Energy Efficiency in AODV using Flower Pollination Algorithm

Dissertation

Submitted in partial fulfillment of the

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in

Electronic and Communication Engineering

By

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(April, 2015)

CERTIFICATE

This is to certify that the Dissertation titled "Energy Efficiency in AODV using Flower Pollination Algorithm" that is being submitted by "**Harneet kaur**" in partial fulfillment of the requirements for the award of MASTER OF TECHNOLOGY, is a record of bonafide work done under my guidance. The contents of this Dissertation, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree or diploma and the same is certified.

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Examiner I

Examiner II

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Place: LPU, Jalandhar — Harneet kaur

Date: April, 2015 — Reg.No: 11307222

CERTIFICATE

This is to certify that Harneet kaur bearing Registration no. 11307222 has completed objective formulation of thesis titled, **"Energy efficiency in AODV using Flower Pollination Algorithm"** under my guidance and supervision. To the best of my knowledge, the present work is the result of his original investigation and study. No part of the thesis has ever been submitted for any other degree at any University.

The thesis is fit for submission and the partial fulfillment of the conditions for the award of Degree of **Master of Technology** in **Electronics & Communication Engineering**.

Signature of Advisor:
Mr Gunjan Gandhi
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Date:

DECLARATION

I, **Harneet kaur**, student of **Master of Technology** under Department of Electronics and Communication Engineering of Lovely Professional University, Punjab, hereby declare that all the information furnished in this Dissertation report is based on my own intensive research and is genuine.

This thesis does not, to the best of my knowledge, contain part of my work which has been submitted for the award of my degree either of this university or any other university without proper citation.

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ABSTRACT

Currently, the wireless sensor network is facing four major issues namely power management, localization, routing and deployment techniques. Out of these in power management, energy conservation and coverage efficiency are the main issues. Energy is the main constraint of wireless sensor networks (WSNs) due to irreplaceable and limited power sources of the sensor nodes. We will study the AODV routing protocol and use some algorithms to improve the AODV routing and to make the AODV routing protocol more efficient and reliable. AODV is the ad-hoc on demand routing protocol in which the routes are created and terminated as per requirement of the data transfer in the network. Hence the shortest path is required for data transfer. If the same path is followed again and again, nodes will be out of battery and whole network will be affected. So we need to decrease the power consumption by the nodes by decreasing the load on the nodes and hence thereby increasing the lifetime of the nodes. In wireless monitoring systems, these quality of service factors are very crucial and are required to make the system reliable. In this report we have discussed C-AODV, MCPR and CASNCP algorithms for efficient and reliable wireless monitoring system as per base paper. Futher we have developed a more efficient optimized routing technique using flower pollination algorithm.

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CHAPTER 1

INTRODUCTION

1.1 *Wireless Sensor networks*: A wireless sensor network consists of sensors which are spatially distributed to monitor the physical conditions and provide feedback to the main location. WSNs provide relation between the real physical and virtual worlds. In the past years, wireless sensor networks have gained attention from local users as well as researchers. In wireless sensor networks the sensing, processing and communication are combined on a tiny device. Sensors are the heart of wireless sensor networks. These sensors are small in size, easily available and are low in cost. These sensor nodes are deployed randomly and, sense and gather the information and transmit the information to the user. A sensor node consists of a small sized transceiver, a microcontroller, a micro electronic circuit for interfacing with sensors and an energy source.

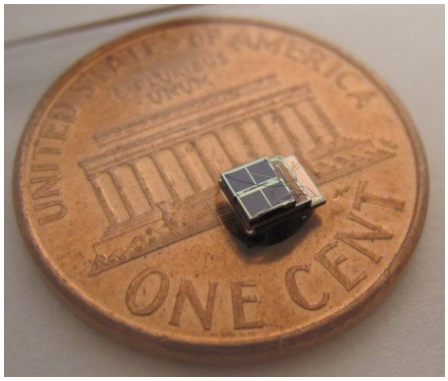

Figure1. Sensor

The size of the sensor node may vary from a tiny dust particle to the size of a shoe box; but smaller the size of the node, more efficient is the wireless sensor network. Deployment of the sensor nodes becomes easier if the size of node is smaller. Smaller the size of the node, lesser is the cost. Sensor nodes are deployed densely in the network. Sensor nodes are equipped with power batteries and are deployed in harsh environments. These batteries are usually rechargeable. Main advantage of sensor networks is that fewer nodes can be deployed with low network maintenance as well as lower cost. The design constraints taken into account are low bandwidth, short communication range, limited amount of energy and limited processing and storage in a particular sensor node. Efficient working of a sensor node depends upon its lifetime as well. Lifetime of a node is

depending upon collision, control packet overhead and idle listening. Lifetime of a node can be increased by using energy efficient routing. Data redundancy is also main objective in wireless sensor networks. As the sensor nodes are densely deployed in same area, so the multiple sensor nodes sense the redundant data. To avoid this, data redundancy is taken into account. Sensor nodes are equipped with GPS; hence they can find their address in a particular network. But it is not possible to provide GPS system to each node. So we equip some of the nodes in the network with GPS system and the neighboring nodes find their address with respect to the location of the GPS equipped nodes.

In wireless sensor networks, quality of service (QOS) is required in different applications in terms of delay in delivery and packet loss. In wireless sensor networks, few design constraints are: limited energy capacity, limited hardware resources, data aggregation, scalability, network characteristics and unreliable environment.

1.2 *Architecture of wireless sensor networks* is explained below:

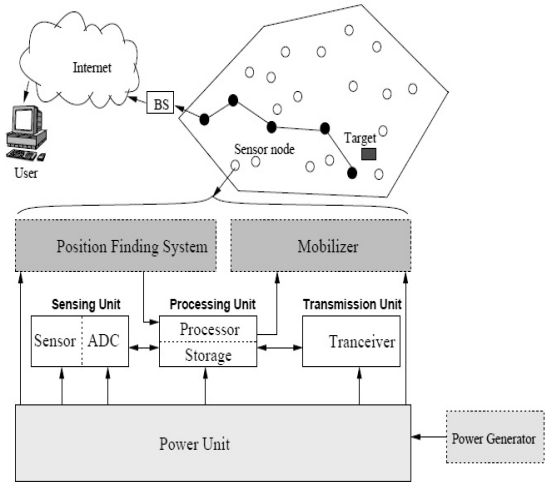

Figure2. Sensor node architecture

A sensor node comprises a block for sensing purpose, a block for processing purpose, a block for transmission purpose and power source block as shown in figure2. The position finding unit, power generator and mobilizer are the application dependent units.

Sensor unit is further divided into two sub-units: sensors and ADC. Sensors collect the information from the physical environment and the analog to digital converter converts

the analog information collected from the surroundings to digital output and passes it to the processor unit.

The processor unit consists of a storage unit which temporarily stores this information and passes this information to other nodes to perform sensing tasks. The transceiver connects the current node to the network i.e. passes the data to the other nodes present in the network. The transceiver unit may be active or passive device or radio frequency device. In most of the research projects, RF communication is preferred because in RF communication, the size of transmitted packets is small, low data rate and frequency reuse is high.

The power unit consists of energy sources such as batteries, solar cells. Location finder or position finding system consists of a GPS system which helps to find the exact position of the node. To make the nodes mobile, a device is used, named as mobilizer which makes the node adaptive to the environment. Wireless sensors networks are used for both military as well as civilian tasks.

1.3 *Applications of WSNs':* WSNs' has gained popularity in research as well as civilian applications. So we have discussed major applications of WSNs' below:

1. Intelligent parking: As in metropolitan cities, traffic issues are very common. Vehicle owners or drivers face problems in finding vacant place to park their vehicles. Due to which traffic is generated on roads and parking lots. So to overcome the traffic congestion, parking management systems have been deployed using wireless sensor networks. Parking can be made easy by deploying sensor nodes in the parking lots. The sensor nodes collect the data and then this information is processed to find the parking time of vehicles, payment of parking lot etc. Hence beneficial to the parking lot managers and the vehicle owners. Hence traffic can be controlled by using WSNs.
2. Biomedical signal monitoring: WSNs are used in bio-medical signal monitoring to monitor the health details of the patient periodically. With the help of this technology we can take a record of patient's health and diseases. Remote sensing can be done for monitoring the patient periodically. We can diagnose and examine the patient if we are distant apart from him. Hence the medical instruments are made more efficient using wireless sensor networks and processing and

transmission of bio-medical signal has been made easy. Hence revolutionary in the field of medical sciences.

3. Habitat surveillance: A Wireless sensor network can be used for monitoring the habitat of animals at zoo or sanctuary. With the help of WSNs, we can take record of health of animals by tracking their body temperature, footsteps etc. Tracking can be done by deploying sensor nodes in the network. With the help of this application we can get to know about new species and record their specifications.
4. Weather forecasting: As wireless sensor network is data-centric in nature. Hence data is collected and then processed. Wireless sensor networks are use for monitoring the climate conditions. By knowing the climate conditions, crop yield can be increased. For weather forecasting sensor nodes are deployed in remote areas to gather the climate information of various zones. Hence climate conditions like rainfall, wind speed, wind direction, humidity, temperature etc. can be estimated using wireless sensor networks.
5. Military applications: WSNs play vital role in the area of military applications. WSNs can be used for surveillance at borders, commanding and targeting at the enemy. WSNs can be used by military forces at battlefields, in urban environments, disaster relief applications etc. Sensor nodes can be deployed at various areas. Hence information about enemies or disasters can be gained easily. Wireless sensor network technology is cost effective. Hence easily affordable by military forces.
6. Industrial applications: WSN gives us very advantageous applications in the industrial field. Distributed architectures are being used in the industrial application and they are dependable inexpensive and flexible. We can improve the system performance by interfacing the sensors and the actuators are directly deployed to the communication network. For the safety purposes in coal mines we use many sensors of gas, temperature wind speed etc. when the value exceeds the given threshold value an alarm will occur. GPRS technologies have been reduced the investment on the layout that is underground. GPRS provides the timely ensure and the rapid and accurate transmissions in underground mining zones and this is how the efficiency is being improved.

1.4 *OSI Model*: In wireless sensor networks, the data transmission and reception is based upon OSI reference model. OSI stands for Open System Interconnection and OSI model is a seven layered model as shown in figure given below:

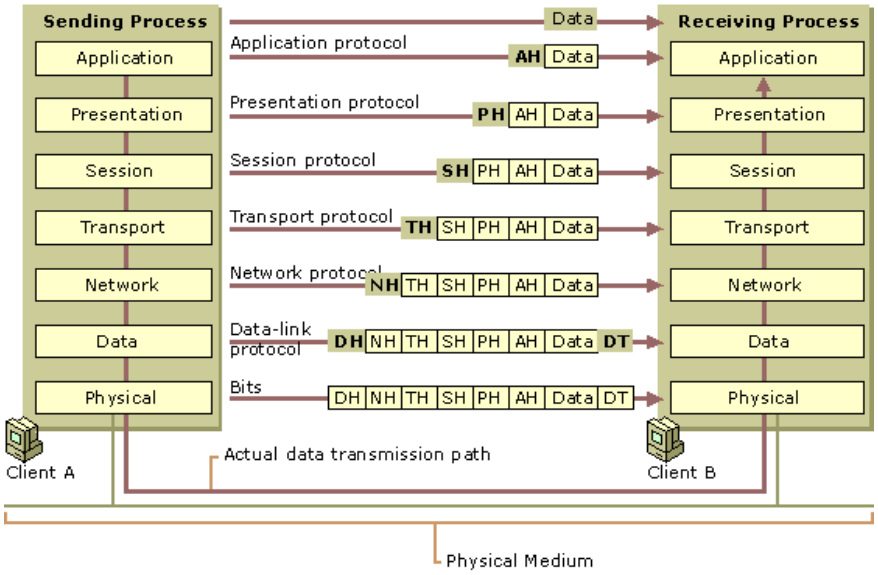

Figure3. OSI model

OSI reference model is an ISO standard to design the various network protocols in wireless sensor networks. In OSI model, each layer can communicate with either the layer above or below it i.e. the data-link layer can only communicate with network layer or physical layer. Layers in the model are independent to each other. Encapsulation is done in OSI model i.e. when the data is transmitted from one layer to another; the relevant data by each layer is attached to the previous information.

Physical layer: It is responsible for transmission of stream of bits (0s' and 1s'). Physical layer defines the interface used between transmission medium and devices. During transmission, the sender and receiver must be synchronized at bit level. Physical layer tells us about line configuration used for communication i.e. point-to-point and point-to-multipoint. Physical topologies like mesh, star, bus, ring etc. used to connect the devices are decided at physical layer. For communication system the mode is selected by physical layer. The mode of transmission may be simplex, half duplex or full duplex.

Data-link layer: In data link layer the communication is based on physical address. Frames of bits are exchanged between sender and receiver between two nodes. It organizes the bits from physical layer into logical groups known as frames. In data link layer errors are detected and corrected in the bits sequence and flow of data is controlled. The frames contain source and destination addresses. Data link layer is sub-divided into two layers: LLC (logical link control) is responsible for controlling errors in the information and controlling flow of data at both receiving and transmitting end. And MAC (medium access control) which carries the physical address of each device on the network. MAC is a 48-bit address which is burned on Network interface card (NIC) by the manufacturer. Data link layer is responsible for framing, physical addressing, flow control, error control and access control.

Network layer: Network layer deals with the delivery of packets from source to destination. In network layer, addressing and routing issues are taken into account. Network layer deals with the delivery of packets between different networks while data-link layer deals with delivery of packets in the same network. Network layer selects the route to be followed for transmission of data. Logical addresses are needed to send the information in the different networks. Hence the network layer adds header to the packets coming from the data link layer, known as source and destination logical addresses. Information is sent through the devices known as routers.

Transport layer: Transport layer is responsible for process to process delivery of message i.e. it delivers the entire message from one process to another. The network layer delivers the packets from source to destination while the transport layer is responsible for delivery of entire message from one end to another; and oversees the error control and flow control as well for process to process delivery. The end to end connection between source and destination is maintained by the transport layer. TDPU (transport protocol data unit) is the name given to the data unit in transport layer. In transport layer, the running processes are provided with a header containing the port address to ensure the process to process delivery. The messages are segmented into small segments with a unique sequence number and are reassembled at the destination with the help sequence numbers given to the transmitted segments. With the help of segmentation and reassembly process, the packet loss can be identified. Transport layer may be connection oriented or connectionless. If it is connection oriented, the connection is established with the destination, packets are sent and then the connection is terminated. But if it is

connectionless, each segment is treated as independent packet and delivered to the transport layer. Error control and flow control are also performed by transport layer.

Session layer: Session layer takes care of ongoing communication between two parties across a network. During a session, the applications on the other end can transmit or receive data as long as the session is active. The session layer looks up the session identification such that only the authenticated parties participate in the communication, hence provides the security to access the session information. Session layer allows the session to move in two directions simultaneously, or in one direction at a time. Hence provides one or two way communication which is named as dialogue control. In session layer, process called token management is used to avoid the both sides from performing the same process simultaneously. During the token management, the tokens are provided to the parties. The party having the token at a time is allowed to perform the task. Session layer provide synchronization to avoid the latency. Let's assume that the data is sent from the sender side. If there occurs a packet loss or any other problem, the data is retransmitted. This process of transmitting the data starts again. So session layer inserts checkpoints in the data stream, so if there is a crash or packet loss, whole data stream will not be retransmitted, only the data after the checkpoint will be retransmitted. The data unit in session layer is named as SDPU (session protocol data unit).

Presentation layer: As the name suggests, presentation layer deals with the format of the data being transferred during the communication. It deals with the syntax and semantics of the data. It converts the data being transmitted to the generic format and data being received to the format understandable to the receiver. Different computers are provided with their different codes for representation of data. With the help of presentation layer it becomes possible for computers with different representation of codes to communicate with each other. Presentation layer is concerned with cryptography and data compression. Cryptography provides security and authenticity to the information being exchanged. Data compression helps to avoid or remove the redundant information. The data units in presentation layer are named as PPDU (presentation protocol data unit).

Application layer: Application layer connects the real world with the network. It is an interface between the human or software and the network. With the help of this layer, network can be accessed by human or software. User interface and services such as email, file transfer and sharing the database are the services provided by the application layer.

The services from the presentation layer are accepted by the application layer. Application layer is responsible for the movement of files in the remote areas, reading as well as writing the remote files i.e. the application layer is responsible for the remote file storage management. As application layer works as an interface between the real world and the network; hence it serves the applications to be accessed by the computers in different remote areas through real simulator and this service provided by the application layer is known as network virtual terminal. Application layer provides services such as exchange of data through electronic medium. With the help of directory service, the names can be matched with the addressing information and services for network management are provided by the application layer.

1.5 *ROUTING IN WIRELESS SENSOR NETWORKS*: Routing is basically a technique of providing path to the packets from source to destination. Router is the device used for routing purpose. Router helps the packet or message to be sent to move from one node to another and reach the destination and routing is the key mechanism of the internet. In routing mechanism, a routing table is used to find the best path and send the message over this path. The intermediate nodes pass the data with the help of these routing tables. In networking, often bridging is confused with routing. But routing is used at a high level cause it is performed with software and is a very complex process because analyzing the best path for the packets to be transmitted is performed with the help of routing tables whereas the bridging is performed at low level and is implemented using the hardware.

Now we will discuss about the routing techniques. How the routing mechanism takes place is the main area of interest and how the best path for the packets to be transmitted from the source to destination is being selected. Routing mechanism is performed in accordance with the routing protocols. Routing protocols are basically the rules specified for routing mechanism. Routing protocols make the routers communicate with each other and enables the routers to select the best path for communication between nodes present in a network. Routers are having the prior knowledge about the networks attached to it directly. At first, a router communicates with its neighboring nodes and shares the information with them and then sends the information in the whole network. In wireless sensor networks, routing protocols are divided into three main types which are given below:

(a) Flat based routing protocol

(b) Hierarchical based routing protocol

(c) Location based routing protocol

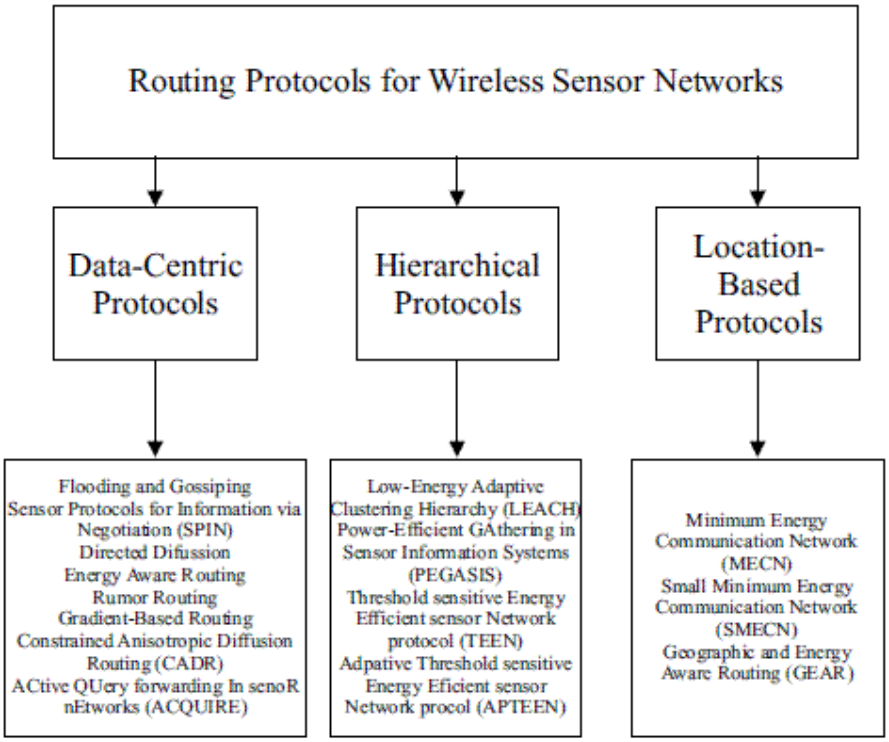

Figure 4. Routing protocols in WSNs

1.5.1 Flat-based routing protocol: In flat-based routing, the routers are placed without any organization or hierarchy. In flat based routing, each and every node plays a different role. Huge number of nodes is required for routing in flat based routing protocol. Flat base routing approach is required when each and every node plays the same role. In flat based routing protocol, a approach known as data centric routing is required. In this approach, the base station sends queries to the group of nodes in a particular area and waits for the feedback or response. In flat based routing as there are required a large number of nodes, so it is not possible to provide an address identifier to each bode. Hence some of the nodes in the region are equipped with GPS and the neighboring nodes identify their exact location with the help of the nodes equipped with GPS. Some examples of the flat based routing protocol are: SPIN (sensor protocols for information via negotiation), SAR (sequential assignment routing),DD (diffusion directed), EAR (energy aware routing), ACQUIRE (active query forwarding in sensor network), MCFA

(minimum cost forwarding algorithm), AODV (ad-hoc on demand distance vector) routing protocol.

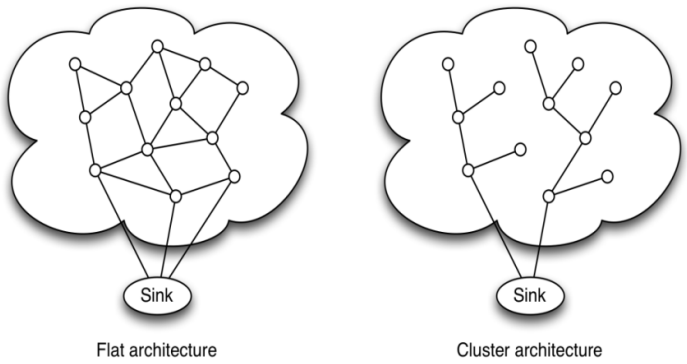

Figure5.flat based routing

1.5.2 Hierarchical based routing protocol: Hierarchical based routing is used for efficient communication and is used for efficient network scalability. In hierarchical based routing, the routers are placed according to a particular hierarchy. Cluster based routing is the other name given to the hierarchical based routing protocol. In hierarchical based routing protocol, the higher energy nodes and lower energy nodes are separated and assigned for different tasks. In hierarchical based routing protocol, the lower energy nodes are used for sensing the information and sending the information to the cluster heads while the higher energy nodes perform different tasks. Higher energy nodes select the data for processing and send the data. Using hierarchical based routing, we can improve the scalability factor, increase the lifetime of the nodes and make the network energy efficient. Some examples of hierarchical based routing protocol are: TEEN (threshold sensitive energy efficient sensor network protocol), APTEEN (adaptive power threshold sensitive energy efficient sensor network protocol), LEACH (low energy adaptive clustering hierarchy), HPAR (hierarchical power active routing), MECN (minimum energy communication network).

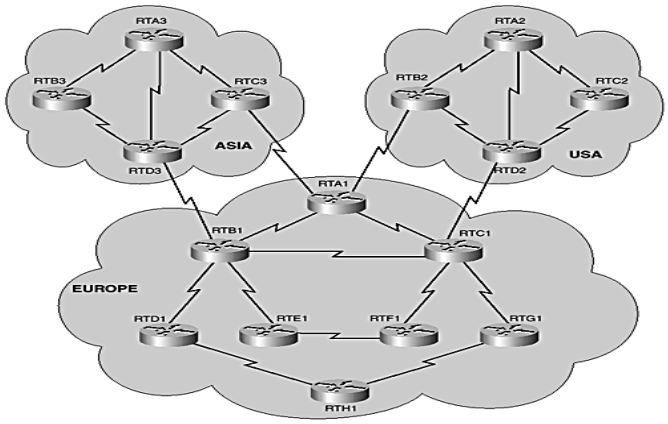

Figure6. Hierarchical routing

(c)Location based routing protocol: In location based routing protocol, the nodes are equipped with GPS and are scattered in a particular network. Hence the position of the nodes can be determined with the help of the GPS. In location based routing protocol, the nodes communicate with each other and the signal strength is determined between the nodes. With the help of this parameter, we can calculate the distance between the nodes. When the distance between any two nodes in the network is determined with the help of signal strength, we can know about the co-ordinates with the exchange of information or data with the neighboring nodes. Location based routing protocols are: GOAFR (greedy other adaptive face routing), GEAR (geographic and energy aware routing), GAP (geographic adaptive fidelity), GEDIR (geographic and energy aware routing), APS (ad-hoc positioning system).

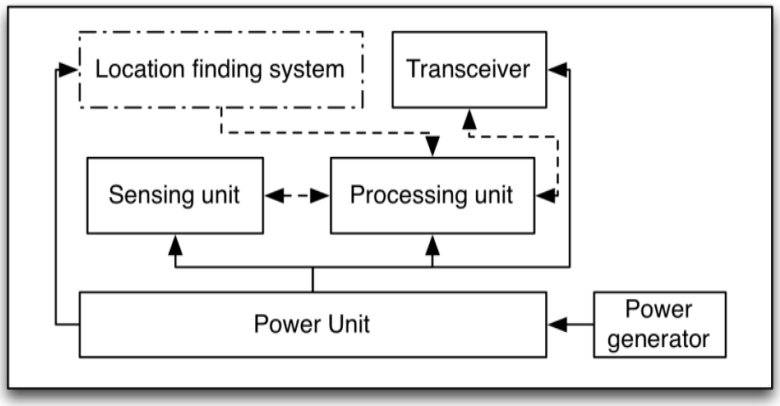

Figure7. Node with position finding system

1.6 *AODV*: AODV is a flat based routing protocol and as in flat based routing the routers or nodes are placed without any hierarchical manner, so it is known as ad-hoc protocol. AODV routing protocol is mainly used for wireless sensor networks which are ad-hoc in nature such as MANETS i.e. mobile ad-hoc networks. Basically in AODV, the network remains still until the transmission or link is needed. When a node needs a route or path to transmit data, it sends the request for the path in the whole network. The nodes present in the network, receive the request and send the replies in the form of temporary routes. The node which is waiting for the connection, checks for the temporary paths and selects the path to the destination node. The path selected by the source node is reliable and contains less number of hops. After the data has been transmitted, the path is terminated. In AODV protocol, the route is created whenever needed, so the energy can be saved and network becomes efficient. When there is a failure in the network, a routing error message is circulated in the whole network. The source node receives the routing error message and repeats the process for creating a new route. In AODV, the temporary route requests sent by the nodes are having a unique sequence number so that the routes are not repeated again and again. Every route request has a certain lifetime, so that they are not retransmitted after their lifetime ends. But due to this feature, when a link fails, the new route request takes time to be sent because it takes time twice to lifetime to retransmit the same route request. AODV routing protocol decreases the traffic during communication and is simple and hence no complex computation is required for it.

1.6.1 *Route Discovery and Maintenance in AODV:* In AODV routing protocol, the process of creating or discovering the route and terminating the route or connection is based on a mechanism in which routing messages are circulated in the whole network. These routing messages are RREQ, RREP and RERR. These messages are circulated during the discovery and termination of the routes. RREQ stands for route request. Whenever a node present in the network needs to send the data or information, it needs a route for it. As we know in AODV as the name suggests, the route is created whenever the data is to be sent. So the source node sends the route request message i.e. RREQ message in the whole network. When the RREQ message is broadcasted in the network, the destination as well as the intermediate nodes send the route replies i.e. RREP message to the source node. The source node receives the RREP message from the nodes. Each route reply message consists of a sequence number. The source node selects a path with less intermediate hopes and hence the connection is established. If there occurs a path

failure, the intermediate node will send the RERR message i.e. route error message to the source and the process of detection and termination of the path will be repeated again. As in AODV the shortest path is selected for communication. In AODV routing, there arise many problems like data aggregation, congestion, energy consumption, grey hole/ black hole effect which effect the routing in AODV. Hence to overcome these problems we use various algorithms or techniques. We will study further about these problems and how to avoid these problems. So as to make the AODV routing more energy efficient and reliable. Hence we will use algorithms like spanning tree, cooperative based AODV, MST, distance vector routing etc. techniques to mitigate these problems being faced in AODV and to make the AODV more efficient.

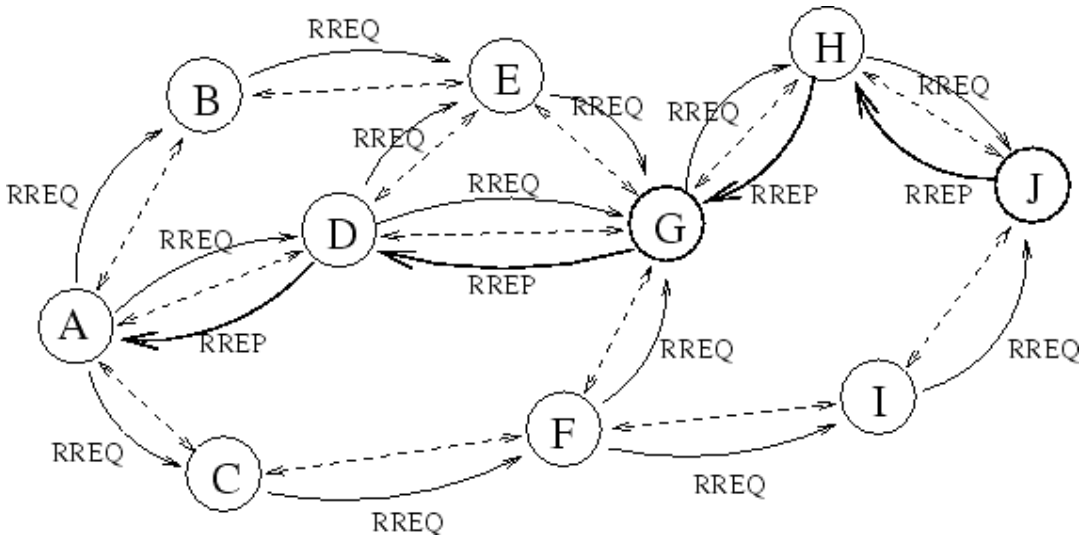

Figure8. Routing in AODV

1.6.2 *Challenges in AODV:* In a wireless sensor network using AODV routing protocol, the nodes are deployed without any hierarchy. Hence WSN is a self configured network in which nodes are connected by wireless links. The deployment of a wireless sensor network is easy, cost effective and fast. But few challenges are faced by wireless sensor networks during maintenance and hence performance is affected. As the nodes are battery operated, so the delay or power loss must be minimum. QoS factor must be taken into account to improve the performance of the network. Some of the challenges by which the performance of ad-hoc networks is affected are:

1.6.2.1 Security: It is one of the critical issues that arise in AODV. It occurs due to presence of malicious nodes present in the network. These malicious nodes are responsible for denial of service. Hence the packet dropping takes place. To avoid malicious attacks detection and bye-passing of malicious nodes is done. Cryptography approach is used to detect and bye-pass the malicious nodes present in the network. Hence various encryption algorithms can be used to make the AODV routing protocol more secure. Mainly two procedures, detection of malicious nodes present in the network and bye-passing the malicious nodes, are used to make the Ad-hoc network secure. Ad-hoc networks are established in military or disaster relief areas which are insecure networks. Hence secure network is required for communication. Hence enhancement of AODV routing protocol is needed in terms of security. Security attacks in AODV are Grayhole attack, wormhole attack and blackhole attack.

1.6.2.2 Scalability: As in large ad-hoc networks, large numbers of nodes are deployed. Hence it becomes difficult to provide service at acceptable level. So parameters like end to end delay, throughput etc. must be considered. Scalability is basically the ability of the network to provide efficient service even if large number of nodes is present in the network. So it is required to optimize the routing in ad-hoc networks to improve the scalability factor and to make the communication more reliable.

1.6.2.3 Quality of service: Quality of service means the fare use of various resources offered by the network. it is characterized by some factors (jitter, throughput and loss). The parameter is defined by the QOS that which is better. Quality of service is also an important challenge in the domain of wireless sensor networks. AODV has a challenge to provide quality of service with least delay and bandwidth. In quality of service there are many factors that are included like end to end delivery of the packet, packet loss, effective and efficient use of the protocols. As there is lack of resources and the frequent change of the topology, that is why the quality of service is becomes a challenging task in AODV. Some of the changes have been done and the AODV-D provides better quality of service.

Energy consumption: In ad-hoc network, nodes are placed without any hierarchy. And the routes are created as per requirement. Whenever the sender wants to send the packets, it broadcasts the route request message in the network and the nodes present in the network send the route reply messages with their unique sequence numbers. Hence the route with

less hop count is selected. Now as the ad-hoc networks are established in remote areas, so nodes which are deployed in the network must have longer lifetime i.e. longer battery life.

In AODV routing protocol, the path with less hop count is selected for transmission of packets. So if this path is selected as shortest path again and again for faster transmission, the nodes present in the path may exhaust faster, creating a network failure. Hence the network will be disconnected and communication will be stopped. Hence an energy efficient network is required to make the communication more reliable. Battery lifetime time should be maximized to increase the lifetime of the network. Performance of ad-hoc networks can be enhanced by making the nodes energy efficient, reducing the data aggregation and by improving other quality of service factors. Ad-hoc networks are used for direct communication between the nodes when they are present at a range at which communication is possible. Hence for communication between nodes at large distances needs to be done with the help of intermediate nodes and this is known as multi-hop communication. As the network is a wireless network, the nodes need energy as well for operation so they are equipped with batteries with limited lifetime. By reducing the transmitting power of the nodes, we can increase the lifetime of the nodes. But these nodes can reduce their transmitting power by modifying their area of communication but due to this there may be an effect on connectivity. Hence we need to maintain the connectivity as well. As we know wireless devices are having low bandwidth range, so these devices may make the communication unreliable by increasing the packet loss. When the data is being transmitted over long distances, we require short distant hops rather than long distance hops to decrease the packet loss as well as the energy consumption by the nodes. Hence the shortest path algorithm is used in ad-hoc networks. A lowest energy path is detected, if found, the packets are sent on that path due to which the nodes present on the path will be exhausted quickly and hence the lifetime of the nodes will be decreased. Hence enhancement of energy in AODV is required to improve the performance of ad-hoc networks.

CHAPTER 2

LITERATURE SURVEY:

2.1 *MANETS:* The main issue in wired and wireless networks is network security; it is the main requirement in the emerging field. The main attributes which should be satisfies in any network are authentication, confidentiality, access of integrity and non repudiation. Black hole attacks are prone in MANET's (Mobile Ad-hoc Network). MANET is a self configurable, self deployable and infrastructure less network in which nodes are continuously moving and creates dynamic topology. Mobile ad hoc network (MANET) is a collection of mobile hosts without the required intervention of any existing infrastructure or centralized access point such as a base station. The nodes of MANET do not require any infrastructure to communicate with one another. MANET's are used basically in the conditions where the wired and wireless infrastructure is inaccessible, overloaded, and destroyed. E.g. disaster relief applications and tactical battlefields. MANET are not dependent on the fixed infrastructure where each node acts as an intermediate switch. The transmission of data or we can say that routing is done through different routing protocols. It is the recent active field and is getting spectacular attention because of self configuration and self maintenance, but security is the main issue which should be kept under consideration to protect the communication from the hostile environment. The present status of a node should be broadcasted to its neighbors before the source node wants to communicate with the target node. Because the current routing information is not known to the other nodes.

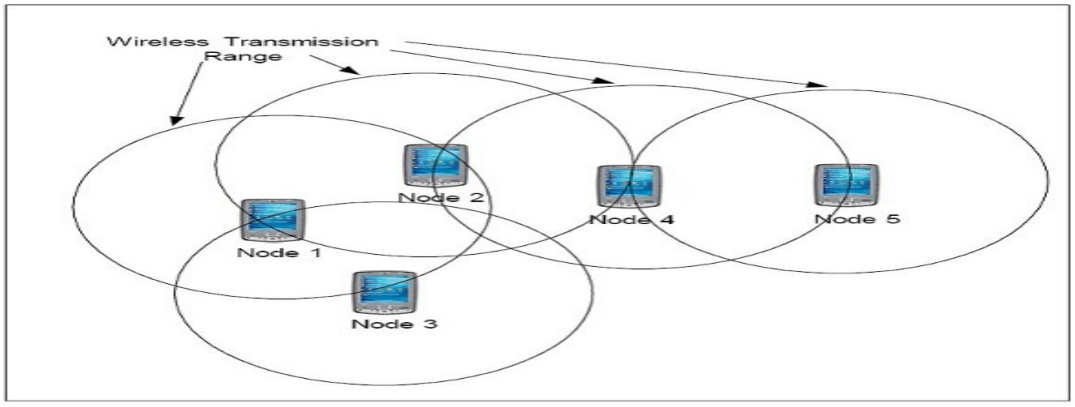

Figure9. MANETS

2.2 *AODV*: is a flat based routing protocol and as in flat based routing the routers or nodes are placed without any hierarchical manner, so it is known as ad-hoc protocol. AODV routing protocol is mainly used for wireless sensor networks which are ad-hoc in nature such as MANETS i.e. mobile ad-hoc networks. Basically in AODV, the network remains still until the transmission or link is needed. When a node needs a route or path to transmit data, it sends the request for the path in the whole network. The nodes present in the network, receive the request and send the replies in the form of temporary routes. The node which is waiting for the connection, checks for the temporary paths and selects the path to the destination node. The path selected by the source node is reliable and contains less number of hops. After the data has been transmitted, the path is terminated. In AODV protocol, the route is created whenever needed, so the energy can be saved and network becomes efficient. When there is a failure in the network, a routing error message is circulated in the whole network. The source node receives the routing error message and repeats the process for creating a new route.

In AODV, the temporary route requests sent by the nodes are having a unique sequence number so that the routes are not repeated again and again. Every route request has a certain lifetime, so that they are not retransmitted after their lifetime ends. But due to this feature, when a link fails, the new route request takes time to be sent because it takes time twice to lifetime to retransmit the same route request. AODV routing protocol decreases the traffic during communication and is simple and hence no complex computation is required for it.

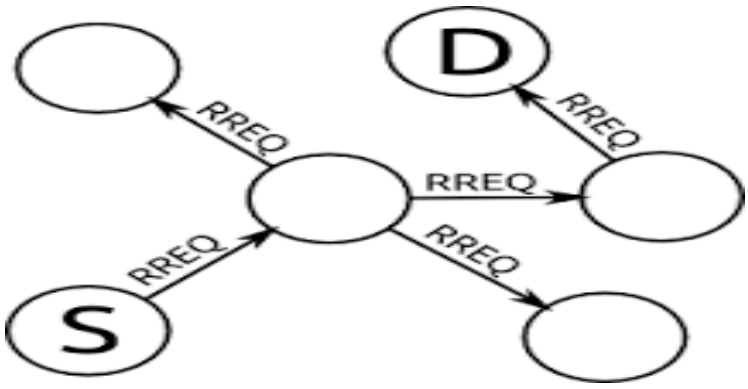

Figure10. Broadcasting of rreq and rrep messages in aodv

In AODV routing protocol, the mechanism for path discovery is followed by three messages which are broadcasted in the network: RREQ(route request),RREP(route reply),RERR(route error). These messages are circulated during the discovery and termination of the routes. RREQ stands for route request. Whenever a node present in the network needs to send the data or information, it needs a route for it. As we know in AODV as the name suggests, the route is created whenever the data is to be sent. So the source node sends the route request message i.e. RREQ message in the whole network. When the RREQ message is broadcasted in the network, the destination as well as the intermediate nodes sends the route replies i.e. RREP message to the source node. The source node receives the RREP message from the nodes. Each route reply message consists of a sequence number. The source node selects a path with less intermediate hopes and hence the connection is established. If there occurs a path failure, the intermediate node will send the RERR message i.e. route error message to the source and the process of detection and termination of the path will be repeated again.

In AODV, hence RREQ, RREP and RERR messages are broadcasted in the whole network for path discovery and path maintenance processes as shown in figure.

In AODV routing protocol shortest as well as reliable path is selected for communication. So the two main issues that arise during path selection in AODV routing protocol are security and energy efficiency. To overcome security and energy efficiency issues in AODV routing protocol, various algorithms have been developed. So in AODV path selection is a very crucial process.

2.3 *Issues in AODV:* Two main issues that arise in AODV are security and energy issues which degrade the performance of the AODV algorithm. In the next section we will have a brief discussion about these issues.

2.3.1 *Security issues in AODV:* It is one of the critical issues that arise in AODV. It occurs due to presence of malicious nodes present in the network. These malicious nodes are responsible for denial of service. Hence the packet dropping takes place. To avoid malicious attacks detection and bye-passing of malicious nodes is done. Cryptography approach is used to detect and bye-pass the malicious nodes present in the network. Hence various encryption algorithms can be used to make the AODV routing protocol more secure. Mainly two procedures, detection of malicious nodes present in the network and bye-passing the malicious nodes, are used to make the Ad-hoc network secure. Ad-

hoc networks are established in military or disaster relief areas which are insecure networks. Hence secure network is required for communication. Hence enhancement of AODV routing protocol is needed in terms of security. Security attacks in AODV are Grayhole attack, wormhole attack and blackhole attack.

2.3.2 Energy issues in AODV: In ad-hoc network, nodes are placed without any hierarchy. And the routes are created as per requirement. Whenever the sender wants to send the packets, it broadcasts the route request message in the network and the nodes present in the network send the route reply messages with their unique sequence numbers. Hence the route with less hop count is selected. Now as the ad-hoc networks are established in remote areas, so nodes which are deployed in the network must have longer lifetime i.e. longer battery life.

In AODV routing protocol, the path with less hop count is selected for transmission of packets. So if this path is selected as shortest path again and again for faster transmission, the nodes present in the path may exhaust faster, creating a network failure. Hence the network will be disconnected and communication will be stopped. Hence an energy efficient network is required to make the communication more reliable. Battery lifetime time should be maximized to increase the lifetime of the network.

To enhance the AODV routing protocol in terms of energy, various algorithms have been developed. With the help of these algorithms, researchers enhanced the lifetime of the Ad-hoc networks. We will discuss these algorithms below.

2.4 *ENERGY EFFICIENT ALGORITHMS FOR AODV IN AD-HOC NETWORKS:* As AODV routing protocol must be energy efficient to have longer lifetime. So researchers have developed various enhancements in AODV to make it energy efficient. These algorithms are discussed below:

2.4.1 *EE-AODV:* As the ad-hoc network is a battery operated network, energy is an important perspective for efficient communication. So shortest path is not optimal path for communication. So the algorithms which are created to make the routes energy efficient are known as minimum energy routing. Energy efficient AODV protocol is the enhanced version of AODV. In this protocol every node is provided with an threshold energy level. If the energy of the node decreases than the level provided, the node is not considered as next hop

or intermediate hop. During the route discovery, after the RREQ message is broadcasted in the network, the nodes send REPEL message in addition to RREP message. REPEL stands for reply energy level. Hence we know about the energy of the node and determine if the node is having required energy level with respect to threshold energy or not. If the node is having less energy than the threshold level, an alternative route will be selected.

2.4.2 *MEL-AODV:* In maximum energy level-AODV routing algorithm, the route selection is done on the basis of overall remaining energy present in the nodes. Hence maximum energy path is selected. Selection of path depends upon highest combined energy of all the hops present in the route. MEL-AODV is based upon few assumptions which are:

1. In ad-hoc networks, the hops or nodes are having randomly distributed energy levels.
2. Signal attenuation remains same during the communication or transmission between two hops.
3. Power information may be provided to the network layer.

On the basis of these assumptions, we can get information about the energy level of the hops. Most of the algorithms take into account loss ratio, delay etc. while neglect the energy level of the nodes. Due to which link failure takes place. So the MEL-AODV protocol is proposed to select optimal path for communication. Hence we can find the effective energy efficient path for transmission, thereby balancing load on the hops (nodes).

2.4.3 *RSEA-AODV*: As we know AODV is on demand routing protocol. Hence path is created as per requirement. We must avoid the path in which the intermediate nodes are having less residual energy. The energy aware routing protocols basically increase the lifetime of the nodes thereby reducing the power consumption in the nodes. The cost of the battery must be low. In RSEA-AODV route discovery is done by sending RREQ message which consists of accumulated path stability(APS), accumulated energy metric(AEM) and required energy(REQe) as well. Hence required energy as well as residual energy can also be calculated. Hence by sending RREQ message throughout in the network, we can calculate the residual energy of the

hops and can compare with the required energy. If the residual energy of the node meets the requirement, path is selected.

RSEA-AODV has a feature i.e. known as make-before-break route maintenance feature. In RSEA-AODV if during communication, any intermediate node reaches to low energy level, it broadcasts HLP message to its neighboring hops. Neighboring hops find the new route with the help of the routing table and communication takes place through the new route. Hence the packet loss can be avoided. If by any chance the destination is the node having low battery level, it sends the intimation to source node to stop the transmission. Hence wastage of resources can be prevented. Route change request messages are sent by the node with low battery level to the source node if there is no next hop present. Hence re-route discovery takes place.

2.4.4 *EC-AODV:* In AODV, the maximization of lifetime of the batteries of nodes is a critical issue. So energy efficient protocols are developed by researchers. In EC-AODV, the optimal path for communication between source and destination hop depends upon two parameters that are energy factor and lifetime of the node. In this routing protocol a threshold energy level is set for nodes. If any node is having energy less than the threshold level, it is not considered as next hop during route discovery process.

During the route discovery process, nodes first check their energy level. If it is higher than the provided threshold level, the node will check its routing table if the path is available or not. If available, communication starts. But if the path is not available in the routing table, route discovery process is initiated. In EC-AODV, with RREQ message, energy factor(EF) and node lifetime(NLT) are also attached to calculate the residual energy and lifetime of the node. As we know, a threshold level is set for the nodes. Hence when RREQ message is broadcasted in the ad-hoc network, the nodes check for their energy level. If the energy level of the hop is less than threshold level, it discards the RREQ message. But if the energy level is higher than the threshold level, nodes calculate their EF and NLT, and update the routing table with current values, sending RREP message to the source. Hence best path is selected on the basis of hop count, EF and NLT.

In EC-AODV, the nodes keep sending HELLO messages to their neighboring nodes to detect if the nodes are exhausted or not. If the packet drop is detected by neighboring nodes, the nodes send the RERR message to the source node. Hence communication is stopped, and routing tables are updated by deletion of failed nodes and re-route discovery takes place

2.4.5 *NDj-AODV:* It is Node disjoint routing technique. As the name suggests, this algorithm creates node disjoint routes to the destination and this algorithm balances the load and provides energy efficient path. The cocept of overhearing is used in NDj-AODV. This concept was first proposed in AODVM(Ad-hoc on demand distance vector multipath routing)

In NDj-AODV, multiple paths are created from source to destination. These paths are node disjoint i.e. they are independent of each other and do not have any node in common and are less in number than link disjoint paths. In NDj-AODV, each node is having its cache in which it stores source address, broadcast id, previous node address and hop count of the previous node. During the route discovery process, when RREQ message is broadcasted, each node checks its cache if empty it stores the information as described above. But if the cache is not empty and the RREQ message was not sent from sibling node, it is rejected. When the destination hop receives the RREQ message, it sends RREP message and intermediate nodes forward the RREP message to the source node through reverse route using the routing table. Routing tables are checked, if any two paths are sharing same intermediate nodes, one path is deled from the table. If there arise any link breakage in the paths, the paths are discarded immediately on receiving RERR message. Hence by using various disjoint node paths for communication. Energy can be saved and lifetime of nodes can be increased.

2.4.6 *EASR:* Energy aware source routing. In this algorithm, various paths are created which do not overlap each other. Hence they are not aware of packet transmission on other paths. Hence overhearing energy waste can be avoided by using EASR algorithm. EASR is implemented to enhance the lifetime of the nodes present in the AODV network. Hence, the transmission of the packets between source and destination takes place through a path which is energy efficient. In this algorithm, we must take care of two parameters. One

is the total summed energy of all the nodes present in the path and the other is the residual energy left in the nodes present in the ad-hoc network.

In EASR, in RREQ message, a parameter accumulated battery indicator is added which indicates the battery level or energy level of the node. Hence, when the source node wants to send the message, it broadcasts RREQ message in the whole network and the intermediate nodes also broadcast the RREQ message in the whole network and intermediate nodes also broadcast the RREQ message. The destination node waits for some time, so that all the RREQ messages are broadcasted in the network. Destination node then selects an energy efficient path with the help of accumulated battery indicator present in RREQ message. It selects the path with maximum energy level. The route reply message consists of two parameters (Locx,Locy) which help to find location of the node. Hence, the distance between any two adjacent nodes in the network can be calculated by using friis transmission equation infree space based on the distance. With the help of this distance minimum power required for transmission can be calculated and hence can be kept constant to make the batteries energy efficient.

2.4.7 *Energy optimized routing algorithm*: As we know nodes are battery powered in ad-hoc networks. So to increase the lifetime of the nodes various energy efficient protocols are developed. Hence main issue that arises in AODV is energy consumption. This algorithm finds an energy efficient path by indicating the battery level of the nodes. Battery level is indicated by a low battery alert mechanism. As in AODV routing algorithm, shortest path is selected for communication but selected shortest path may not be the optimized path. Hence energy aware routing must be done. There may exist multiple paths between source node and destination node. Hence path must be selected such that low transmission power is required. Hence less energy consumption.

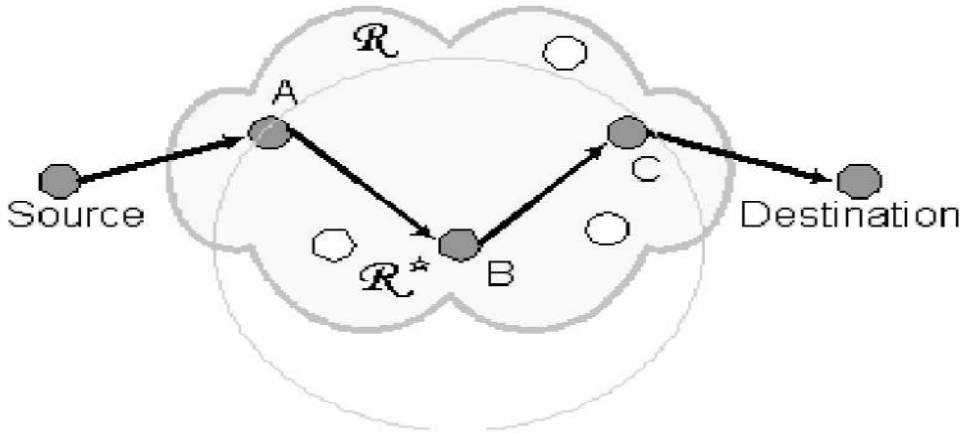

Figure11. An ad-hoc network where R is set of relay nodes
R is set of neighboring nodes of B*

Hence in AODV, while route discovery process takes place, a RREQ message is broadcasted with TTL (pre-defined lifetime). Hence with respect to this TTL, a path is selected. When RREQ message reaches to destination node, it sends RREP message through the reverse route. Hence energy optimized path is formed. But if any intermediate node is already having a path to destination, it sends G-RREP (Gratuitous route reply message to the destination node and RREP message to the source node. Hence a bi-directional energy optimized path is formed.

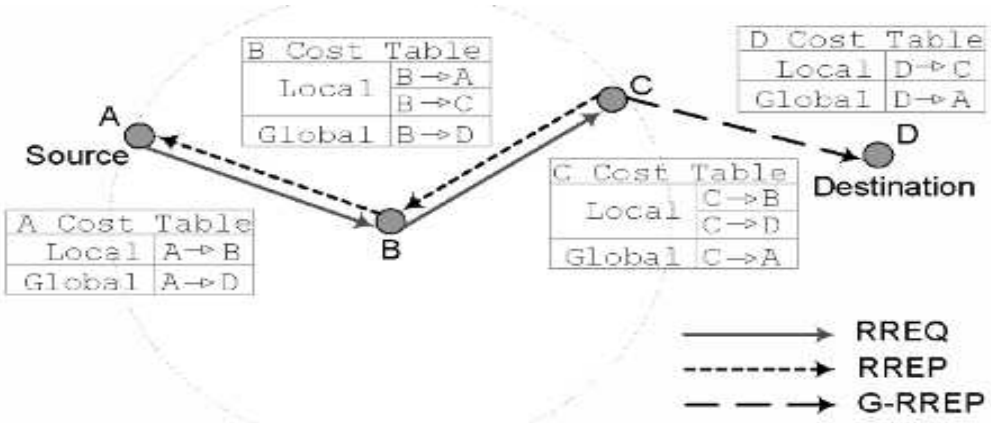

Figure12. Route discovery process in energy optimized AODV

2.4.8 *EM-AODV*: In EM-AODV, instead of selecting one optimized path for transmission, multiple paths are formed from source to destination. Hence data transmission takes place through new path every time. Hence depletion of battery life of nodes present in the single optimized path can be avoided. Hence, in EM-AODV load balancing is done. In this algorithm three

parameters are taken into account which is bandwidth along the paths affinity and battery life of the node. In EM-AODV, the route discovery process of AODV is enhanced and multiple node disjoint paths are created for source hop.

In EM-AODV, route discovery process is initiated by source node. It broadcasts the RREQ message in the whole network. The RREQ message from the source hop contains the address information of the immediate next hop to the source node through which the RREQ message has been passed. Multiple routes from source to destination are stored in the routing tables of the nodes. The battery level of the nodes is checked if it is less than threshold level, the node discards the RREQ message. If there exist multiple routes between source and destination as per routing tables, the data is split into parts and sent through multiple paths. If there is no route present in the routing table, route discovery process is initiated.

During route discovery process, when destination node gets the RREQ message from multiple optimized paths, it sends RREP message through multiple routes. These route replies are dependent on R-max value i.e. R-max determines how many route replies will be accepted by source node to avoid overhead. Two more tables in addition to routing table are managed: SNR average table and Bandwidth table. With the help of SNR average table, we can calculate affinity. Hence during path selection affinity and bandwidth must be kept minimum and energy must be kept maximum. Hence the best paths are selected for communication. Transmission of data by parts through multiple paths helps to balance the load.

2.4.9 *EA-AODV*: For an energy efficient Ad-hoc network, the energy consumption at nodes during transmission of data, route discovery and route maintenance, must be kept low. The consumption of energy is an important factor for QoS in ad-hoc networks[26]. Hence enhancement in AODV is done to make it energy efficient. In Energy aware-AODV, whenever the source node demands for a path, it first broadcasts a RREQ message in the network. The latest sequence number of the destination is broadcasted as well. The intermediate hops keep forwarding the route request message in the network and also keep the record of the reverse route to the source hop. Hence energy efficient path is created.

The link quality between any two adjacent hops is dependent upon signal to interference ratio(SIR). If the SIR ratio between any two nodes decreases the pre-defined threshold value, the link is broken. This information is sent to the source hop by route reply message. Hence re-route discovery process takes place. Instead of sending periodic HELLO messages to maintain a link, in EA-AODV, the neighboring nodes check whether the link is available or not. The link availability is checked on the basis of SIR ratio. Physical layer detects the link breakage using SIR ratio and informs to the network layer by a message indication. Due to this protocol, we can save energy of nodes as periodic transmission of HELLO messages is not required.

2.4.10 *C-AODV:* AODV is on demand routing protocol. Routes are selected on the basis of shortest path. Sequence numbers are assigned to the messages sent by the source nodes during path discovery. A path with higher sequence number is a fresh route. But in AODV energy consumption is the major issue. Battery of the nodes may exhaust if same path is used again and again. Hence C-AODV is enhanced routing protocol which provides energy efficiency. C-AODV is derived from two protocols MPCR and CASNCP. It is a cooperative routing algorithm in which data sharing is done to avoid congestion and to balance the load. C-AODV is an enhancement to AODV routing protocol. In C-AODV, two phases are there: route discovery and route maintenance. During route discovery process, when RREQ messages are broadcasted by the source node, the intermediate nodes on receiving RREQ message from source node rebroadcast it. When the destination node gets the RREQ message, RREP message is sent. Hence intermediate nodes may receive more than one RREP message. But instead of storing the path with fresh RREP message in the routing table of node, all the paths are stored. The nodes keep on sending HELLO messages during communication to know about the queue length of the neighboring nodes. A threshold value for congestion is set. If it increases than the threshold value, the data traffic is shared on some other route. Hence in C-AODV algorithm each node is having two alternate paths to avoid congestion. Hence load balancing and energy can be saved.

In mobile and ad-hoc networks, energy consumption factor is a very crucial factor. Due to depletion of energy of nodes, link failures may occur. Hence

researchers enhanced the AODV routing algorithm to make it energy efficient. In this paper, we have discussed various different enhanced and energy efficient algorithms. For future work, optimized routing will be done by using flower pollination algorithm. Hence the optimized path will be selected on the basis of maximum energy level. Further work can be done in this area by proposing more energy efficient techniques and to save the energy of the nodes when idle. As it is merely wastage of energy.

CHAPTER 3

PRESENT WORK:

Problem formulation: Wireless ad-hoc networks are self- configuring networks. Nodes are deployed in large areas for remote sensing and processing. In ad-hoc networks, the routes are created on demand and shortest route is selected for communication. As the nodes are battery powered in ad-hoc networks, so energy efficient communication is the area of concern in ad-hoc networks. In ad-hoc networks when the routes are selected, the packets are routed from source to destination through shortest path. But if the shortest path is selected multiple times for communication, the nodes present on the path may exhaust immediately. Hence communication is stopped, hence packet loss takes place. In military applications and disaster relief applications, the lifetime of the nodes must be high. So enhancement of lifetime of nodes is required to continue the communication. Energy efficiency is the major issue in ad-hoc networks. Ad-hoc networks can be made energy efficient by using optimized routing techniques instead of using shortest path algorithms. We have studied the co-operative routing technique to enhance the energy of the nodes. In co-operative routing, the optimized routes are selected on the basis of energy levels of the nodes. If the energy level of the nodes decreases than the threshold level, neighboring nodes share energy on the basis of co-operative routing. But co-operative routing is not efficient enough because if all the neighboring nodes are having low energy, the communication will stop, resulting in packet loss. So we developed an optimized routing technique using flower pollination algorithm. Flower pollination algorithm was developed in 2012 and it gained popularity very soon. With the help of this algorithm we can make the AODV routing protocol more efficient and communication can be improved. We will be using artificial intelligence for optimized routing. In flower pollination algorithm, the routes are selected on the basis of threshold levels of the nodes. Effective paths can be selected on the basis of the size of the packets being transmitted. If the size of the packets is small, path consisting of lower energy nodes can be selected but if the size of the packets is large path with higher energy node is selected. Hence optimized routing can be done using artificial intelligence and flower pollination algorithm.

Objective:

- To make the AODV routing protocol more energy efficient.
- To create optimized paths for communication rather than shortest paths.
- To use artificial intelligence optimization techniques for finding best solutions for route discovery process.
- To enhance the packet delivery ratio and end-to-end delivery at nodes.
- To select the paths on the basis of energy levels of the nodes.
- To use NS2 simulator tool for simulation of results.
- To compare the results of optimized routing technique with the co-operative routing technique developed earlier.

Methodology: The flowchart of the work which we have done in our thesis using ns2 simulator tool.

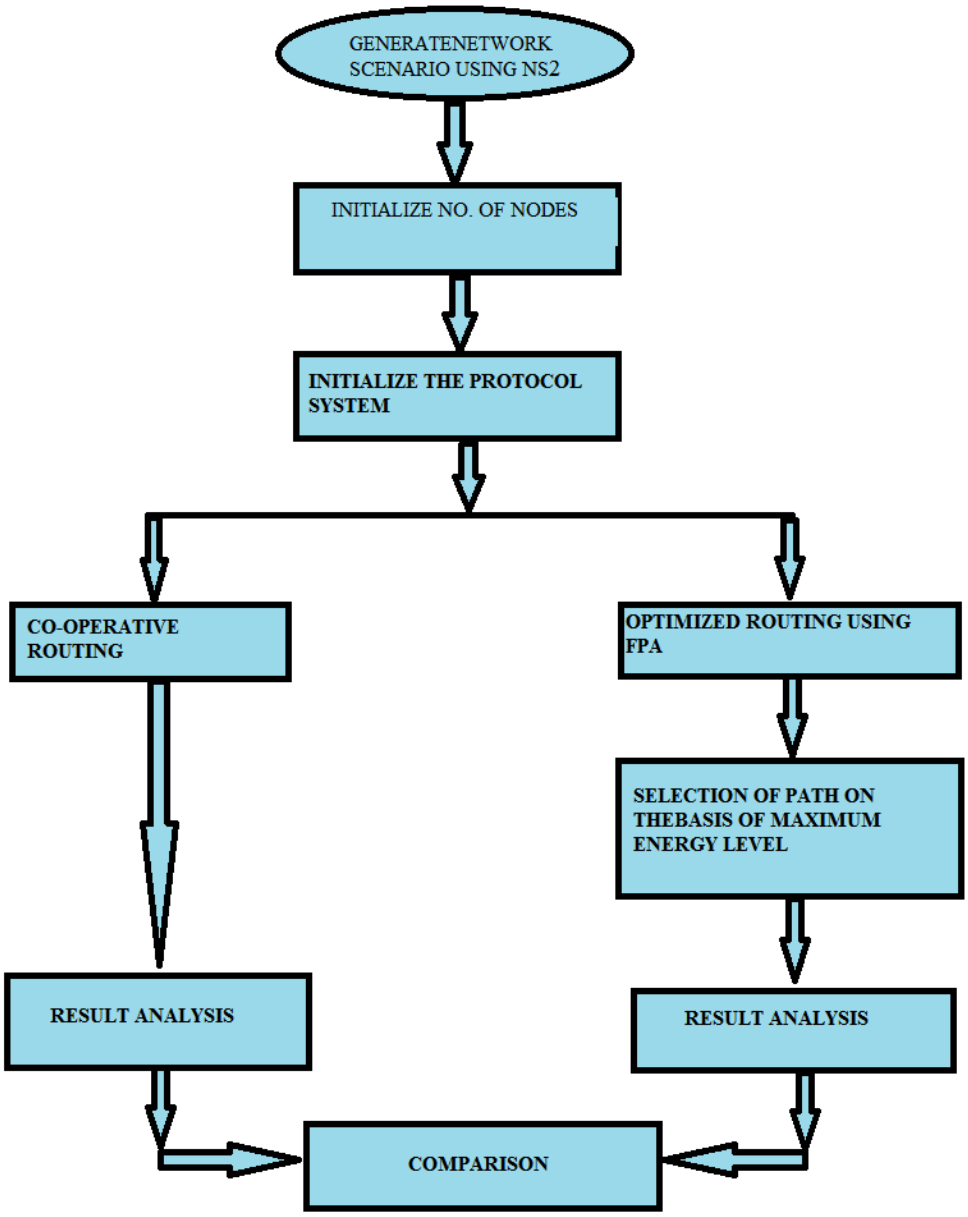

Figure13. Flow-chart

The flowchart shown above explains the steps we followed to make the AODV more energy efficient. We chose a paper based on co-operative routing in which the researcher enhanced the efficiency of ad-hoc network on the basis energy sharing between neighboring nodes. Then we developed an optimized routing technique using artificial intelligence and flower pollination algorithm. After obtaining the results we compared the results obtained by co-operative routing and optimized routing using FPA. Now we will discuss the steps one by one that how we carried out the research and how we obtained the results:

1. *Generate network scenario using NS-2:* Network simulator is a tool used by researchers for protocol studies, protocol comparison, traffic analysis, implementation of new architecture, designing of the various architectures. It provides freely distributed open source environment. Hence results obtained using NS2 are more accurate and precise. In NS2 tool basically two languages are used for programming: c++ and OTcl. With the help of programming we can create a network structure and topology. First of all area of network, no. of nodes, topology of the network, traffic agent etc are selected. C++ is the heart of the NS2 tool. Protocol designs are implemented in the network are implemented using c++. The processes that are running in a node during communication like packet flow are designed using c++. It is also used to change the running protocols in NS2. Research details can also be saved in NS2 tool using c++. Two languages are used by NS2 tool to make it more efficient because c++ runs faster while OTcl can be coded faster. NS2 tool supports following protocols:
   a. It supports unicast, hierarchical, flat, multicast routing etc.
   b. Transport agents used by NS2 are TCP, UDP etc.
   c. Traffic agents used by NS2 are ftp, cbr, telnet etc.
   d. Drop-tail queuing, RED(random early drop) etc are used.

   In NS2 simulator, NAM files are created with the help of which we can view the animations of the network and communication carried out between the nodes. Traffic agents and topologies are selected for the network. traces are generated automatically when we run the codes. We create the awk files in which the formulation is written. Traces can be analyzed by using awk files or tcl files. In NS2 we create an event by setting the instance. After setting the

instance the traces are generated automatically in NS2. Then the network scenario is created including the area of the network, number of nodes in the network, the position of the nodes in the network etc. The routing protocol is set as per need. Then errors are inserted. Then the connection is created. The connection between the nodes may be tcp or udp. Then the traffic agents are selectedfor communication. If we are selecting udp connection then cbr traffic agent is used. If we are using tcp connection then the ftp traffic agent is used. Other traffic agents are telnet, web etc. In NS2, the format of the trace file is :

< event > < time > < from > < to > < pkt − type > < pkt − size > < f lags > < f id > < src > < dst > < seq > < uid >

In ns2 the topology is defined first as it is a basic facility and the relationship between two is defined. Containers and helpers are used to facilitate this process. Then models are established e.g. UDP, point to point devices and links and applications. Then the node and the link configuration are come into existence. The values of the models are defined by default. Sometimes attribute system is used to set the values of the models. Execution is done on the logged data and the requested data. Once the execution is done then the performance analysis done and the graphical interpretation can be visualized in a very fine way.

2. *Initialize number of nodes:* Once the network scenario is created using NS2 tool, we will initialize the number of nodes in the network. The selection of number of nodes in the network is based on the type of protocol and topology we are using for communication.

3. *Initialize the protocol system:* After selecting the number of nodes in the network, we will initialize the protocol system. As we are working on ad-hoc networks, we will initialize the AODV protocol system.

4. *Co-operative routing:* Co-operative routing is the routing in which enrgy sharing takes place between neighboring nodes. Researcher studied the algorithms MCPR, CASNCP and C-AODV to improve the energy consumption by the nodes in the network and make the AODV routing more

reliable. MPCR constructs a minimum power route by taking into account the cooperative communications. Some formulas are derived by the researcher to create a minimum power route. It makes the AODV routing more energy efficient. CASNCP algorithm creates the shortest paths for communication. In this algorithm, the packets from the overloaded nodes or routers is transferred to the nodes which are either idle or have low load. With the help of this scheme we can decrease the effect of traffic in the system. In C-AODV a hop by hop scheme is proposed by the researcher in which the load can be balanced in the network. The CSMA/CA i.e. carrier sense multiple access with collision avoidance technique is used. The node which needs to send the packet checks for the transmission medium if it is idle. But if the transmission medium is busy, the back off time is chosen and decremented in the same way as during collision. The relative position of the node is calculated with respect to all the nodes present in the whole network. And the signal level is calculated with respect to signal threshold as well. Hence load can be balanced by the use of this algorithm to make the system energy efficient. By using these three algorithms, researcher had developed an energy efficient and reliable monitoring system for wireless networks.

5. *Result analysis of C-AODV:* We have analyzed the results of co-operative routing by using the technique proposed by the researcher. The sharing of energy between neighboring nodes takes place whenever the energy level of node decreases. But the problem arises when the energy level of multiple nodes drops below the threshold level. So an optimized routing technique is required to make the communication more efficient. So we developed the optimized routing technique using artificial intelligence and flower pollination algorithm. Hence enhancement of the routing protocol in terms of energy.
6. *Optimized routing using FPA:* In ad-hoc on demand distance vector, the shortest paths are selected for communication. But if shortest paths are selected again and again the energy level of the nodes may drop due to which communication may be stopped. So the selection of path during communication is the area of concern. It is not necessary that the shortest path is the reliable path for communication. It may be possible that the nodes present in the shortest path selected for communication may have lower energy levels. Hence they may exhaust during communication. Hence packets

will drop and communication will be stopped immediately. So instead of selecting shortest paths, optimized paths must be selected. Optimized paths are selected by taking into account all the parameters like energy level of the nodes, delay factor, traffic load etc. To select the optimized path, we used artificial intelligence routing. Artificial intelligence routing has gained popularity in past few years. AI is the intelligence of machines and is highly reliable. AI is a medium between behavior of nature and machines. With the help of machines, the behavior of nature can be simulated. AI is based on nature as well as bio-sciences. On the basis of behavior of nature and biology, the routing algorithms have been developed. The routing algorithms that are based on behavior of biological things are ACO and GA. ACO is ant colony optimization algorithm and it is the routing algorithm in which routes are created on the basis of behavior of ants. Routes are created using graphs and computational techniques. This algorithm explains the process of finding path for communication. Path is selected on the basis of behavior of an ant seeking for path from its colony to the food and vice-versa. When an ant finds a good path between the food and colony, the other ants follow the same path. Hence same is followed for routing between nodes. ACO algorithm is used to find optimized path between source and destination through artificial intelligence. Inspiration of finding the best path is taken from the behavior of ants. When ants move, they release a chemical named pheromone, the other ants can smell pheromone. Hence they follow each other to find the paths. Hence ants follow shortest paths. Similarly optimized routes can be found in case of routing in ad-hoc networks. The other algorithm is genetic algorithm which is based on nature. Genetic algorithms are inspired from inheritance, crossover, mutation etc. Optimized routes can be created on the basis of behavior of genes and chromosomes. But the biological routing is not effective for communication. Because the behavior can be changed at any instance of time. But natural processes remain same under any circumstances. So we prefer natural routing algorithm over biological algorithm. Flower pollination algorithm is a natural routing algorithm developed in past few years and has gained popularity due to its optimized routing. In flower pollination algorithm, pollination process takes place, in which insects carry the pollens. Similarly in our routing scheme, nodes will act as pollens. Information like energy level of node and

data is known to the neighboring nodes. Hence optimized paths can be selected. If the data packets are large, the path consisting of nodes having higher energy levels is selected. If the data packets are small, the path consisting of nodes having lower energy levels can also be selected. Hence optimized routing can be done using flower pollination algorithm. By using flower pollination algorithm different optimized routes can be selected. Out of these optimized routes, the efficient route is selected on the basis of energy levels as per requirement.

3.1 Flower pollination algorithm:

Objective min *or* max $f(x)$, $x = (x1, x2, ..., xd)$

Initialize a population of n flowers/pollen gametes with random solutions

Find the best solution $g*$ *in the initial population*

Define a switch probability $p \in [0, 1]$

Define a stopping criterion (either a fixed number of generations/iterations or Accuracy)

while *(t <MaxGeneration)*

for $i = 1$: *n (all n flowers in the population)*

if *rand* < *p,*

Draw a (d-dimensional) step vector L which obeys a L´evy distribution

Global pollination via $xt+1$

$i = xti + L(g* - xti)$

else

Draw _ from a uniform distribution in [0,1]

Do local pollination via $xt+1$

$i = xti + (xtj - xtk)$

end if

Evaluate new solutions

If new solutions are better, update them in the population

end

for *Find the current best solution* $g*$

end

while *Output the best solution found*

The code given above explains the steps followed in flower pollination algorithm for routing. Hence best path can be found on the basis of this algorithm.

7. *Selection on the basis of maximum energy level:* Using flower pollination algorithm, we can obtain various optimized routes. Now the efficient route is selected on the basis of energy level. The threshold energy level is selected for the nodes. Hence the routes consisting of nodes with the energy level higher than the threshold level are selected for communication. Routes can be selected by taking into consideration the size of the data packets. If the size of packets is large, the route having the nodes with higher energy levels is selected. If the size of the data packets is small, the route consisting of nodes with lower energy levels can also be selected. Hence optimized energy efficient routing can be done by using this technique.
8. *Comparison:* After obtaining the results of co-operative routing in AODV and optimized routing using Flower pollination algorithm, we will compare the results. Hence reliability, delay loss etc. will be compared in both the cases. Hence results will be analyzed.

CHAPTER 4

RESULTS AND DISCUSSION:

In this chapter we will analyze the work which we have done all through the dissertation 2. After the detailed study of the techniques we have used in the report and by simulating it on ns2 we have got some results which are shown below:

3.1 *NAM files of network scenario and optimized routing:*

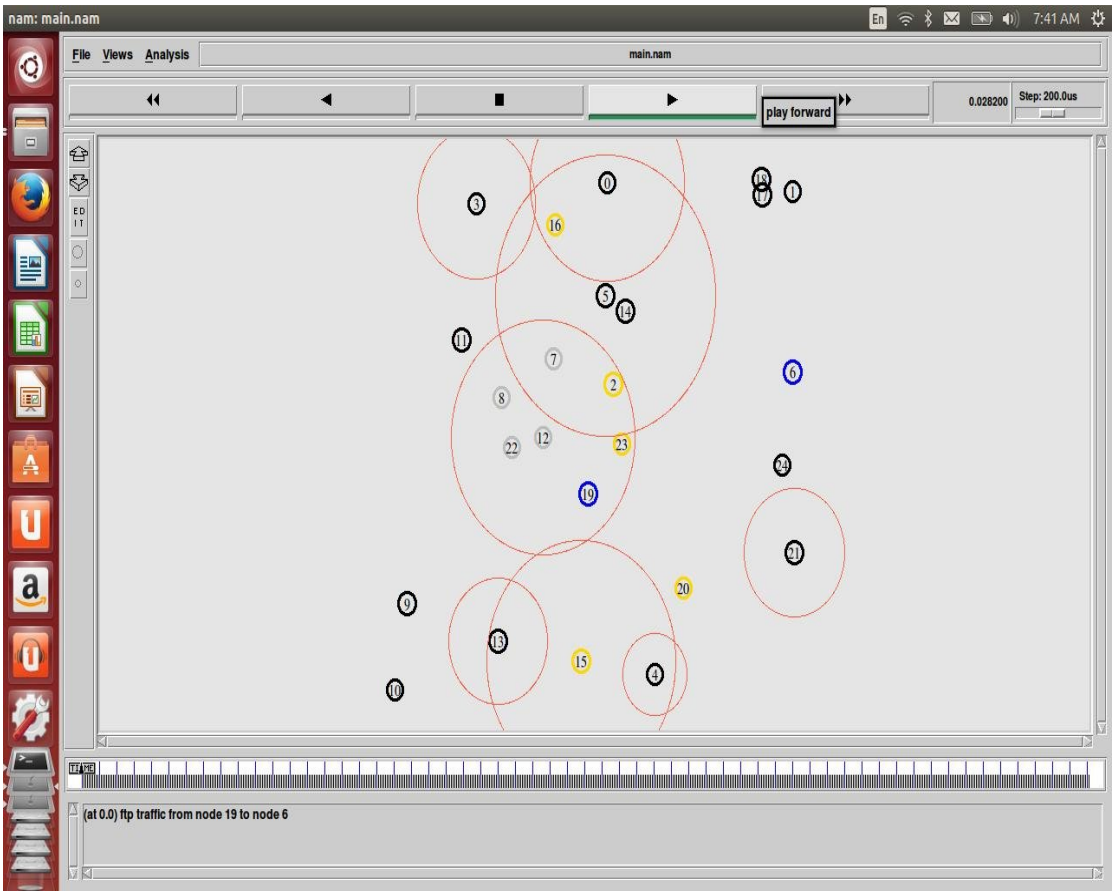

Figure14. nodes broadcasting RREQ message for communication

In this animation, the nodes are broadcasting the RREQ messages for route request. In response to which RREP messages are broadcasted by intermediate nodes and hence route discovery process is initialized.

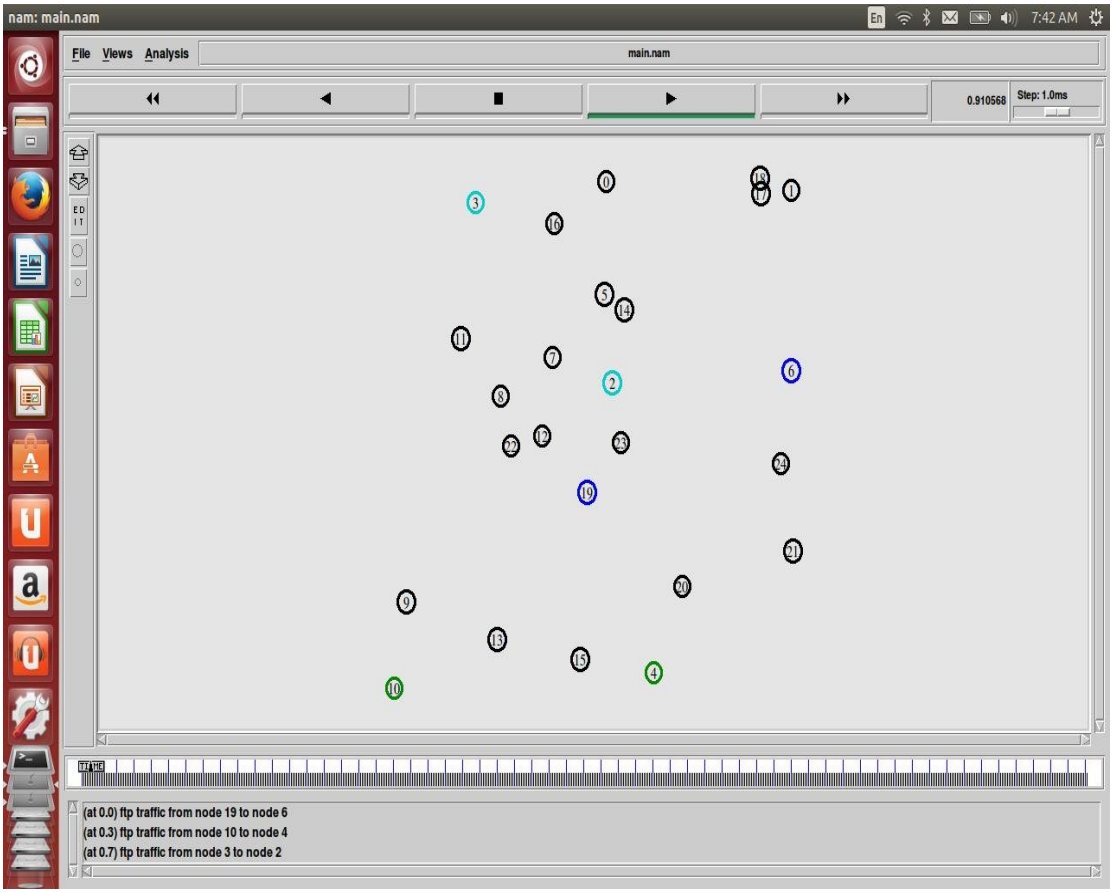

Figure15. Communication between nodes 19 to 6, 10 to 4 & 3 to 2

Communication is initialized between nodes using FTP traffic agents.

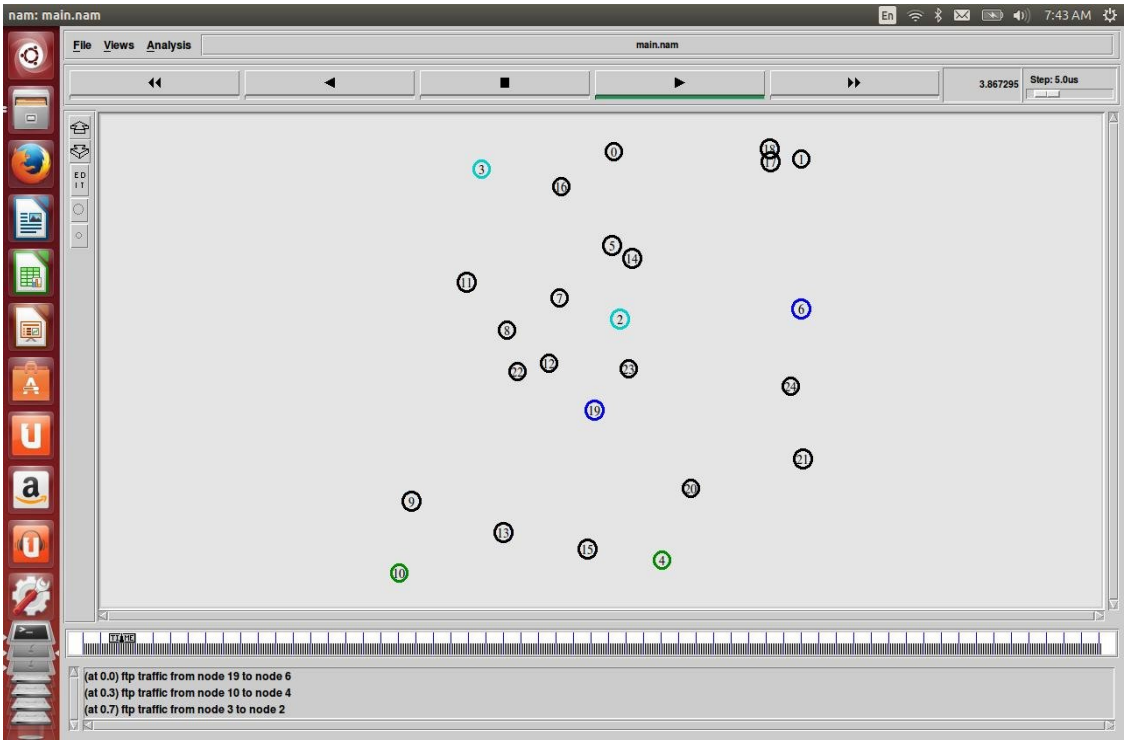

Figure16. optimized path selection

In the above animation, instead of selected shortest path between 19 and 6, an optimized path is selected through 19-20-21-24-6.

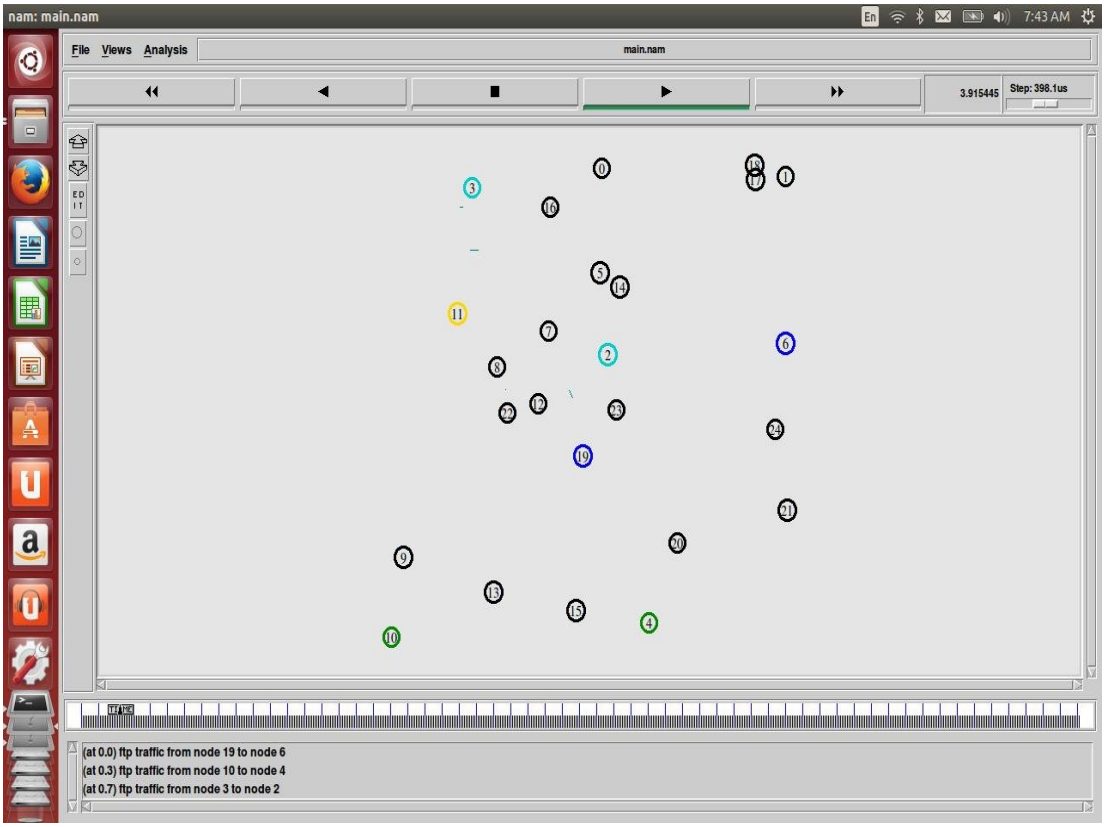

Figure17. Energy sharing using FPA

If the energy of the node in the network decreases than the threshold level, the energy sharing takes place without interrupting the communication.

3.2 *Graphs and Results:*

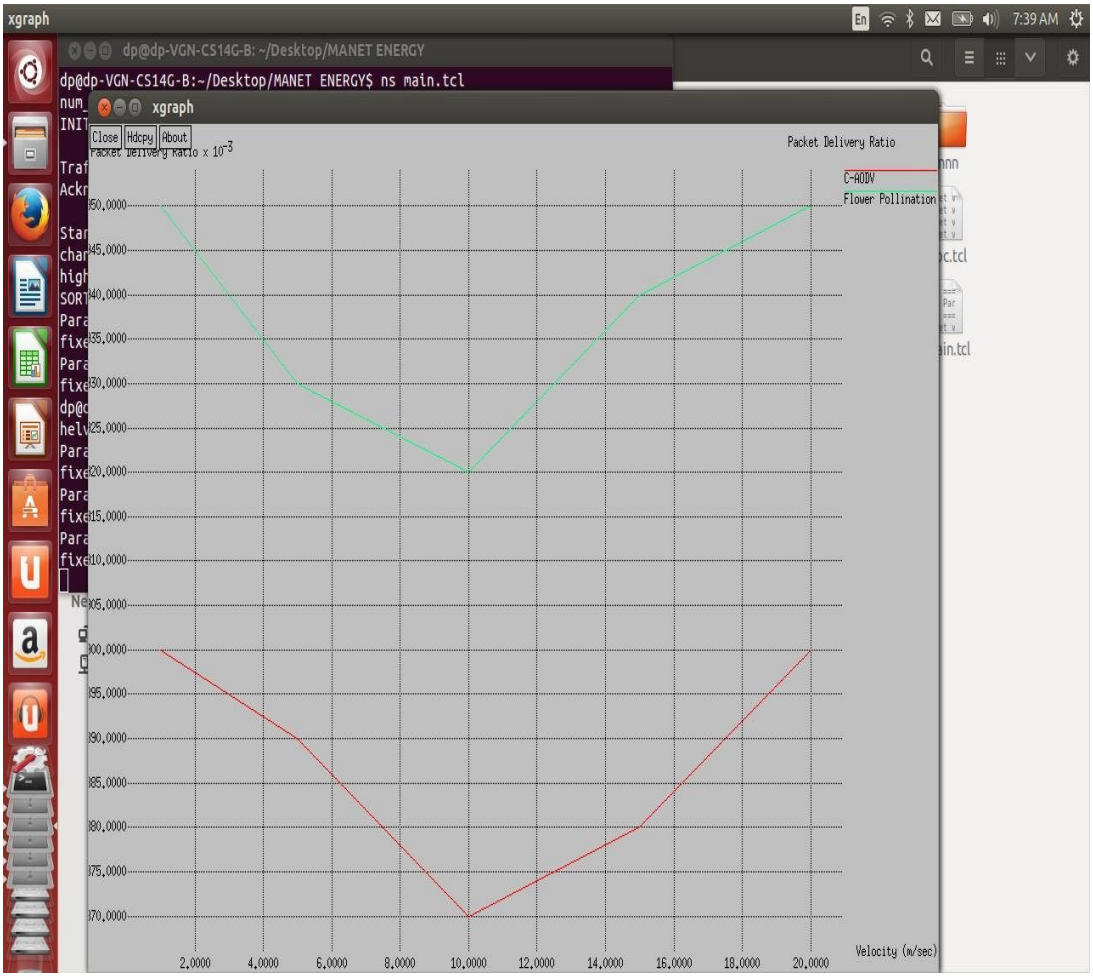

Figure18 Graph for packet delivery ratio

This graph shows a comparison between C-AODV and optimized routing using FPA. The packet delivery ratio is higher in case of optimized routing using FPA.

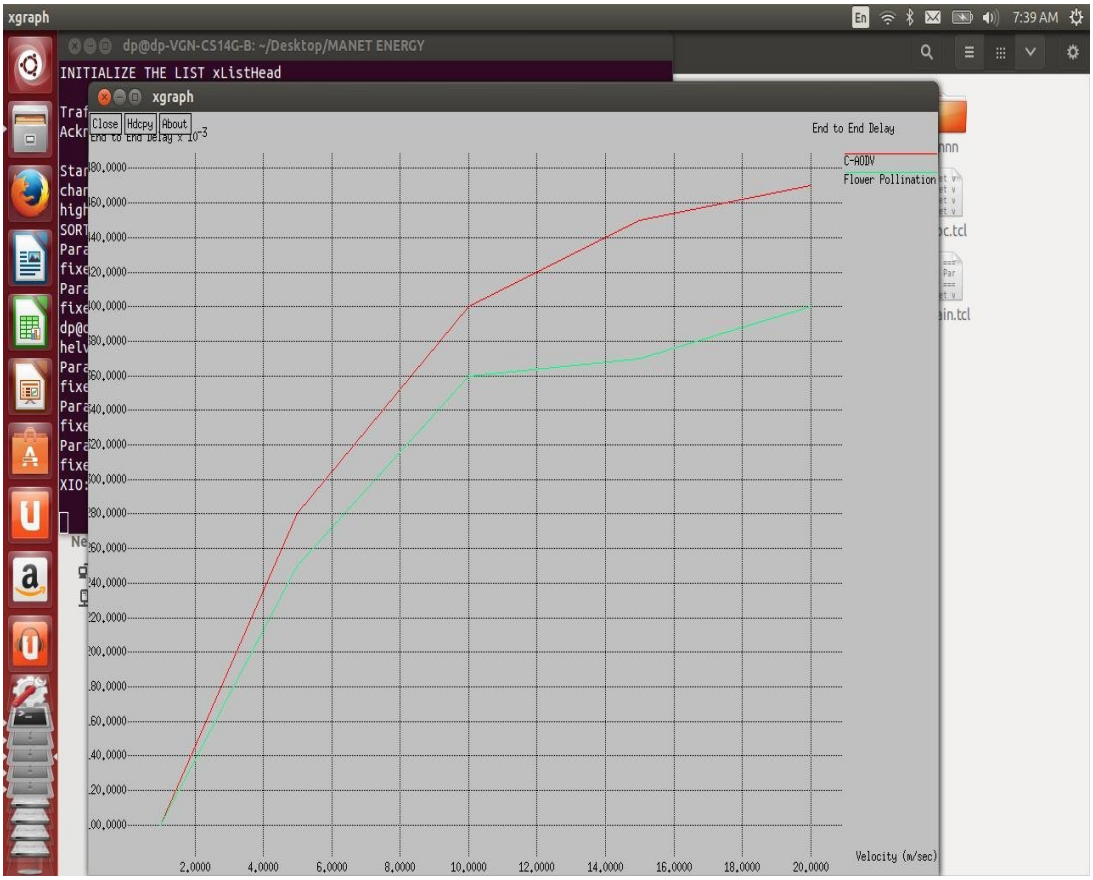

Figure19. Graph for end-to-end delay

End-to-end delay is higher in case of C-AODV and hence optimized routing using FPA is better.

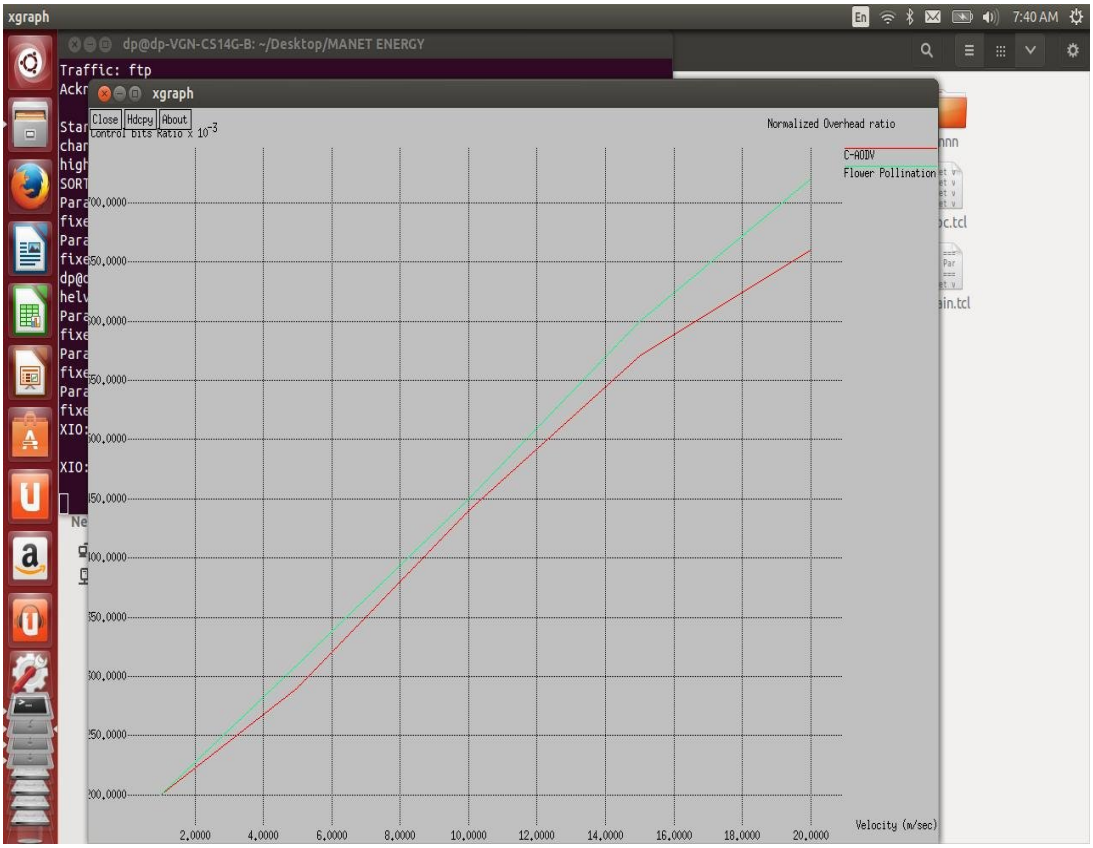

Figure20. Graph for normalized overhead ratio.

CHAPTER 5

CONCLUSIONAND FUTURE WORK: During the research, an optimized routing protocol is created using flower pollination algorithm. Comparison was carried out between the two routing protocols C-AODV and optimized routing using FPA. The results are obtained using simulation tool NS2. With the help of these results, its concluded that end-to-end delivery and packet delivery ratio is higher in case of optimized routing using FPA rather than C-AODV. Optimized routing technique using flower pollination algorithm provides best path for communication and hence energy wastage can be prevented. In future, the more optimized routing technique can be developed by hybridizing the techniques of AI (artificial intelligence).

CHAPTER 6

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CHAPTER 7

APPENDIX:

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