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Energy Efficiency in AODV using Flower Pollination Algorithm

Harneet Kaur
M. Tech (ece) ,
Lovely Professional University
Phagwara, Punjab 144411

***Abstract* — The science of computer networking and the advancements in the mobile devices enabled the capability of communicating with each other even in the absence of pre-existing communication infrastructure. These networks require specialized routing protocols due to their ad hoc nature. 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 paper we have proposed an efficient optimized routing technique using flower pollination algorithm.**

Keywords*— *MANET; AODV, Energy Efficiency, Flower Pollination, Optimization.

I. INTRODUCTION

As the importance of computers in our daily life increases it also sets new demands for connectivity. The wired solutions have been around for a long but there is increasing demand on working wireless solutions. Wireless communication between mobile users is growing more popular than ever before. This growth is due to the technological advancements in the field of computers and communicating devices. Technology has enabled computers and communicating devices (like laptops, mobile phones, tablets, wireless modems, etc) to be equipped with radio interfaces to communicate on fly. Wireless networking enhances the utility of carrying a computing device. It provides the mobile user with versatile and flexible communication and continuous access of networked services. Sarangapani [20] described Mobile Ad hoc Networks as an infrastructure-less wireless communication systems. MANET's routing is one of the key research areas for researchers. Each and every routing protocol of MANET has its own characteristics and performance level. So, it is very important to identify the key routing protocol to be adopted for selected scenario for better performance.

So the main motivation behind this work is to investigate various routing algorithms and identify the best performing protocols for the specified environment.

Characteristics of MANET

Ravi kumar et al [19] stated several salient characteristics of MANETs as follows:

- MANETs do not have any central authority or fixed infrastructure, unlike the traditional network makes MANET decentralized system.
- MANET connects themselves by discovering the topology and deliver the messages themselves makes MANET a self configuring network.
- Mobile nodes in the MANET are free to take random movement. This will result frequent changes in the topology where alternative paths are found automatically. They use different routing mechanisms in transmitting the data packet to the desired nodes by this it exhibits dynamic topology.
- MANET usually operates in bandwidth-constrained variable-capacity links. That results in low bandwidth, high bit errors, unstable and asymmetric links results in congestion problems.
- Power conservation plays a key role in MANET as the nodes involved in this network generally uses exhaustible battery/energy sources this makes MANETS energy-constrained.
- Finally, Mobile wireless networks are more vulnerable to eavesdropping and interception. The network control will increase the robustness of the failure, rather than centralized network dispersion.

Uses of MANET

With the increase of portable devices as well as progress in wireless communication, an ad hoc networking is gaining importance with the increasing number of widespread applications. Lego et al [12] discussed typical applications that include:

- Military battlefield: Military equipment now routinely contains some sort of computer equipment. An Ad hoc networking would allow the military to take advantage of commonplace network technology to maintain an information network between the vehicles, soldiers and military information head quarters. Basic techniques of ad hoc network came from this field.

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- Commercial sector: Ad hoc can be used in emergency/rescue operations for disaster relief efforts e.g. in flood, fire or earthquake. The emergency rescue operations must take place where non-existing or damaged communications infrastructure and rapid deployment of a communication network is needed. The information is relayed from one rescue team member to another over a small handheld. The others commercial scenarios include e.g. law enforcement, ship-to-ship ad hoc mobile communication etc.
- Local level: Ad hoc networks can autonomously link an instant and temporary multimedia network using notebook computers or palmtop computers to spread and share information among participants at a conference or classroom. The other appropriate local level application might be in home networks where devices can communicate directly to exchange information. In other civilian environments like sports stadium, taxicab, boat and small aircraft, the mobile ad hoc communications will have many applications.

- Personal Area Network (PAN): Short-range MANET can simplify the intercommunication between various mobile devices (such as laptops and a cellular phone). Wired cables are replaced with wireless connections such an ad hoc network can also extend the access to the Internet or other networks by mechanisms e.g. Wireless LAN, GPRS and UMTS. PAN is potentially a promising application field of MANET in the future pervasive computing context.

II. CHALLENGES & ROUTING IN MANETS

2.1 Challenges for MANET

Lego et al [12] discussed the following list of challenges shows the inefficiencies and limitations that have to be overcome in a MANET environment:

- Limited wireless transmission range: In wireless networks the radio band will be limited and hence data rates it can offer are much lesser than what a wired network can offer. It requires the routing protocols in wireless networks to use the bandwidth always in an optimal manner by keeping the overhead as low as possible.
- Routing Overhead: In wireless Adhoc networks, the nodes often change their location within network so, some stale routes are generated in the routing table which leads to unnecessary routing overhead.
- Battery constraints: This is one of the limited resources that form a major constraint for the nodes in an ad hoc network. The devices used in these networks have restrictions on the power source in order to maintain portability, weight and size of the devices. By increasing the power and processing ability makes the nodes bulky and less portable so only MANET nodes has to optimally use this resource.
- Asymmetric links: Mostly wired networks rely on the symmetric links which are always fixed but this is not a case with Adhoc networks as the nodes are mobile and constantly changing their position within network.
- Time-varying wireless link characteristics: A wireless channel is susceptible to a variety of transmission impediments such as path loss, fading, interference and blockage.
- Broadcast nature of the wireless medium: The broadcast nature of the radio channel is transmissions made by a node are received by all nodes within its direct transmission range. If a node is receiving data then no other node in its neighborhood apart from the sender should transmit.
- Packet losses due to transmission errors: An ad hoc wireless networks experiences a much higher packet loss due to factors such as high bit error rate (BER) in the wireless channel and it increased collisions due to the presence of hidden terminals, location dependent contention, presence of interference, frequent path breaks due to mobility of nodes, unidirectional links and the inherent fading properties of the wireless channel.
- Mobility-induced route changes: A network topology in ad hoc network is highly dynamic due to the movement of nodes and hence an on-going session suffers frequent path breaks.

2.2 Routing in MANETs

Kumar [11] described routing is an act of moving information from a source to a destination in an internetwork. At least one intermediate node in the internetwork is encountered during the transfer of information. The two activities are involved in the concept of determining the optimal routing paths and transferring the packets through the internetwork. The transferring of the packets through the internetwork is called as packet switching which is straight forward and the path determination could be very complex.

Routing protocols use several metrics as standard measurement to calculate the best path for routing the packets to its destination that could be number of hops which are used by the routing algorithm to determine the optimal path for the packet to its destination. Process of path determination is that routing algorithms which find out and maintains routing tables and which contain the total route information for the packet. Information of route varies from one routing algorithm to another and the routing tables are filled with entries in the routing table are ip-address prefix and the next hop. The destination/next hop optimally by sending the packet to a route representing the address prefix specifies a set of destinations for which the routing entry is valid.

Ad-hoc On-demand Distance Vector (AODV)

The most well known protocol which uses distance vector algorithm is Ad-hoc On-demand Distance Vector designed for MANET which is an updated version of DSDV protocol.

Routing Mechanism in AODV

Perkins et al [15] suggests that AODV uses DSDV mechanism for routing and consists of few key contents in the routing algorithm, detail of these algorithm are listed below,

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- Sequence Number
- Route Request
- Route Reply
- Route Error
- Local Repair

III. PROPOSED WORK

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.

The Step wise Algorithm for proposed work is as follows:

Step 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.

Step 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.

Step 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.

Step 4: 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

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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.

Step 5: 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.

IV. SIMULATION RESULTS

Simulation Setup

We implemented our programs based on the NS2 (Network Simulator 2). Recently NS2 has been the predominant simulator in wireless communication researches. In order to evaluate the performance of the protocols as the networks size scales up, each experiment was carried out on the 50m × 50m square simulation fields of 25 mobile nodes. Nodes were generated randomly at random position. Nodes were generated at random time as if few nodes were entering into the topology. Nodes were moving at constant random speed. Radio propagation model used was two-Ray Ground. Antenna model used was Omni Antenna. Movement was linear and node speed was constant for a simulation.

Node Characteristics:

- Link Layer Type: Logical Link type (LL)
- MAC type: 802_11
- Queue type: Drop-Tail
- Network Interface type: wireless
- Channel type: wireless

To evaluate and compare the effectiveness of these routing protocols in a Mobile Ad-Hoc network, we performed extensive simulations in NS2.34. Each simulation is carried out under a constant mobility.

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.

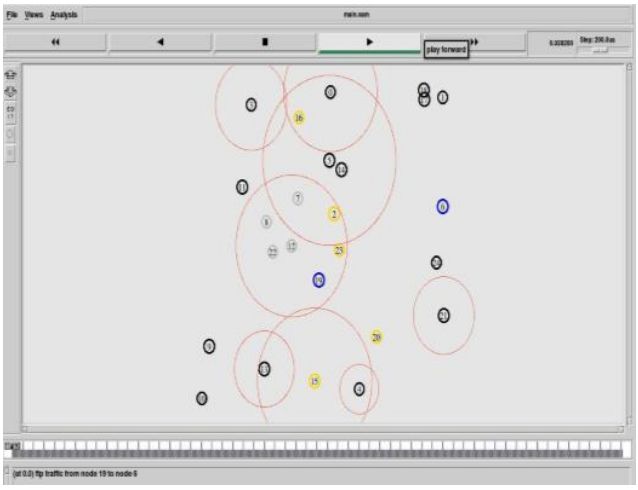

Fig 1: nodes broadcasting RREQ message for communication

Communication between nodes: Communication is initialized between nodes 19 to 6, 10 to 4 & 3 to 2 using FTP traffic agents.

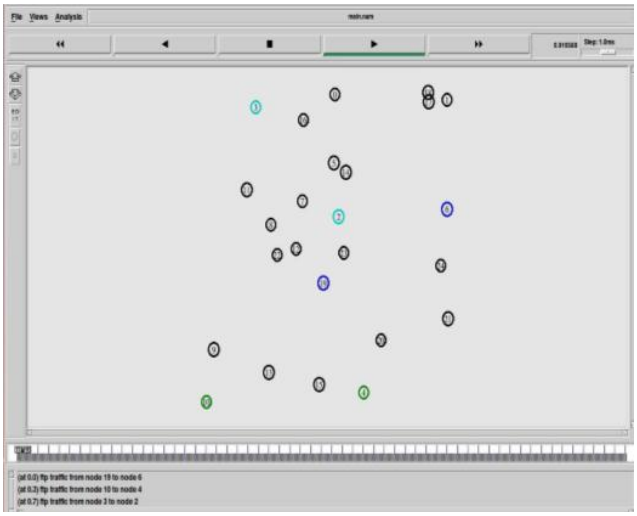

Fig 2: Communication between nodes

Optimized Path Selection: In the below animation, instead of selected shortest path between 19 and 6, an optimized path is selected through 19-20-21-24-6.

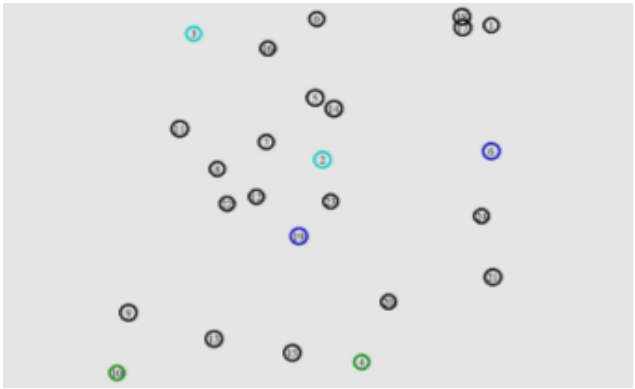

Fig 3: Optimized Path Selection

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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.

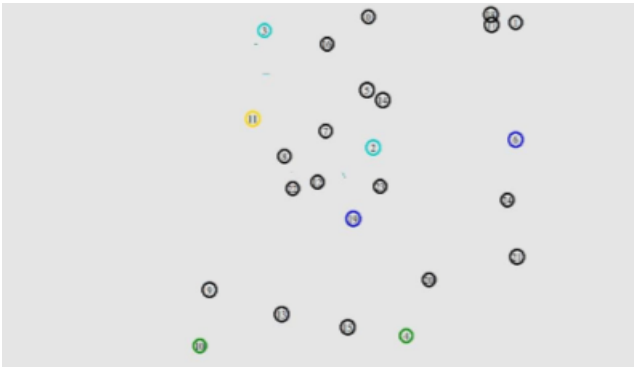

Fig 4: Energy sharing using FPA

Parameter Analysis

The results are based on the simulation of the scenario defined and performance analysis is based on some performance matrices like packet delivery ratio (PDR), End to End Delay & Normalized Overhead Ratio.

Packet delivery Ratio (PDR): It is the ratio of all the received data packets at the destination to the number of data packets sent by all the sources. It is calculated by dividing the number of packet received by destination through the no. of packet originated from the source.

$$PDR = (P_r / P_s) * 100$$

Where, P_r is total packet received and P_s is total packet sent. Fig 5 shows a comparison between C-AODV and optimized routing using FPA. The packet delivery ratio is higher in case of optimized routing using FPA.

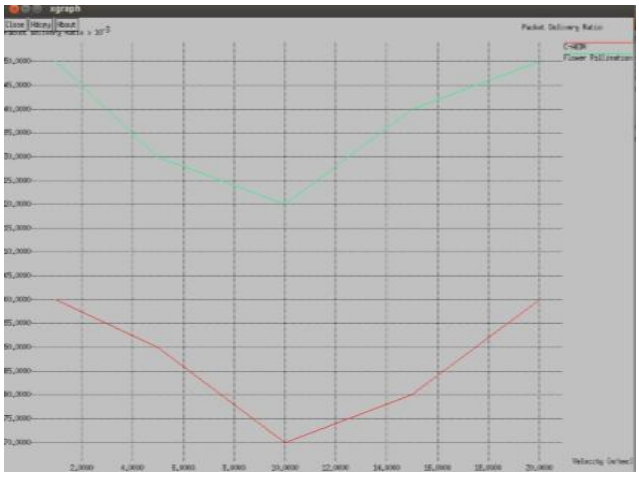

Fig 5: Packet Delivery Ratio

End to End Delay: This includes all possible delays caused by buffering during route discovery, latency, and retransmission by intermediate nodes, processing delay and propagation delay. It is calculated as

$$D = (T_r - T_s)$$

Where, T_r is receive time and T_s is sent time of the packet. Fig 6 shows the comparison of proposed method. End-to-end delay is higher in case of C-AODV and hence optimized routing using FPA is better.

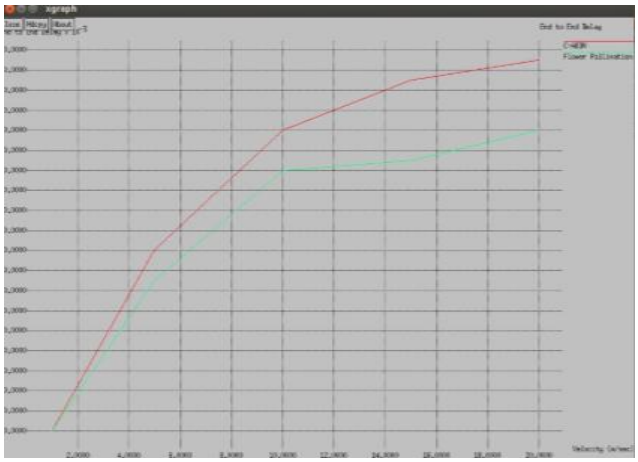

Fig 6: End to End Delay

Routing Overhead: This is the total number of routing control packets generated by all nodes to the total data packets during the simulation time. Fig 7 shows the comparison of proposed method by calculating normalized overhead ratio.

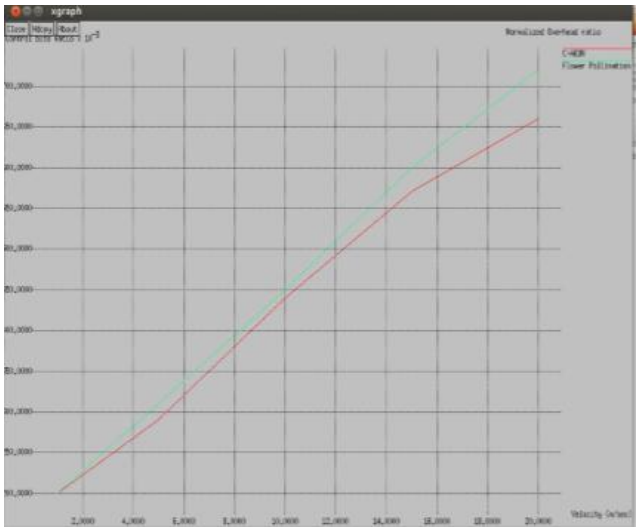

Fig 7: Normalized Overhead Ratio

V. CONCLUSION

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).

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