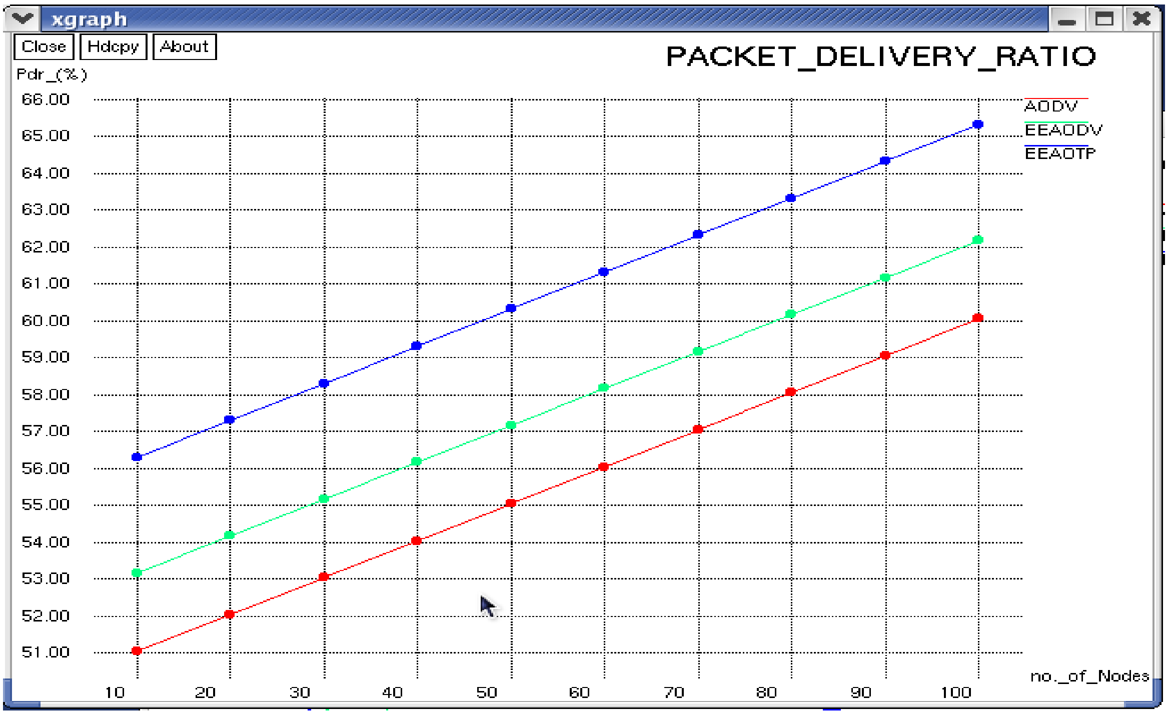

Figure 4.3: Packet delivery ratio among AODV, EEAODV and EEAOTP

Packet delivery ratio increase in all the protocols as the numbers of nodes increased because distances amongst nodes get decreased, signal strength is increased and possibility of path stability also increased. We can say that the performance of network lifetime gets better by increasing the number of nodes because destination node is able to receive data over higher energy routes. Thus, node's lifetime is extended by using energy saving routing protocol. For 10 to 100 nodes, it shows successful packet delivery ratio. From graphs, it is clear that EEAOTP plays an important role in extending node's lifetime and improved the data transfer.

4.2.2 End-to-end Delay

This metric represents average end-to-end delay, indicates how long it took for a packet to travel from the source to the application layer of the destination. It includes all possible delay caused by buffering during route discovery latency, transmission delays at the MAC, queuing at interface queue, and propagation and transfer time. It is measured in seconds. The result of End-to-End delay among AODV, EEAODV and EEAOTP are shown in Figure 4.4. The x-axis represents number of nodes and y-axis represents end-to-end delay in millisecond (msec).

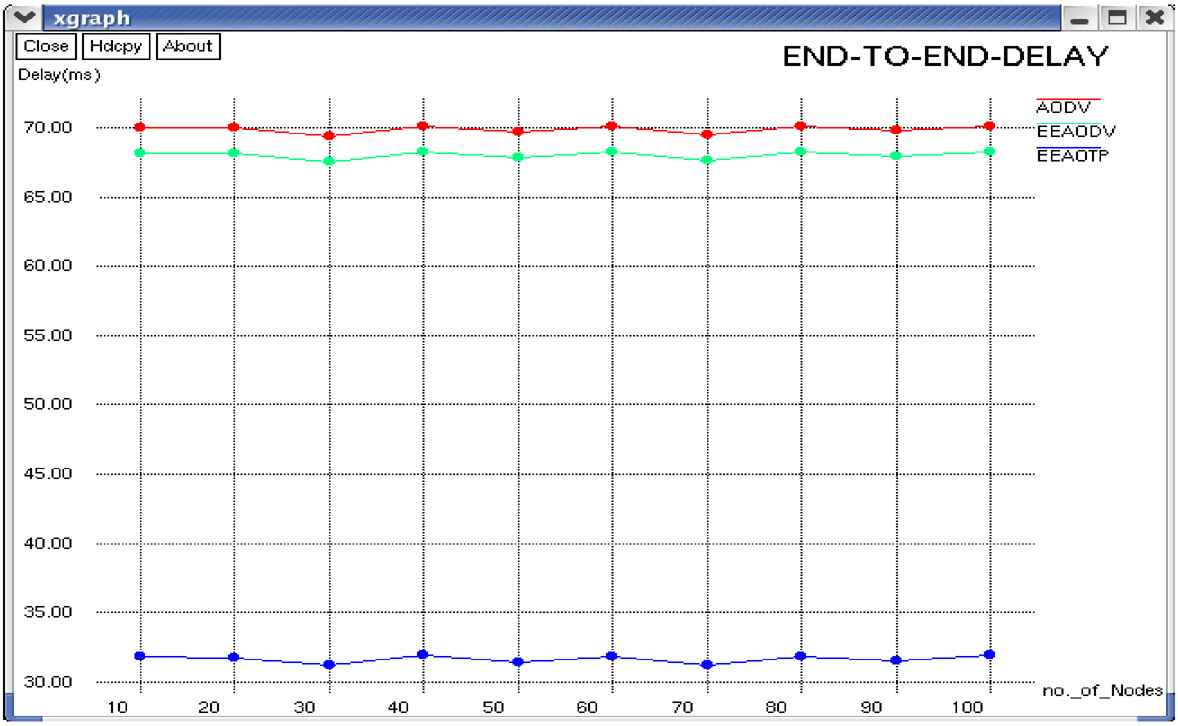

Figure 4.4: End-to-End delay among AODV, EEAODV and EEAOTP

Compared to AODV and EEAODV; EEAOTP is improved in the end-to-end delay. Due to the three-path of improved protocol, the source node does not need to re-initiate the route discovery process but select the backup route for data transmission directly when the transmission link is broken. So the reliability and stability are highly improved with three paths, transmission delay is shorten (It is depicted in Figure 4.4).

4.2.3 Throughput

Graph (Figure 4.5) shows the average throughput comparison for AODV, EEAODV and EEAOTP. The average throughput of EEAOTP is higher than all other protocol because EEAOTP selected the three paths having high energy for simultaneously data transfer source to node. Due to these three paths traffic or congestion is reduced and higher energy will increase the network capability to transmit the data to the destination node for a particular interval of time.

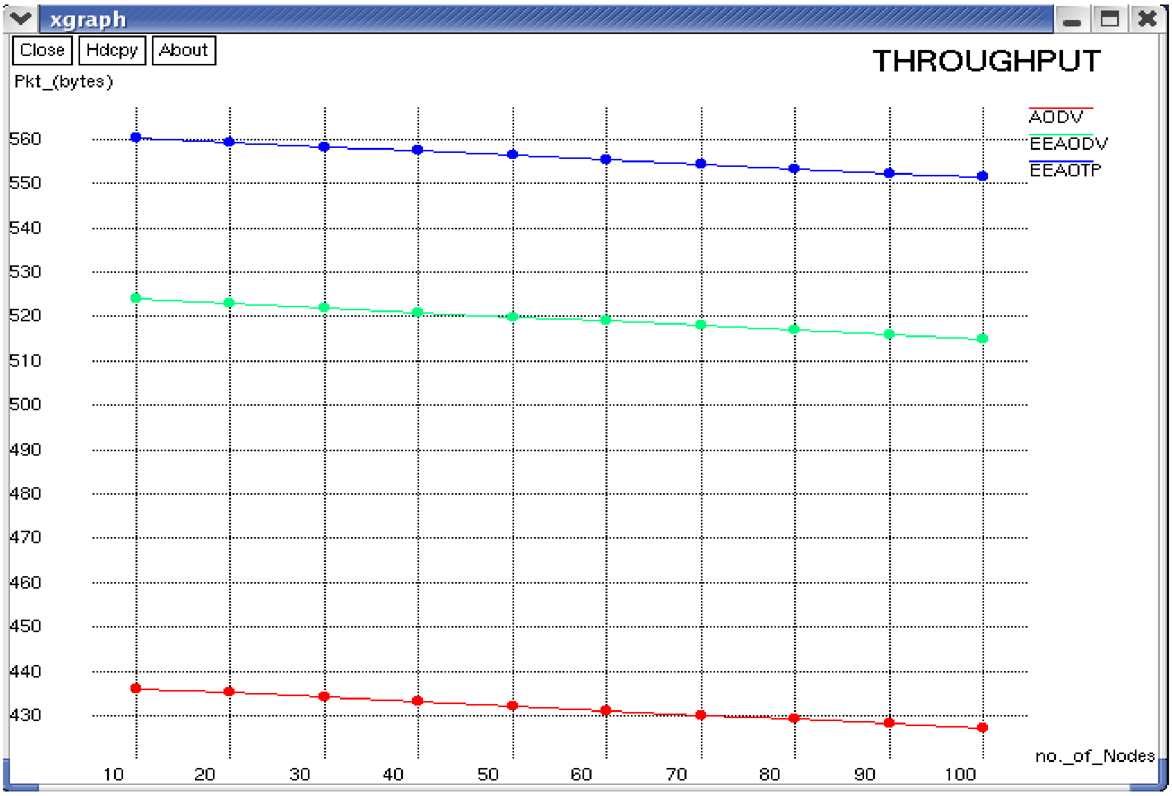

Figure 4.5: Throughput comparison among AODV, EEAODV and EEAOTP

The first two metrics i.e., PDR and End-to-End delay are the most important for best-effort traffic. Note, however, these metrics are not completely independent because delay decrease then PDR increase. So we conclude that EEAOTP increased the PDR to increase the quality of services in the network.

4.2.4 Energy consumption

Energy consumption graphs (Figure 4.6) show the energy consumed by AODV, EEAODV as well as proposed EEAOTP. This show that our proposed protocol performs better than AODV and EEAOD.X-axis represents number of nodes and y-axis represents energy consumed in Joules (J).Figure show that the proposed EEAOTP reduces the energy consumption than AODV and EEAODV even when number of nodes are increased because EEAOTP reduces the overhead in the network by reducing the link breakage problem of AODV and route discovery process by considering three paths having high energy.

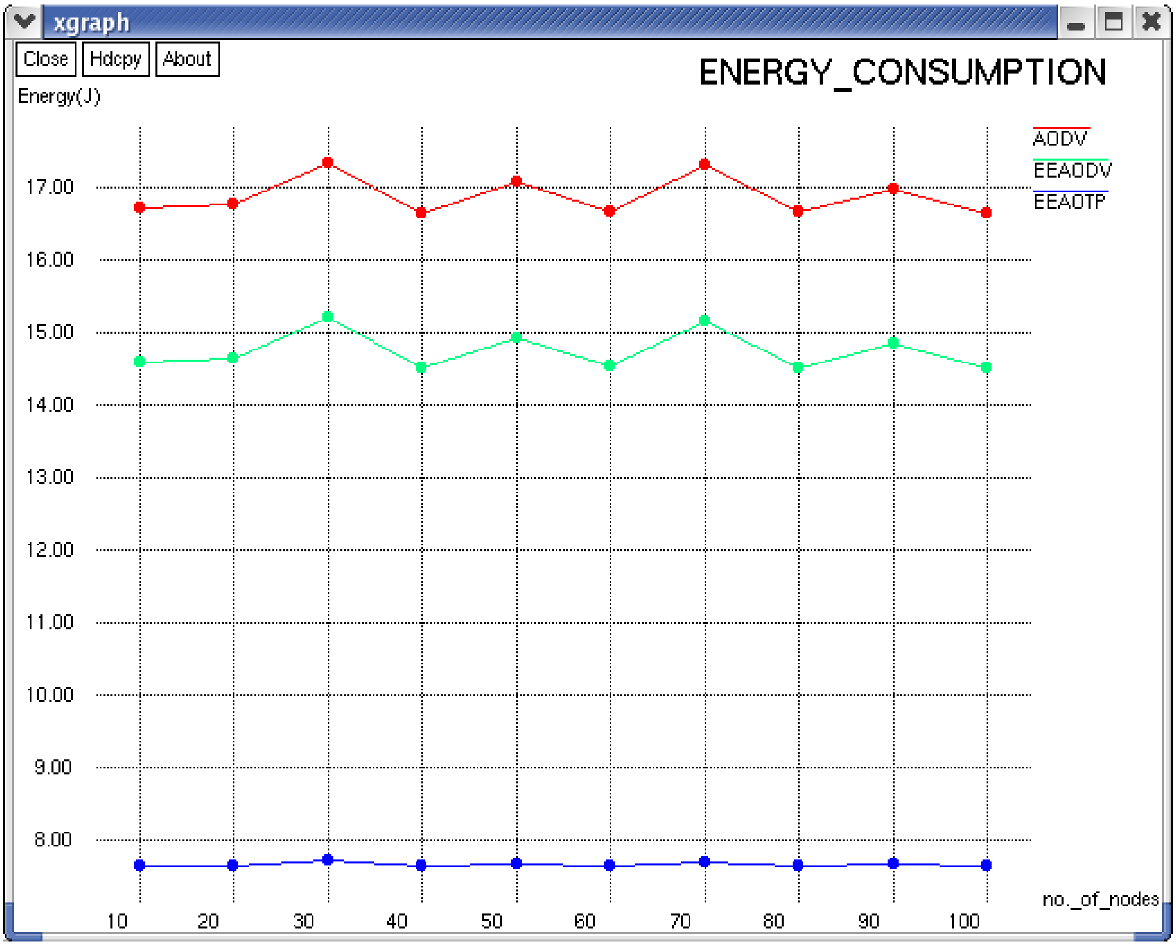

Figure 4.6: Energy consumption among AODV, EEAODV and EEAOTP

The energy consumed of EEAODV reduced by the average of 9.20 % than AODV and 7.07 % than EEAODV.In the graphs the energy consumption is fluctuating due to the link failure or again re-initiating route discovery process. So it is concluded that EEAOTP prolong the lifetime of network.

4.2.5 Packet loss

The comparison of packet loss among AODV, EEAODV and proposed EEAOTP is shown in Figure 4.7. EEAOTP perform better than existing two protocols as shown in the graphs. The number of nodes represents by x-axis and packet loss represents by y-axis (in Figure 4.7).

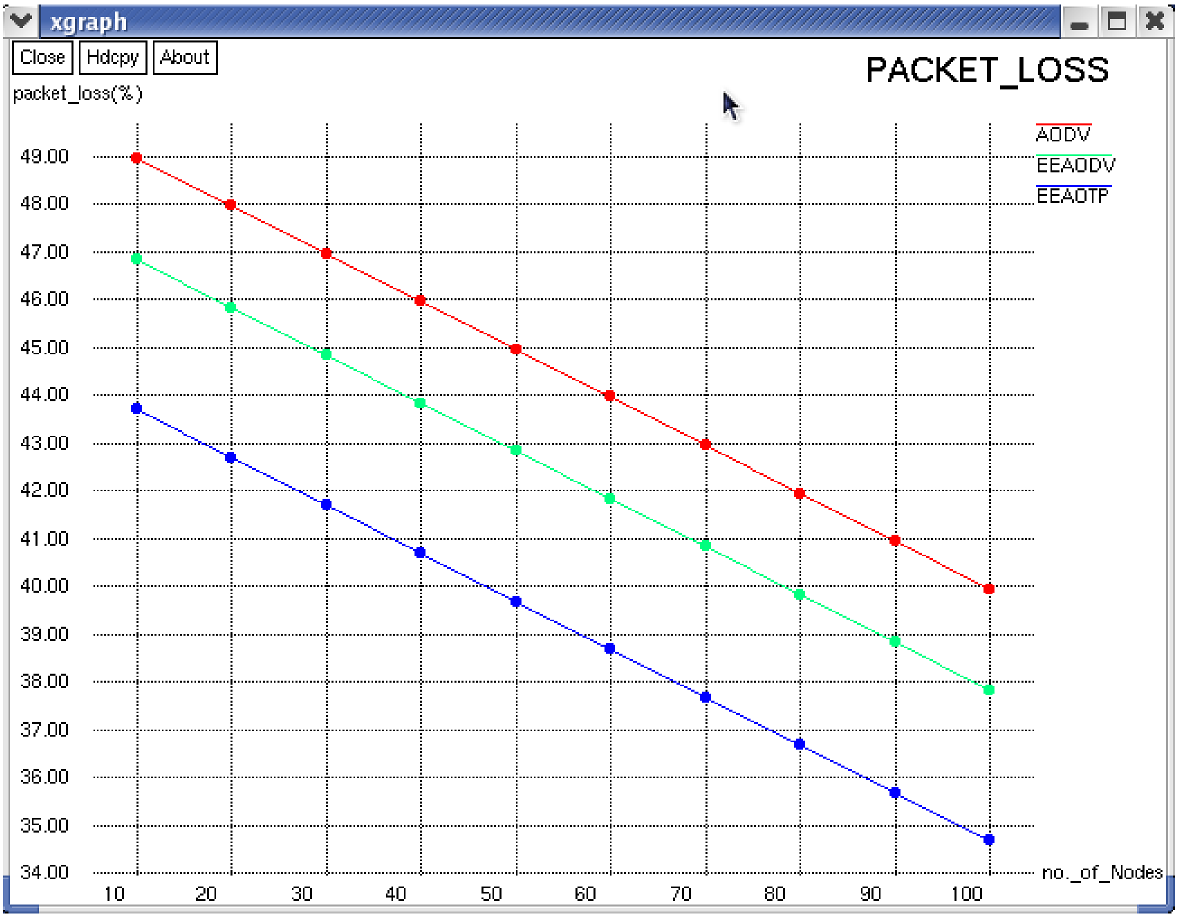

Figure 4.7: Packet loss among AODV, EEAODV and EEAOTP

The above graph show that the packet loss during the data transfers between source and sink pair is high initially. This high loss may be due to high traffic and link failure in the network. As in network the no. of nodes increases, the packet loss is decreases due to increasing signal strength of nodes and more stable route.

SUMMARY AND CONCLUSIONS

5.1 Conclusion

The aim of this thesis has been to improve scalability and increase Quality of Service in Ad hoc networks. Different routing protocols have been studied and their performance evaluated for the thesis work. A modified Three path routing protocol named Energy Efficient Ad hoc On Demand Three path (EEAOTP) has been proposed to enhance scalability and QoS to meet the different demands of the nodes in the ad hoc networks. It is clear from the simulations results that the proposed three path protocol (EEAOTP) solution is a better routing protocol to enhance scalability and increase QoS in Ad hoc networks. EEAOTP applies both the advantages from ad hoc on demand distance vector (AODV) routing protocol and the advantages of energy efficient ad hoc on demand distance vector (EEAODV) routing protocol. This protocol design avoids the excessive traffic generated reactive routing by considering three paths with respect to the top three higher energy level during discovering new routes over a large network. The results show that EEAOTP is scalable as protocol shows stable behaviour on increase number of nodes. The delay is decreased, throughput is increased, energy consumption is reduced, and PDR is increased as compare to AODV and EEAODV. This show better QoS is achieved by EEAOTP.

5.2 Future Work

The protocol can be improved for the future work as following aspects: ·

- The simulation results have shown better energy efficiency, PDR and throughput for the proposed EEAOTP protocol than AODV and EEAODV due to traffic avoidance measures. This assumption should be examined further, to ascertain the cause for the increase in PDR and throughput.
- Experiments may be done to try and improve the protocol by employing statistical methods, hidden Markov model (HMM) and neural network for identifying the percentage i.e. 50-30-20.

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ABSTRACT

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Thesis Title	: **A Modified Energy Efficient Ad Hoc on Demand Three Path Routing Protocol**		
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A mobile ad hoc network (MANET) is a combination of multiple nodes wishing to communicate with each other with the help of wireless medium. MANET is highly adaptable network because it can change itself according to need. In MANET, each node serves as a router as well as host due to limited range of communication. In MANET, all nodes have limited battery charge and each node is mobile in nature. It is necessary to save battery of those nodes which are having low battery so that the network lifetime can be long lasting because continuous change in position and connection degrades the battery charge of the nodes. Energy efficient techniques are required to enhance the lifetime of MANET.

In our research considered top three routes from source to destination having high energy. An energy threshold level is defined for each individual node followed by dividing total data packets in the ratio of 50-30-20, sending over the selected three routes with respect to energy level of routes simultaneously. If first route is broken, data is sent on remaining two routes 60% and 40% respectively with respect to energy level of routes. If two selected routes broken then all the data is sent on the remaining single route. Results are compared to two existing approaches AODV and EEAODV. Our proposed protocol performs better than these existing approaches.

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शोध शीर्षक : **एक संशोधित उर्जा कुशल अस्थायी मांग पर तीन पथ मार्ग प्रोटोकॉल**

सलाहकार : डॉ. राजीव सिंह

एक मोबाइल अस्थायी नेटवर्क (मनेट) वायरलेस माध्यम की मदद से एक दूसरे के साथ संवाद करने की इच्छा से कई नोड्स का एक संयोजन है। मनेट अत्यधिक अनुकूलनीय नेटवर्क है। क्योंकि यह जरूरत के हिसाब से खुद को परिवर्तित कर सकता है। मनेट में, संचार की सीमित रेंज के कारण प्रत्येक नोड एक राउटर के साथ-साथ ही मेजबान के रूप में कार्य करती है। मनेट में, सभी नोड्स की बैटरी चार्ज सीमित है और प्रत्येक नोड स्वभाव में गतिशील है। जिन नोड्स की बैटरी कम है उनकी बैटरी बचाने की आवश्यकता है ताकि नेटवर्क जीवनकाल लंबे समय तक चलाया जा सके। क्योंकि स्थिति और कनेक्शन में लगातार परिवर्तन नोड्स की बैटरी चार्ज कम करता हैं। मनेट के जीवनकाल को बढ़ाने के लिए ऊर्जा कुशल तकनीक जरूरत हैं।

हमारे शोध में स्रोत से गंतव्य तक उच्च ऊर्जा वाले तीन शीर्ष मार्गों पर विचार किया है। एक ऊर्जा दहलीज स्तर प्रत्येक नोड के लिए परिभाषित किया इसके बाद डाटा पैकेटस को 50-30-20 के अनुपात में विभाजित किया, और एक साथ तीन चयनित मार्गों के ऊर्जा स्तर के अनुसार भेजा है। अगर एक मार्ग टूट गया है, तो डेटा मार्गों के ऊर्जा स्तर को अनुसार क्रमशः शेष दो मार्गों में 60% और 40% डेटा भेजा जाता है। अगर दो चयनित मार्ग टूट गये तो सभी डेटा शेष एकल मार्ग द्वारा भेजा जाता है। परिणामों की तुलना मौजूदा दो दृष्टिकोण ए.ओ.डी.वी और ई.ई.ए.ओ.डी.वी से की हैं। हमारी प्रस्तावित प्रोटोकॉल इन मौजूदा दृष्टिकोण की तुलना में बेहतर प्रदर्शन करती है।

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