Optimization Routing Algorithms for Energy Efficiency in Mobile Ad Hoc Networks

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***Abstract*- Mobile Ad hoc Network (MANET) is a collection of mobile nodes that are arbitrarily located in the network environment. With the dawn of the new era and rising demands of customers, the mobile ad hoc networks has come into full force. But large amount of data usages and complex applications demands the devices to be more and more efficient in terms of utilization of their batteries thus giving rise to most important energy conservation problem in MANETs. The interconnections between the nodes are dynamically changing. Mobile nodes form a temporary network without the use of any existing network infrastructure or centralized administration. A routing protocol is used to find routes between the mobile nodes to facilitate communication within the network. The limited battery power of each node in the MANET requires the optimum use of energy.. Ant colony optimization (ACO) Algorithm has shown to be good techniques for optimizing the solutions for energy constrained problems. The Ant Colony Optimization (ACO) routing technique is adaptive and reliable approach to find the path in routing for MANETs. In ACO algorithms the ant as agent traverses across the network to find the shortest path from the source to destination. The high probability of pheromone is chosen as the optimized path to transfer data packets between the source and destination. The selection of the optimal path is based on the residual energy of the nodes in that path. This algorithms highlights the ability to use ant as an agents to perform foraging activities to communicate between the nodes and to achieve the robustness of an energy efficient shortest path in MANETs. This paper describe the detailed survey of energy based ACO algorithms in MANET.**

***Index Terms*- MANET; Power conservation, Energy Efficiency, Power management, Topology, Event Based Schemes.**

I. INTRODUCTION

Mobile Adhoc Network (MANET) is a collection of nodes connected through a wireless medium with rapidly changing topologies. It can be set up anytime, anywhere without the need of any centralized base station. Hence find wide applications in areas where network needs to be quickly established such as disaster recovery operation, battlefield communication etc. In traditional wireless network the nodes communicate with other nodes over the path defined by Base station (BS). In Adhoc networks tracking, routing and route maintenance is done solely by nodes. These nodes are mobile and battery operated. Due to limited battery resources and node mobility, multihop routes are used to cover changing network environment. Thus a single node failure in MANET can lead to losing connectivity and network partitioning. Moreover it is very difficult or even impossible to recharge or replace the batteries of nodes once deployed in many applications. It is therefore required to limit power consumption, improve the robustness of system and prolong the battery life.

Mobile Ad Hoc Network (MANET) is a self-configuring, self-organizing and infrastructure less network of mobile node which allows the systems to be communicated without any wires. Each device in a MANET is free to move independently in any direction and will therefore change its likes to other devices frequently. Ad Hoc Network have many challenges in MANET‟s are asymmetric links, Dynamic topology, routing overhead, inference, limited power supply and routing range, energy, consumption, mobility induced changes, security. In MANET energy efficiency directly affects the network lifetime, it is important as general performance measures such as delay, remaining energy, and packet delivery ratio. The network under investigation is a set of wireless energy limited transceiver processors. Each transceiver processors is energy limited in the node where its battery operated

and unattended, once its battery energy has been depleted, the transceiver processors can no longer support packet transport. The nature inspired algorithms such as Ant Colony Optimization (ACO) algorithm have shown to be good techniques for developing routing algorithm for MANETs. The Swarm intelligence (SI) is to design algorithms inspired by collective behavior of insects such as bees, termites, ants and other animal societies that exist in decentralized, self organized systems. These insects live in a hostile, dynamic environment and co-ordinate and co-operate to survive. They communicate directly with one another or indirectly through the environment to accomplish their tasks such as foraging, brood sorting, etc. the ACO is one of the SI techniques inspired by the foraging behavior of ants. In nature, ants always determine the path from their nest to food by following the trails they create using a chemical substance known as pheromone. The ACO technique for routing in MANETs uses this stigmergy process to determine the best possible routes from a source node to a destination node. Artificial ants are placed at each node and they mark their trails with pheromones as they move within the network. ACO algorithms the ant act as an agent traverses across the network to find the shortest path from the source to destination. The high probability of pheromone is chosen as the optimized path to transfer data packets between the source and destination. The selection of the optimal path is based on the residual energy of the nodes in that path. A roust route with minimum energy path cost with short hop count is select for pheromone deposition. This algorithm highlights the ability to use ant as agents to perform foraging activities to communicate between the nodes and to achieve the robustness of an energy efficient shortest path in MANETs. There are a few issues of productive routing, medium access, power administration, security and "Quality of Service" (QoS). Due to the spread of laptops, sensor gadgets, PDAs and other portable electronic gadgets, ad-hoc wireless networks are expanding in fame. In order to communicate with one another without an infrastructure to depend on, these gadgets need routing protocols that can work without any gateway to interface with. Swarm intelligence has been used to solve optimization problems in data networks. One such optimization problem is routing where swarm intelligence has been applied. Due to the absence of any dedicated router, here every node acts as a router and aids in forwarding packets to the destination node. That's how information sharing among mobile nodes is made available. Due to the limited power supply of the batteries carried by portable mobile devices, the processingpower of node is restricted.[10] For a wireless network, the devices operating on battery try consume the energy while performing the various tasks on devices or nodes. Minimum energy paths have more issues like the devices in these paths exhaust their energy very fast

II LITERATURE SURVEY

In mobile ad hoc networks (MANET), the existing route discovery may result in traffic overflow and overhead. In order to overcome these issues, in this study [1], the authors proposed an ant based multipath backbone routing for load balancing in MANET. When the source wants to transmit data towards destination, it selects the multiple routes with maximum path preference probability using swarm based ant colony optimization technique. The path preference probability is estimated based on next hop availability, delay and bandwidth. During route discovery, the nodes subjected to faults are found and the relevant path is skipped. Then the network load on the routes is balanced by an index by each backbone node to distribute the data traffic equally on the links from source to destination. By simulation results, the authors show that proposed technique reduces the network load. In this work [2], the authors have done an extensive survey of fault tolerant protocols and ant colony algorithms applied to routing in MANETs. They have proposed a QoS constrained fault tolerant ant look ahead routing algorithm which attempts to identify valid route and look-ahead route pairs which might help in choosing the alternate path in case of valid route failure. The results prove that the proposed algorithm takes better routing decisions with 20-30 percent improvement compared with existing ant colony algorithms. The authors in [3] have studied the estimation of residual link lifetime (RLL) in mobile ad hoc networks (MANETs) using the distances between the link's nodes. They first prove that to compute uniquely the RLL, at least four distance measurements are required. They also demonstrate that random

measurement errors are the dominant factor in prediction inaccuracy and that systematic errors are negligible. The authors have then proposed a mobile-projected trajectory (MPT) algorithm, which estimates the relative trajectory between two nodes from periodical measurements of the distances between them. Using the relative trajectory, the algorithm estimates the RLL of the link between the two nodes. For comparison purposes, they derive a theoretical upper bound on the achievable prediction inaccuracy by any distance-based RLL prediction algorithm with unknown but finitely bounded measurement-error distribution. Toaccount for velocity changes, the MPT is enhanced with a velocity-change detection (VCD) test. Performance evaluation demonstrates robustness in RLL prediction for piecewise-linear trajectory and multiple velocity changes during the link lifetime

The authors in [4] have observed that tree-based routing algorithms have high forwarding efficiency and low consumptions of bandwidth, and they may have poor robustness because only one link exists between two nodes. As a tree-based multicast routing protocol, MAODV (Multicast Ad hoc On-demand Vector) shows an excellent performance in lightweight ad hoc networks. As the load of network increases, QoS (Quality of Service) is degraded obviously. In this paper, they analyze the impact of network load on MAODV protocol, and propose an optimized protocol MAODV-BB (Multicast Ad hoc On-demand Vector with Backup Branches), which improves robustness of the MAODV protocol by combining advantages of the tree structure and the mesh structure. It not only can update shorter tree branches but also construct a multicast tree with backup branches. Mathematical analysis and simulation results both demonstrate that the MAODV-BB protocol improves the network performance over conventional MAODV in heavy load ad hoc networks. A framework for integrated multicast and unicast routing in mobile ad hoc networks (MANETs) is introduced by the authors in [5]. It is based on interest-defined mesh enclaves that are connected components of a MANET spanning the sources and receivers of unicast or multicast flows. The Protocol for Routing in Interest-defined Mesh Enclaves (PRIME) is presented to implement the proposed framework for integrated routing in MANETs. PRIME establishes meshes that are activated and deactivated by the presence or absence of interest in individual destination nodes and groups and confines most of the signaling overhead within regions of interest (enclaves) in such meshes. The routes established in PRIME are shown to be free of permanent loops. Experimental results based on extensive simulations show that PRIME attains similar or better data delivery and end-to-end delays than traditional unicast and multicast routing schemes for MANETs (AODV, OLSR, ODMRP). The experiments also show that signaling in PRIME is far more scalable than the one used by traditional multicast and unicast routing protocols such as AODV, OLSR, or ODMRP.

In this paper [6], the authors have considered the issue of efficient broadcasting in mobile ad hoc networks (MANETs) using network coding and directional antennas. Network coding-based broadcasting focuses on reducing the number of transmissions each forwarding node performs in the multiple source/multiple message broadcast application, where each forwarding node combines some of the received messages for transmission. With the help of network coding, the total number of transmissions can be reduced compared to broadcasting using the same forwarding nodes without coding. They exploit the usage of directional antennas to network coding-based broadcasting to further reduce energy consumption. A node equipped with directional antennas can divide the omnidirectional transmission range into several sectors and turn some of them on for transmission. In the proposed scheme using a directional antenna, forwarding nodes selected locally only need to transmit broadcast messages, original or coded, to restricted sectors. They also study two extensions. The first extension applies network coding to both dynamic and static forwarding node selection approaches. In the second extension, they design two approaches for the single source/single message issue in the network codingbased broadcast application. Performance analysis via simulations on the proposed algorithms using a custom simulator and NS-2 is presented.

The authors in this study [7] have focused on energy efficiency by making use of two bio inspired algorithms namely ant colony optimization and firefly algorithm. While the ant colony optimization would achieve the shortest paths making use of the

pheromone value, at the same time the firefly algorithm would take into account quality of the nodes using the attractiveness factor. The shortest path is usually the one having the highest pheromone value whereas the best node to forward the packet is the one having the highest attractiveness. In [7], initially the time stamps of the different pair of the nodes are achieved by using the Hello flooding throughout the network. The timestamps between the two nodes is calculated as the end to end delay. So, after the Hello messages are the flooded in the network, the table for the timestamps is maintained. The authors have put forward the concept of the controlled broadcasting. In this concept the route request messages are not flooded throughout the network, instead they are restricted in a particular area. The area is defined by the factor of spread. This would consequently reduce the energy consumption of the nodes during the path searching process. When the request reaches the destination node, the paths are selected according to highest pheromone value of the paths as well as highest attractiveness of the nodes

III. ISSUES AND FACTORS AFFECTING ENERGY EFFICIENCY

Security: Intrusion Detection System (IDS) serves as one of the tool for the purpose of detecting the malicious node in the network and prevent them from further attacks. This IDS is placed on each and every nodes and it kept in an active state forever to ensure the safety of the network. This is the point where the concentration of energy efficiency becomes obsolete and would result in depletion of the energy resources in a limited battery powered nodes. Here the motive is to ensure the network safety, where withdrawal of other essential parameters takes place which results in short lifespan of the network. So the IDS must be operated in an efficient manner where, when required to be active it must be functioning in the network in order to make sure that the energy levels of the node have a balanced resource power, other than monitoring continuously illicit free networks. Providing security in the dynamic volatile network is mandatory, where during this process lack of energy efficiency is obtained as a result. [8]. So there must be a balanced approach in saving energy of the nodes without compromising the security constraints. [25].

Overhearing

Overhearing of the nodes is another factor that causes energy of the nodes to be depleted. It is a common process that the source node which intends to send a packet to a destination node will pass a multicast request to all the neighbour nodes. All of them receive any packet transmitted even though one of them is the intended receiver. As a result each node overhears a plethora of packets which are not directed to it. [1]. This is a significant waste of each and every node's energy, especially when the load and intensity of the traffic is very high. Before overhearing the individual energy levels of each node must also be considered to avoid energy depletion. A solution to overcome the menace of overhearing is provided by a protocol termed as "PAMAS" (Power Aware Multi-Access protocol with Signalling). [5]. This protocol study the network and their nodes and detect the pattern of them which are not actively transmitting or receiving packets and makes them in a hibernate state intelligently without causing any delays in the network and without affecting the throughput of the result. This is the combination of the Signalling channel protocol and the MACA protocol. The RTS/CTS (Request to send/Clear to send) mechanism used in 802.11 wireless networking protocols takes place over a separate channel which differs from the channel where actual data

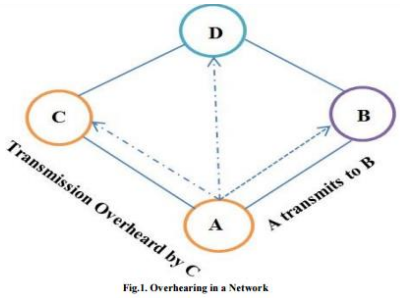

Fig 1: Overhearing in a Network

Collision

A Collision in the network is an anticipated one but it is one of the unlikely events that would incur in a network. Collisions are caused by one or more reasons in a network. When one or more nodes try to access a shared medium to reach a destination, a collision can occur [7]. The major factors for collision are heavy traffic in a network, large number of nodes involving in a communication

simultaneously, improper usage of acknowledgement mechanisms and so on. As a result of collision, even packet drop can occur which causes network failure. Retransmission after the sender/receiver acknowledgement is one of the solutions to rectify the effects of collision. This overall process of packet drop, acknowledgement and retransmission causes the nodes involved in this communication to transmit and receive rigorously and continuously until the problem is fixed and the transmission is successful, resulting in depletion of energy of the limited battery powered nodes very soon. As a result the lifetime of the nodes involving in the transmission is gradually decreased. This must be avoided in order to incur an energy efficient networking. Unlike networks with predefined infrastructure like wireless sensor networks there are number of solutions to choose which would be optimal for what kind of scenarios such as EC-MAC (Energy conserving medium access control) which uses a central arbiter to manage collisions occurred and DCF (Distributed coordination function). [9]. In this case CSMA/CA is a default option opted for a mobile adhoc networks which implements listen-before-talk scheme. It works with physical carrier sensing which employs acknowledgement mechanisms and virtual carrier sensing which also uses similar handshaking mechanisms. Providing collision free network in this dynamic adhoc environment is a challenging issue where the scope is at its pioneer stage.

IV METHODOLOGY

Load Distribution approach

The load distribution in a wireless network balances the loads on the sensor nodes. Communication between the nodes takes places in a manner without affecting or depleting the energy levels of the node in such a way that the nodes in the state of lower end energy (over utilized nodes) will be avoided during the routing process. [5]. Hence this approach enhances and makes considerations both on routing efficiency and energy efficiency of the sensor nodes, which on the whole increases the network lifetime. Load distribution approach is one of the key factors contributing in the power management of the nodes by even usage of all the nodes involved in a particular communication. The fact is that, the shortest path to the destination is always preferred during any transmission. But in this case rather than preferring a shortest path, the routes which consist of underutilized nodes is chosen here. Although this may result in longer turnaround time for the nodes involved in this communication, they are energy-rich nodes where they avoid the continuous overloading of other intermediate nodes. As a result this approach ensures a longer network lifetime.

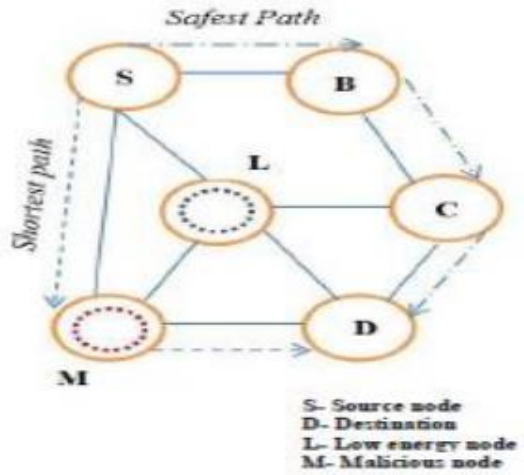

Fig.2. Significance of routing and energy efficiency

Localized energy aware routing (LEAR) is a load distribution protocol which is advancement to the DSR approach, where the route request message in DSR directly directs the message to the destination after examining the header of the request message. In contrast, in the LEAR protocol the node takes down the ultimate authority of deciding whether to forward the route request message to the destination node or not. The node analyses the threshold value of the energy levels. When the Energy (Er) is higher than the Threshold (Tr) then the node forwards the request message. Otherwise it drops the message and ignores to participate in the further transactions. Conditional max-min battery capacity routing (CMMBCR) is another load distribution proposal where it follows the similar threshold approach as that of LEAR. In this an expiration sequence is maintained which is related to the battery capacity. This expiration sequence gives information about how fairly the energy is expended. [6]. The minpower route is selected between the source and the destination, if the nodes in between them have energy levels higher than the threshold level, whereas the max-min route is selected when the intermediate nodes has energy level minimum when compared with the threshold. [23].

Topology control

The topology control approach is used in mobile ad hoc networks in order to minimize the depletion rate of the nodes energy levels. Unlike in the wired networks which have a fixed infrastructure, each node in the network have the capability of making unanticipated changes in the topology of the network. [9]. Therefore the main aim of the topology control approach is to protract the network lifetime and throughput by providing a control mechanism which improves the network connectivity and provide performance optimization. Topology in MANET is affected by controllable factors such as transmission power and un-controllable factors such as interference, node mobility and so on. [10].Topology control involves in clustering of the nodes in a particular formation and communicates with the nodes according to the status of them in the clusters. Clustering sensor nodes improves network scalability and also decreases the probability of network failure due to communication overheads and so on.

Power Management

The Power management approach is mostly followed in many circumstances to ensure energy efficiency in a mobile adhoc network. The mobile node not only consumes its battery power while transmitting and receiving but also during idle state, where it continuously listens for any communication requests. [3]. The aim here is to reduce the energy spent by the mobile node at its period of inactivity. The node can save the energy by switching its state to sleep mode when there are no data to transmit or receive at a particular time in the network scenario. The node in a network will be in one of the three possible states which are as follows - Active: Transmit/Receive packets - Idle: Waiting for the traffic - Sleep: Switching off its radio transceiver The motive in this approach is that, either the node must be in active state and effectively transceiver the data packets or it must be in the sleep state. It must not be in the idle state waiting for the traffic and expel its energy. The switching between the sleep mode and active mode must take place effectively in case of any event detected, in order to avoid overheads during this process. This effective switching is termed to be as on-demand schemes or event-based schemes. [1]. Synchronous Scheme It is another approach which follows the on-demand scheme with a difference such that it portrays a time interval scenario in the active/sleep combination. [1]. At regular time intervals all the nodes in the network will be either in the sleep mode (or) in the active mode. But this scheme is most likely simulated in the test cases with trivial chance of implementations.

V. CONCLUSION

The conclusion we have drawn from our survey is that Power Optimization in MANETs has greater impact as the residual battery level of node is a very crucial and critical resource for determining lifetime of network. Hence designing of energy efficient routing protocols, routing schemes and algorithms is required. A lot has been done for the same with the scope wide open for further study and research. This paper explores the factors which are affecting the energy efficiency in a dynamic mobile adhoc networks and the solutions to overcome the overheads which affects the power levels of nodes. The factors are not limited with which, those are specified in this study. There are also various uncontrollable factors which may be taken into consideration. Various study and experiments are taken into consideration in order to know the precise effort to be undertaken to improve the node efficiency in the network. Also we have discussed the techniques and protocols related with the techniques undertaken to improve the energy efficiency. The techniques such as Load distribution approach, Power management approach and Topology control approach are carried out effectively in many cases of survey and are believed to be more energy efficient approaches and protract the network lifetime without compromising the routing efficiency, throughput and scalability. This paper concludes with open scope for research in improving energy efficiency.

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