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DEVELOPMENT OF ENERGY EFFICIENT PROTOCOL FOR AD HOC NETWORKS

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Abstract

The term adhoc network refers to a network that is created spontaneously, self-powered and infrastructure less networks. The energy in adhoc network does a crucial role in lengthening the network life span. The energy saving techniques in adhoc networks help to overcome the problem of link breakage. adhoc networks are generally used for specific scenarios, such as Earth Quakes, Military, Wild Life Monitoring, under water surveillance monitoring and disaster management. In this type of scenario, adhoc network nodes are located normally far away from each other and each node is independent in network and individually powered by batteries. So, Battery is the major constraint of this type of adhoc network. In an adhoc network, communication between nodes is possible by one another through forwarding packets and finding the paths to the destination by itself. Path selection in an adhoc network keeps in consideration energy usage, to increase the duration of the network. The selection of the optimal path can increase the duration of the network, if the highest leftover energy parameter is used to choose a path and a path with less hop count, the possibility of increase in network lifetime is more. The path selection is performed using the adhoc routing protocols and the AODV protocol has already been proven by researchers that it is appropriate for use in an adhoc network to increase battery efficiency and to lengthen the network life span. But, the AODV protocol has many disadvantages while determining the optimal path due to the reason, such as AODV protocol always tends to choose the shortest path without calculating the intermediary node residual energy, and then this leads to link breakage in the path. To overcome this drawback of the AODV protocol, we have designed a newly modified protocol called the Optimized Residual Energy Selection Adhoc On Demand Distance Vector (ORES-AODV) protocol, which selects the optimal path by calculating the average of maximum residual energy and by finding the average energy overhead of the intermediate nodes in the path and the mobility of the nodes are compared using mobility models. This protocol is 7% efficient than the other protocols proposed by taking AODV as the base protocol. Another Adhoc Network, the Wireless Sensor Network, has seen tremendous research in several years to solve the energy dissipation problem. To address the issue of energy waste in Wireless Sensor Networks, a new protocol called Modified Mobile-sinks-based Energy-efficient Clustering Algorithm (M-MECA) is introduced, which is based on mobile sink and clustering. The proposed protocol is compared with other protocols and the protocol developed is 6% efficient as evaluated with other protocols.

Keywords:

Energy Saving, AODV protocol, Optimized Residual Energy Selection Adhoc on Demand Distance Vector, Mobile-sinks-based Energy-efficient Clustering Algorithm

1. INTRODUCTION

The adhoc network is formed basically in scenario where the deployment of network topology formation does not require any preparation, and the network can be instantly formed in any hostile environment, in which the radio range of cellular network service providers are unavailable. The topology of the network is formed in real time is useful in a number of scenarios where nodes are in mobility and want to communicate with other nodes immediately. The network is decentralized and every node can act as a router or intermediate node or transmitter or receiver. The adhoc network keeps two neighboring nodes in its vicinity so that it can communicate with them and form an adhoc network quickly. The nodes that make up the network can move unpredictably, some of the migration of nodes is faster, this quick movement of the node changes the adhoc network topology, a few nodes may move less frequently and slow mobility is observed. Therefore, the node migration from one site to another is unpredictable is another challenge faced by adhoc protocol other than the battery constraint. In an adhoc network, the mobility models used will determine the behavior of the mobility of nodes in the adhoc network. The two different used mobility models in network scenarios are the Gauss Markov Mobility model and Random Way Point Mobility Model. The network nodes can move in any random unpredictable direction, the proposed protocol ORES-AODV is compared in Random Way Point Mobility Model and Gauss Markov Mobility Model. The mobility model will describe the movement of a node in the network, its location, velocity and acceleration.

The mobility model does a random walk, and is classified in to two types. First, Indoor Mobility Model and Second, Out Door mobility model.

In Indoor Mobility Model, an Indoor scenario is chosen, where nodes travel from one location to another randomly. In this model, three different types of mobility can be identified, random walk, random waypoint and random direction. For example, consider two individuals within a room walking and moving from one place to another holding a cellular phone. In this scenario, participating node1 can visit the location of participating node 2 and vice versa. In the indoor mobility model, by selecting the direction and speed at random, the mobile node goes from its current site to its new one. This method is known as random walk, the attributes which are used here are minimum speed and Maximum speed.

Direction $[0,2\pi]$, which means it can move in 360 Degree. Also, the parameters constant time interval and distance '*d*' are also used. In random walk mobility, the direction, speed and acceleration are dynamic. In pause time is zero and does not store its status in memory, which is known as a memory less pattern. Also, the current speed does not depend on past speed of the node. It also difficult to forecast the movement of nodes because of their rapid turns.

The second classification of indoor mobility model is Random Way point Mobility Model. The difference between the Random Mobility and Random Waypoint Mobility Models is that the Random Way Point Mobility Model stops the transition between speed and direction change. Mobile Node stays for a certain period, before making the next move.

The third classification of indoor mobility model is Random Direction Mobility Model, in which the model the probability of new destination is always in centre of the simulation Area, also the path passes the simulation area centre. This will form a cluster in the middle of the network area. In the Random Direction Model, From the ranges [0,2π] and [0, V_{max}], the node selects a random direction and velocity. The node will then slowly reach the border of the simulation area. When the node reaches the simulation area edge, it waits for the pause period. When the pause timer expires, the node selects a new direction from [0, π], and begins approaching the boundary.

In the outdoor mobility model, the protocol Gauss Markov mobility model, this protocol was proposed for simulating personal computers and its mobility. The Gauss Markov mobility model has several features such as easy adaption to random mobility. Initially in Gauss Markov mobility model, the nodes are assigned by current speed and direction. Since, the mobility is out door, area of simulation is infinite, and there is no initial point and then it randomly takes some direction. The nth value of the speed and direction instant is calculated using the following equation.

$$K_n=\alpha K_{n-1}+(1-\alpha)\, k + \sqrt{(1+\alpha^2)}\, Kx_{n-1} \quad (1)$$

$$Dt_n=\alpha Dt_{n-1}+(1-\alpha)\, Dt + \sqrt{(1-\alpha^2)}\, Dtx_{n-1} \quad (2)$$

where, K_n and Dt_n are the random variables of gaussian distance, α is the index of randomness, k is the average speed, Dt is average distance and K_n is the new speed, Dt_n is the new direction. If the new speed and direction must be assigned, Eq.(1) is employed to determine the new speed and direction. The nodes are mostly expected to be inside the simulation area, if there is any possibility that any node crossing the boundary of the simulation area, then by using the equation and a specific mean value, the node can be pushed inside the simulation area.

Another protocol in the outdoor mobility model, is the Random Walk Mobility Model in Probabilistic Form. A probability matrix is used in this mobility model to calculate the position of a specific Mobile Node in the next step, in the probabilistic matrix the state 0 indicates the mobile node current location and state 1 denotes the previous location of the mobile node and the node next position is indicated by state 2.

$$\Pr = \begin{pmatrix} pi(0,0) & pi(0,1) & pi(0,2) \\ pi(1,0) & pi(1,1) & pi(1,2) \\ pi(2,0) & pi(2,1) & pi(2,2) \end{pmatrix}$$

Based on the probabilistic matrix given, the current, previous and next moves of the mobile node are determined in the Random Walk mobility model with a probabilistic twist. As given in matrix movement of node from the next state to the previous state is directly impossible and node will remain in their current state, mobile node can move from the previous state to the next state only once they reach the current state.

The Wireless Sensor Network is an information-gathering network from sensor nodes throughout the network, the wireless sensor network is also suitable for a hostile environment, where quick adaption of the network is necessary. The proposed protocol highlights the benefits of using multiple sink node for gathering data to overcome the issues such as sink holes and the methods for creating cluster heads to avoid the hot regions near the base station. The proposed protocol creates a virtual star cell with in a circle formed using two symmetrical equilateral triangles, where two mobile sinks move to reduce the communication overhead and energy hotspot near the sink.

1.1 OBJECTIVES

The objectives of the proposed work are,

- To tackle the energy-related issues, an energy-efficient technique was developed for Adhoc network.
- To extend the Adhoc Network life span.
- To decrease issues related to packet loss and to increase the count of packets sent.
- To enhance the ratio of packets delivered.
- To distribute the load among mobile sink node to overcome the hot spot issues.

2. RELATED WORK

Different types of research are performed for energy evaluation and analysis of Mobile Adhoc Network and Wireless Sensor Networks. The research carried out in the areas of Mobile Adhoc network is focused on mobility models, which initially select less mobility and eventually variation is granted to get the accurate results.

When using the AODV protocol with a higher number of nodes, its performance declines. Due to battery limitations, nodes have a limited lifespan. EELMAR and EMV are two algorithms that potentially improve the energy efficiency of network nodes.

The energy consumed by AODV, DSDV, DSR, and TORA routing protocols was determined using different mobility speeds, traffic patterns, node counts, and area. They concluded that TORA performed the worst in all cases.

Random Waypoint, RPGM, and Manhattan Grid models are compared with AODV, DSR, and DSDV. Under RWP and RPGM, AODV consumes more energy, whereas DSR consumes more energy under the Manhattan Grid model, Feeney energy model is used by the writers.

AODV is a set of protocols that use a combination of balancing loads and transmission power control to extend the lifetime of Adhoc Networks (MANETs). Once a route has been chosen, to reduce node power usage, link by link, the transmission power will be modified.

The authors of [6] use a collection of nodes and links to model an adhoc network. Each link has a cost of energy function that is a function of the overall traffic that passes through it. They concentrate on how to distribute traffic across several paths to cut down on the total amount of link cost of energy.

The RREQ and RREP handling processes in mobile devices have improved owing to the routing algorithm used by the Energy Efficient Adhoc Distance Vector protocol (EE-AODV), Manickam et al. [7] proposed that the existing AODV routing protocol should be improved.

Proposal for an energy-constrained mobile adhoc network protocol called AODV Energy Based Routing (AODV-EBR). This protocol improves the Adhoc on demand distance vector routing protocol by a new data packet routing channel is being introduced in the network active communication.

A perspective AODV-ROE (AODV Reduction Overhead and Energy) is based on reducing the number of control messages required to discover and maintain a route by consuming less energy. The primary goal of this new protocol is to keep the network connectivity as long as possible.

At least at periods when regular performance is almost the same, AODV could extend network life. A new protocol AODV GAF was designed, and the more nodes there are, the better AODV GAF performs.

3. METHODOLOGY

3.1 SYSTEM MODEL FOR ORES-AODV

The proposed protocol ORES is evaluated upon indoor and outdoor mobility models, the Protocol first chooses a random number of packets, which is transmitted by all nodes for the testing scenario. The protocol allows to transmit control packets in a controlled area of the scenario and selects only certain nodes as transmitter and receiver, and the remaining nodes as routers. The protocol is then analysed on the different mobility models, at different speeds and velocities. The protocol must use control packets such as RREQ, RREP and RERR, so the combination of three packets required for one Control Packet C_p, and the time required to transmit the data can be obtained from the equation,

Time of Transmission = C_p×(Size of Packet/Bit Rate)

Therefore, the energy consumed for the transmission can be obtained from the equation,

Energy Consumed = Power×Time of Transmission

The equation clearly states that the energy consumed for transmission is directly proportional to the total time of transmission, hence in this proposed work, mobility models are compared with the number of sent packets and total transmission time with a varying number of nodes, speed and packets.

3.2 SYSTEM MODEL FOR WSNS

3.2.1 Basic Assumptions:

1. The network area has sensing nodes and sink nodes, sensing nodes are with similar characteristics and are static in their locations.
2. Sensor nodes are dispersed throughout the network and have adequate storage capacity.
3. The broadcasting power of the sensor nodes is adjustable by themselves based on the distance from the receiver.
4. Sink movements are synchronous to each other, but are capable of moving in opposite directions to each other.
5. The sinks move in a fixed path, reach a rendezvous point and can send their locations to the nearest neighbors.

3.3 MOVEMENT STRATEGY

The Modified Mobile-Sinks-Based Energy-Efficient Clustering Algorithm (M-MECA), is a naturalistic movement strategy. Due to the benefits that hexagonal forms provide; they may be employed for various applications. The benefits of selecting two symmetrical triangles inside a circle are shown below.

In comparison to other shapes, symmetrical triangles positioned close to each other have fewer empty spaces. In comparison to other forms, this method covers a larger area per circumference, therefore, it can cover more sensor nodes.

We present a cluster-based routing solution that saves energy based on several mobile sinks in this study. The scheme main purpose is to allow cluster heads to get closer to mobile sinks while simultaneously solving the issue of cluster head sinking.

Each sensor node in each cluster may be near two portable sinks. As a result, cluster heads' energy usage of the procedure for transmitting data is reduced. Mobile sinks may simultaneously cover all the areas of a cluster, boosting network performance.

The proposed approach is divided into three phases: initial sink placement and movement strategy, sink halting stations, and an energy efficient hierarchical routing algorithm. Sensing nodes can use various communication channels to convey their data as cheaply as possible to the nearest mobile sink.

In the proposed method, because of the advantages it gives for sensor nodes, the circle form is considered the sensing area. Mobile sinks that travel along the sides of both the triangles in opposite direction of each other, at a predetermined constant velocity V in M-MECA. The sensing nodes can use less energy to convey data to the nearest sink during the procedure for transmitting data, Figure 4 shows one example of this.

The proposed strategy involves using a network of mobile sinks to gather information from additional sensor nodes. A halting station brings each sink to a halt, where it only should communicate its location once. Before any migration or change in location, this action is accomplished.

To gather information from other sensor nodes, each mobile sink is set to wait for a specific period, known as stoppage time. This period was regarded as data collecting period. The data collecting process is separated into several rounds, each of which occurs during toppage time.'

The sensor nodes determine their proximity to this location of the relevant sink after they get the message. Because every node is aware of the quantity and location of neighbours in the vicinity of the sinks, so that it will be easier for other sensor nodes to relay their data. to the nearest sink. After the stopping period has passed, each sink node moves on to the next stoppage station.

3.4 HIERARCHICAL ROUTING ALGORITHM WITH LOW ENERGY CONSUMPTION

When a sensor node uses the proposed hierarchical routing method to send data packets to the sink close to the node, it must follow the following principles, M-MECA is described below.

- The data from the node are sent as cheaply as possible toward the direction of the nearest sink or cluster head.
- The mobile sinks travel along huge diagonals of triangles, the node may be next to the sink.
- In this situation, the node can calculate its distance from the nearest sinks to determine the closest sink.
- One of the four paths used by the node to figure out how much it costs to run: the shortest route to the nearest sink, route to the sink via multiple hops, the CH path, and routing to its CH over many hops.

- Therefore, the node must transmit its data via the least energy-intensive route available. The sensor node in the network must evaluate the optimal relay node (*Kj*) in the multi-hop routing procedure to manage the energy when transmitting data.
- To limit the energy consumption in the multi-hop routing process, each sensor node can save information about the position of the sinks in close proximity and the ID of *Kj* as the optimum node for succeeding transmission of data at each rendezvous point based on the leftover energy of *Kj*.
- If *Kj* remaining energy falls below the threshold, new node for relay has to be selected by the node.

4. SIMULATION FOR ORES-AODV

In the NS3 simulation platform, we evaluated the AODV routing protocol in a MANET using the mobility model in terms of the control packets count with varying mobility, speed, and node density, and found the following outcomes:

Table.1. Simulation parameters for ORES-AODV

Parameters	Value
Time for simulation	300 s
Size of the terrain	700×700m
Total nodes	50
Speeds of mobility	1–20m/s
Connection count	10
Mobility models	Linear, Random Waypoint, Mass, Gauss-Markov Mobility
Protocol for routing	AODV
Power sent out	1mW

Due to an increase in the frequency of connection interruptions between nodes, the number of transmits increases in control packets as mobility increases.

In comparison to the random waypoint model, the total sum of control packets transmitted is lower in the Markov model. This is because each node can anticipate the paths of other nodes, resulting in fewer connection breakage. The rate of change of received control packets increases significantly as network density increases.

4.1 SIMULATIONS FOR M-MECA

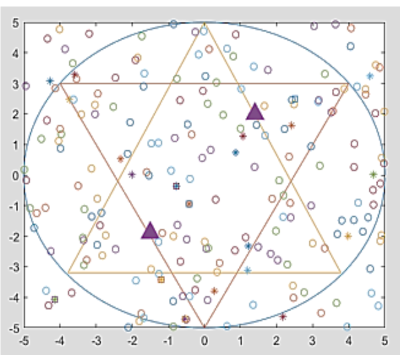

Fig.1. Simulation of M-MECA in MATLAB

5. RESULTS AND DISCUSSIONS

5.1 ORES-AODV

The average and variance of alternative models of 50 node movement in the network are shown in Table 2. When it comes to mass mobility, the typical number of control packets is the smallest, but the variation is the biggest.

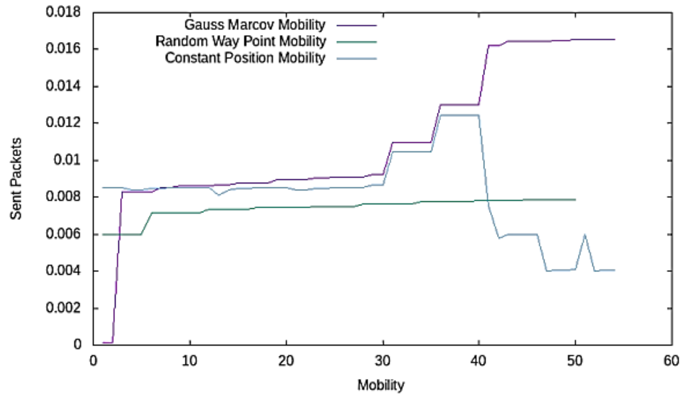

Fig.3. Comparative analysis of Sent packets in ORES-AODV for different Mobility Models

The density of all nodes shows nearly linear behavior in the slow and medium-sized areas, but there is no sudden shift in the transition from medium to rapid because it is a sort of each node has group mobility travels in clusters. The behavior of 30 and 40 node networks in the medium area is consistent, when there are 50 nodes, random waypoint mobility is exhibited throughout the mobility zone, there is a rising zigzag pattern.

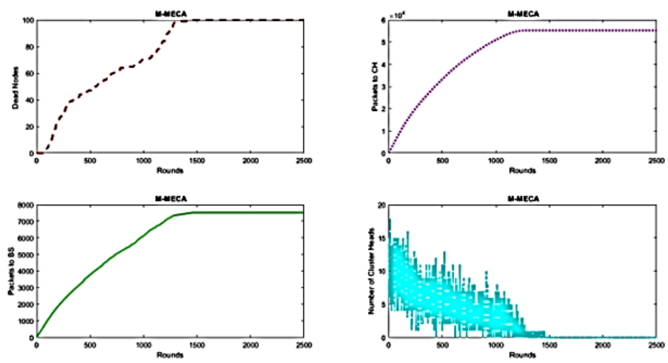

Fig.4. Evaluation of M-MECA in different parameters

The count of control packets sent is lower in the Markov model than in the because each node is a probabilistic model that has a random path that may forecast the course of other nodes, resulting in fewer link breakdowns.

It has also been demonstrated that as network density increases, so does the rate at which things change in the control packets count sent out.

Different mobility models show a similar impact of increasing the count of nodes, i.e., increasing the count of nodes affects the network performance.

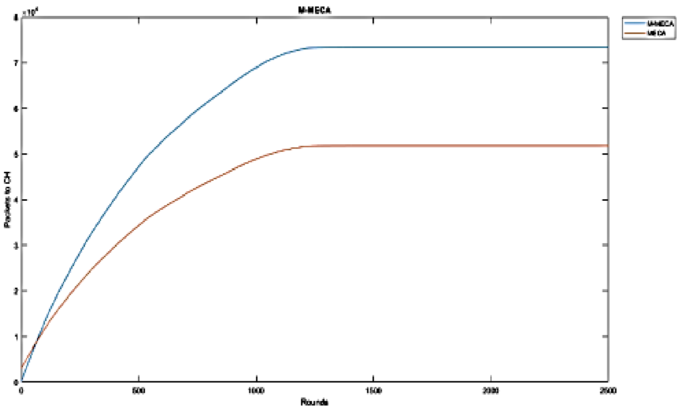

Fig.5. Comparison of MECA and M-MECA on the number of packets to cluster head

5.2 M-MECA

M-MECA protocol is evaluated in the selected simulation area, this protocol can efficiently manage to send and receive packets from cluster heads and the movement of the mobile sink is also monitored efficiently by the protocol. Fig.4 shows the evaluation of M-MECA using evaluation metrics, and M-MECA is found to more efficient in performing data delivery. The comparative evaluation of MECA and M-MECA is shown in Fig.5 and it is observed that the M-MECA is more efficient than MECA in receiving packets from CH.

6. CONCLUSIONS

The total count of transmitted control packets was used to compare alternative mobility models for mobile adhoc wireless networks. Mobility is divided into three categories: slow, medium, and fast. In a mass mobility model, creating links in the moderate and rapid mobility areas requires fewer control packets. The AODV routing protocol needs more control packets in the rapid mobility zone (RREP) than the random waypoint model (RMP). The RMP model contributes more to control packets, so efforts might be taken to reduce the quantity of RREP delivered in the protocol. Lowering minimizing energy usage and increasing network longevity are the significant concerns in wireless sensor networks that should be considered.

Cluster-based techniques based on multi-mobile sinks have been used in the last few years to balance energy usage and extend the longevity of WSNs. Sensor nodes are randomly dispersed inside a region in the proposed technique. This network area is made up of two symmetrical triangles inside a circle. A cluster is defined as any triangle. Sinks moving along diagonals can decrease the distance among the cluster heads and mobile sinks on average, allowing for increased energy conservation in data transfer.

The proposed solution solves the cluster head sink problem, which is a significant challenge in MECA, allowing mobile sinks to connect to additional sensor nodes in each cluster.

In terms of overall energy usage, active node count, and average residual energy among sensing nodes, the proposed technique beats the MECA and M-MECA algorithms, according to the simulation findings.

6.1 FUTURE WORK

The proposed ORES-AODV protocol is evaluated in this work using 100 nodes and, in the future, it can be analysed using a greater number of nodes. The proposed work has evaluated the ORES-AODV protocol under different mobility models to perform energy consumption comparison under different mobility models. This protocol can further be evaluated for security measurements and be evaluated to determine the efficiency of the protocol. The ORES-AODV protocol can be further modified to create clusters among the nodes and then transmit the packets based on the requirement of the cluster heads.

The proposed protocol for WSN can be used in the future by adding a greater number of mobile sinks to capture data from cluster heads from different clusters. A simulation area can be formed using a polygon to cover every edge of the sensing area and protocol developed can be implemented to overcome the energy dissipation issues by obtaining the information about the number of member nodes under each cluster head, so that load distribution can be identified and multiple cluster heads can be assigned to such clusters.

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