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Modified Approach for Secure Routing and Power Awareness in Mobile Ad Hoc Network

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Abstract— Mobile Ad Hoc Networks (MANETs) show better and valuable performance in the circumstances where the generally used wireless networks fail to work. In order to make routing in MANETs secure, number of security based routing protocols have been proposed in the literature but none of them is compliant with the MANETs requirement of security and low power consumption. The monitoring operation is distributed among a few set of nodes called monitor nodes. The set of monitor nodes is selected sporadically which makes the proposed method adaptable to the two important concerns of MANETs: dynamic network topology and energy constraint devices. The proposed method detects malicious packet dropping and packet modification attacks. This algorithm has also been developed to reduce the packet dropping attack in MANET which has been simulated on MATLAB and demonstrated an increase in packet delivery ratio, throughput while decrease in average end to end packet delay.

Keywords: MANETs, Secure Routing, Packet Delivery Ration, Energy Awareness, Threats and Attacks, Power Consumption

I. INTRODUCTION

An ad hoc network comprises of a network of autonomous mobile node formed by means of multi-hop wireless communication without the use of any fixed networks infrastructure [1, 2]. Ad hoc networks have varied application in military services, wars zones, disaster relief during emergency and the like. In an ad hoc network, each mobile node can serves as a router. A mobile ad-hoc network (MANET) is characterized by mobile nodes without any infrastructure. Mobile nodes self-organize to form a network overs radio links. The goal of MANET is to broaden mobility into the area of autonomous, mobile and wireless domains, where a set of nodes form the network routing infrastructures in an ad-hoc manner. This emerging area has initiated the support of applications which range from highly dynamic Vehicular ad hoc networks (VANET) to less dynamic applications such as moderately mobile peer-to-peers wireless networks [1, 2]. In ad hoc network, node communicates with each other by way of radio signal, which are broadcast in nature. Broadcast is a unique case of multicast, wherein all node in the network should get the broadcast message. Multicasting is a communication process in which the transmission of packets is initiated by a single user and the messages is received by one or more end users of the network. Multicasting in wired and wireless networks has been advantageous and used as a vital technology in many applications such as audio/video conferencing, corporate communications, collaborative and groupware applications, distance learning, stock quotes, distributions of software, news and etc [1, 2]. Under multicast communications, a single stream of data cans be shared with multiple recipients and data is only duplicated when required [1, 2]. In the wired setting, there are two popular multicast tree schemes namely, shortest-path tree and core based tree. The procedure to construct shortest-path multicasts trees ensures the shortest path from every source to every destination, but a source node has to construct a tree rooted at itself. Hence, there would exist too many shortest-path tree existing in the network. In core-based multicast trees, shortest path from the source node to the destination node cannot be guaranteed, but only one tree would be needed to connect the set of the source nodes to a set of the receiver nodes [2, 3]. Energy efficiency in multicast routing in MANET is a difficult and challenging task. Its might not be possible to recharge a mobile node that is powered by batteries during a mission. The inadequate battery lifetime imposes a limitation on the network performance. In order to take full advantage of the lifetime of node, traffic should be routed in a ways that energy consumptions is minimized.

MANET are challenging areas because they offers a great potential for varied applications. Research has been carried out in the field of multicast routing protocols namely the taxonomy, performance and capacity of multicast routings protocols over MANET have been studied [4, 5]. O.Tariq ets al. summarized traffic models for multicast routings protocols in MANETs [6, 7]. Multicast routing protocols were categorized into tree-based mesh-based, stateless, hybrid-based and flooding protocols.

A. *Multicasting Routings Protocols*

MANET are useful in areas where rapid deployment and dynamics reconfiguration are necessary and the wired networks is not available. These include military battlefields, emergency search areas, classrooms and conventions where participants share information dynamically using their mobile devices. These are the applications which augurs well for multicast operation. In addition, within a wireless medium, it is even more crucial to reduce the transmission overhead and power consumption. Multicasting can be used to improve the efficiency of the wireless link when sending multiple copies of messages to exploit the inherent broadcast nature of wireless transmission. Hence, multicast plays an important role in MANET [7, 8]. In the wired environment, there are two popular network multicast approaches, namely, shortest path multicast tree and core-based trees [7, 8]. The shortest path multicast tree guarantees the shortest path to each destination. But each sources need to build a tree. Usually, there exist too many tree in the network, so the overhead tend to be large. In contrast, the core-based tree constructs only one tree for each group and the number of tree is greatly reduced. Unlike typical wired multicast routings protocols, multicast routing for MANET must address as diverse range of issues due to the characteristics of MANET, such as low bandwidth, mobility and low power. MANET deliver lower bandwidth than wired networks. Therefore, the information collection during the formation of a routing tables is expensive. Mobility of nodes which causes topological changes of the underlying network also increases the volatility of network information. In addition, the limitation of power often leads user to disconnect mobile units. Multicasting routing protocols have emerged as ones of the most focused areas in the field of MANET. There are three basic categories of multicast method [2, 8] in MANET: A method of flooding the networks in which every node receiving a message floods it to a list of neighbors. Flooding a network acts like a chain reaction that can result in exponential growth. The proactive approach pre-computes paths to all possible destinations and store this information in the routing table. To maintain an up-to-date database, routing information is periodically distributed through the network.

The third method is to create paths to other nodes on demand. The idea is based on a query response mechanism or reactive multicast. In the query phase, a node explores the environment. Once the query reaches the destination the response phase starts and established the path. Recently, many multicast routing protocols have been newly proposed to perform multicasting in MANET. These include ad-hoc multicast routing protocol utilizing increasing’s Id numbers (AMRIS) [9], multicast ad-hoc on-demands vector (MAODV) [10], core assisted mesh protocol (CAMP) [11], lightweight adaptive multicast (LAM) [12], location guided tree (LGT) [13],on- demand multicast routings protocol (ODMRP) [14], forwarding group multicast protocol (FGMP) [15], ad-hoc multicast routings (AMRoute) [16], multicast cores extraction distributed ad-hoc routing (MCEDAR) [17] and differential destination multicast (DDM) [18]. Most of these multicast routing protocols are primarily based on flavors of distance-vector or link-state routing plus additional functionalities to assist the routing operations in particular ways. The goals of all these protocol include minimizing control overhead, minimizing processing overhead, maximizing multi-hop routing capability, maintaining dynamic topology and preventing loops in the networks etc. However, many multicast routing protocol do not perform well in MANET because in a highly dynamic environment, node move arbitrarily, thus networks topology changes frequently and unpredictably. Moreover, bandwidth and battery power are limited. These constraints in combination with the dynamic networks topology make multicasting routing protocol designing for MANET extremely challenging.

B. Taxonomy of Multicasts Routings Protocols

Classifications of multicast routing protocol are important in order to analyze the multicast routing protocol and investigate which one would suit a particular application. Classification methods help researchers and designers to understand the distinct characteristics of different multicast routing protocols and find out the internal relationship among them. These characteristics are mainly related to the information which is exploited for MANET and the roles which nodes may take in the multicast routings process.

C. Tree, Mesh and Hybrid Multicast Routing Protocols

One of the most popular methods to classify multicast routing protocols for MANET is based on how distribution paths among group member are constructed. According to this method, existing multicast routing approaches for MANET can be divided into tree-based multicast protocol, mesh based multicast protocols and hybrid multicast protocols. Tree-based multicast routing protocol can be further divided into source-rooted and core-rooted scheme according to the roots of the multicast trees. In a source-rooted tree-based multicast routing protocol, source nodes are roots of multicast trees and execute algorithms for distribution tree construction and maintenance. This requires a source to be aware of the topology information and addresses of all its receivers in the multicast group. Therefore, source-rooted tree-based multicast routing protocols suffer from high traffic overhead when used for dynamic networks. AMR outer is an example for source-rooted tree multicast routing protocol. In a core-rooted tree multicast routing protocol, cores are nodes with special functions such as multicast data distribution and membership management. Some core-rooted multicast routing protocols utilize tree structure. But unlike source-rooted tree-based multicast routing, multicast trees are only rooted at core nodes. For different source-rooted multicast routing protocol, core nodes may perform various routing and management functions. Shared Tree Ad-hoc Multicast Protocol (STAMP) [19] and Adaptive Core-based Multicast Routing protocol (ACMP) [20] are core-based multicast routing protocols proposed for MANET.

Tree-based protocols provide high data forwarding efficiency at the expense of low robustness. Their advantage is their simplicity. Their disadvantage is that until the tree is reconstructed after movement of a node, packets possibly have to be dropped. In a mesh-based multicast routing protocol, packet are distributed along mesh structures that are a set of interconnected nodes. Route discovery and mesh building are accomplished in two ways: by using broadcasting to discovers route or by using core or central points for mesh building. Mesh-based protocols perform better in high mobility situation as they provides redundant path from source to destinations while forwarding data packets. However, mesh-based approaches sacrifice multicast efficiency in comparison to tree-based approach. Mesh-based Multicast Routing Protocol with Consolidated Query Packets (CQMP) [21], Enhanced On-Demand Multicast Routings Protocol (E-ODMRP) and Bandwidth Optimized and Delay Sensitive (BODS) [23] are the mesh-based multicast routing protocols proposed for MANET. Hybrid-based multicast routing protocols combine the advantages of both tree and mesh-based approaches. Hence, hybrid protocols address both efficiency and robustness. Using this scheme, it is possible to gets multiple routing path, ands duplicate message can reach a receiver through different paths. However, they may create non-optimal tree with node mobility. Efficient Hybrid Multicast Routings Protocol (EHMRP) [24] is an instance for hybrid-based multicast routing protocol.

D. Proactive and Reactive Multicast Routing Protocol

Multicast routing protocols can be divided into proactive routing and reactive routings based on how the routing information is acquired and maintained by the mobile nodes. A proactive multicast routing protocol is called __table-driven multicasts routings protocol. In a network utilizing a proactive routing protocol, every node maintains one or more tables representing the entire topology of the network. These tables are updated regularly in order to maintain up-to-date routing information from each node to every other node. To maintain upto- date routings information, topology information needs to be exchanged between the nodes on a regular basis, leading to relatively highs overhead on the network. On the other hand, route will always be available on request. There are some typical proactive multicasts routing protocol, such as CAMP, LGT and AMRIS [1].

A reactive multicast routings protocol is also called on-demand multicast routings protocol. Reactive protocols seek to set up routes on-demand. If a node wants to initiate communication with a node to which it has no route, the routing protocol will try to establish such a route. Reactive multicast routing protocols have betters scalability than proactive multicast routing protocols. However, when using reactive multicast routing protocols, source nodes may suffer from long delays for route searching before they can forward data packets. ACMP and CQMP are examples for reactive routing protocols for MANET.

E. Architecture and Location for Multicast Routing Protocols

Most of the multicasts routing protocols assume physically flat network architectures with mobile nodes having homogeneous capability in terms of network resources and computing power. In practice however, this assumption may not often hold since there exist various types of mobile nodes with different roles, capacities and mobility patterns. In an architecture-based multicast routing protocol, MANET have physically hierarchical architectures, which are formed \by different types of mobile nodes. For example, Hierarchical Qo Multicast Routing Protocol (HQMRP) [25] for MANET builds a multicast structure at each level of the hierarchy for efficient and scalable multicast messages delivery.

Self-Organizing Map (SOM) [26] is also a typical hierarchical architecture, which provides a way for automatically organizing the hierarchical architecture. In location-based multicast routing protocols, the availability of a Global Positioning System (GPS), Bluetooth or other locations systems easily gets geographical information of mobile node when needed [27]. Each node determines its own location through the use of GPS or some others type of positioning service. A location service is used by the sender of a packet to determine the location of the destination. The routings decision at each forwarding node is then based on the location information of its neighbor and the destination nodes [28]. Location-based Geocaching and Forwarding (LGF) [29], LGT and Scalable Position-Based Multicast (SPBM) [30] protocol are typical location based multicast routing protocols for MANET.

F. Quality of Service

Quality of Service forms another way for protocol classification based on metrics used for multicast routing construction for MANET. Most of conventional multicast routing protocols are designed for minimizing data traffic in the network or minimizing the average hops for delivery a packet. When Quality of Service (QoS) is considered, some protocols may be unsatisfactory or impractical due to the lacks of resources, the excessive computation overhead, and the lack of knowledge about the global networks state or the excessive message processing overhead However, some multicast routing protocol, such as LGT, AMRIS and CAMP are designed without explicitly considering QoS. QoS multicast routing not only requires finding a route from a source to a destination, but satisfying the end-to-ends QoS requirement, often given ins terms of bandwidth or delay. QoS is more difficult to guarantee in MANET than in other types of network, because the wireless bandwidth is shared among adjacent nodes and the network topology changes as the nodes move. This requires extensive collaboration between the nodes, both to establish the route and to secure the resource necessary to provide the QoS. With the extensive applications of MANET in many domains, the appropriate QoS metrics should be used, such as bandwidth, delay, packet loss rate and cost for multicast routing protocols. Therefore, QoS multicasting routing protocols face the challenge of delivering data to destinations through multi-hop routes in the presence of nodes movements and topology changes. Multicast Core Extraction Distributed Ad-hoc Routing (MCEDAR) [31] is an example for QoS-based multicast routing protocol for MANET.

G. Energy Efficiency

Since MANET are a set of node that agree upon forming a spontaneous, temporary network with the lack of any centralized administration, any form of infrastructure and nodes are typically powered by batteries with as limited energy supply, each node ceases its function when the battery exhausts. Therefore, given the energy constraints placed on the network‘s node, designing energy efficient multicast routing protocols is an important issue for MANET, maximizing the lifetime of its nodes and thus of the network itself [32, 33]. Minimum Weight Incremental Arborescence (MWIA) [34], RB-MIDP and D-MIDP [35] are examples for energy- efficient multicast routing.

H. Reliable Multicast Routing Protocols

In ad-hoc environments, every link is wireless and every node is mobile. Those features make data loss easy as well as multicasting inefficient and unreliable. Reliable multicast routing protocol becomes a very challenging research problem for MANET. In the sender-initiated approach, the sender is responsible for the error detection. Error message are signaled using ACKs signal sent from each receiver. A missing pieces of data at a receiver is detected if the sender does not receive an ACK from the receiver. In this case, the need to retransmit a missing packet is handled by retransmitting the missing data from the source through as unicast. When several receivers have missing packets, the senders may decide to re-multicast the missing packets to all receivers in the multicast group. In the receiver-initiated approach, each receiver is responsible for error detection. Instead of acknowledging each multicast packet, each receiver send a NACK once it detects a missing packet. If multicasts packets are times stamped using a sequence number, a missing packet can be detected by a gap between sequences numbers of the receiving packets. When the sender-initiated approach is applied, only the sender is responsible for retransmitting the missing packet, and the corresponding retransmitting method is called a sender oriented. Note that when the sender receives ACKs signals from all the receivers, the corresponding packet can be removed from the history. There are three ways to retransmit the missing packet when the receiver-initiated approach is used: (1) senders oriented, (2) neighborhood-oriented, and (3) fixed neighborhood- oriented. Examples of reliable multicast routing protocols include Era Mobile [36], Busy Elimination Multiple Access (BEMA) [37] and Reliable Multicast protocol for wireless mobiles multihop ad- hoc networks (ReMHoc) [38].

I. Overlay Multicasts Routing Protocols

In most protocols, both group members and nonmembers on a tree/mesh link must maintains the multicast states to forward data packets. Thus, multicast protocols must detect and restore link failure, which can be a result of migrations by non-group members as well as group members. As a result, many control messages are issued to repair broken links. To provide data forwarding without involvement of non-group members and to constrain the protocol states on group members, overlay multicast protocols for MANET enhance the packet delivery ratio by reducing the numbers of reconfigurations caused by non-group members‘ unexpected migration in a tree or mesh structure. The advantages of overlay multicast come at the cost of low efficiency of packet delivery and long delay. However, when constructing the virtual infrastructure, it is very hard to prevent different unicast tunnels from sharing physical links, which results in redundant traffic on the physical links. Overlay multicast based on heterogeneous forwarding (OMHF) [39] is an example for overlay multicast routing protocols for MANET.

J. Single and Multiple Source Multicast Routing Protocols

A multicast group may contain multiple sources due to different kinds of services or applications simultaneously provided by the networks. Each single sources multicast routing protocol induces a lot of overhead and thus wastes tremendous network resources in multisource multicast environments. In multiples source multicast routings protocols , using the clustering technique, a large network can be divided into several sub-networks with only a few cluster heads needing to maintain local information, thus preventing flooding of useless packets and avoiding wasting bandwidth. To achieve efficient multicasting in a multi-source multicast environment, the clustering technique is employed to design an efficient multicast routing protocol for multisource multicasting. Cluster and multicast path maintenances is expected to adapt dynamic network topology [40].

Multiple source routings is essential for load balancing and offering quality of service. Other benefit of multiple source routing include: the reduction of computing time that router‘ CPUs require, high resilience to path break, high call acceptance ratio (in voice applications) and better security. Special attention should be given to transport layers protocols as duplicate acknowledgments could occur, which might lead to excessive power consumptions and congestion [41].

K. Performances Criteria

Many multicast routing protocols are proposed for MANET based on different design points of view to meet specific requirements from different application domains. There are three different ways to evaluate and compare the performance of multicast routing protocols for MANET: The first one is based on user parameters and configuration, such as the average multicast degree, the control overhead, the average delay, the throughput and the multicast service cost [42]. The second way is comparing different multicast routing updating methods. Multicast routing update can be done in one of three ways: (a) Store and update store the information in a routing table and update it by listening to routings messages (b) Delete all and refresh: discard all olds routes (timeout) and start over and (c) Unicast protocol support: use the services of a separate unicast routing protocol for route updating. In another method, the performance of multicast routing protocols is evaluated with different simulation tools, such as NS-2, Opnet, Matlab, CASSAP and SPW [43, 44]. With the popularity of MANET and considering the dynamic network features of MANET, integrated criteria for evaluating performance of MANET multicast routing protocols should be proposed to meet the different mobile application requirements in different environment and different design targets [45–47].

L. Challenges in MANET

As written above, MANET consist of dynamic collections of low powers nodes with quickly hanging multi-hop topologies that usually composed of relatively low bandwidth wireless link. These constraints make multicasting in MANET challenging. General solutions to solve these problems are to avoid global flooding and advertising, construction of routes on demand, and dynamically maintains memberships to names a few. Multicasting can efficiently support a wide variety of applications that are characterized by a close degree of collaboration, typical for many MANET. The design of the multicast routing protocol for MANET are driven by specific goals and requirement based on respective assumptions about the network properties or application area. All protocol have their own advantages and disadvantage. Some constructs multicast tree to reduce end-to-end latency whiles others build mesh to ensure robustness. Some protocols create overlay networks and use unicasts routing to forwards packets. Energy aware multicast protocols optimize eithers total energy consumption or system lifetime of the multicast tree.

M. Challenges Addressed in this Study

The objective of a multicast routing protocol for MANET is to supports the propagation of data from a sender to all the receivers of a multicast group while trying to use the available bandwidth efficiently in the midst of frequent topology changes. Though multicasting can improve the efficiency of the wireless link by exploiting the inherent broadcast property of wireless transmission, it is extremely difficult in MANET due to its limited resource of bandwidth. The next issue is the limited battery power routing protocols in MANET, establish the path between the source and the destination based on the number of hops. Establishment of the shortest path alone is not sufficient to prolong the network life–time. Energy consumption reduction techniques are necessary as the nodes in MANET are limited by battery supply. Energy is drained when the MANET nodes transmits and receive the data. Energy consumptions in MANET also depend on the residual battery capacity, distance between the nodes, and retransmission as overhearing. As such, energy management techniques are necessary in order to improve the performance of the multicasts routing protocol. Further, QoS support in MANET is a challenging task due to the dynamic nature of Mobile Ad hoc Networks. The resources must be assigned or reserved in order to achieve a desired QoS. The constraints of MANET, namely, bandwidth, dynamic topology, limited processing and storing capabilities of devices must be concentrated to support QoS in MANET. QoS in MANET can be achieved by the QoS model, QoS signaling and QoS routing. Wes have specifically investigated and achieved QoS routings utilizing the MAODV protocol.

N. *Organization of the Paper*

Literature survey of the key issue of energy efficient multicast routing protocols for MANET are addressed in Section 2. Section 3 explains a novel implementation namely, Energy Drain Reduction using Multicast Routing Protocol. Section 4 explains the simulation model and results. Section 5 discusses the results obtained and gives the conclusion.

II. PROBLEM DEFINITION

We have addressed the energy and QoS related challenges in multicast routing protocol for MANET. Wes have worked on the above issues and proposed the following solutions to the above challenges. Energy Drain Reduction usng Multicast Routings Protocol Improved Energy Efficiency using Distributed Swarm Intelligence (DSI) in Wireless Mobile Networks Design and Implementation of a Novel Energy Efficient Multicast Routing Protocol for MANET QoS enabled MAODV for Mobile Ad hoc Networks

III. PROPOSED MODEL

A. *Introduction*

Mobile Ad hoc Networks (MANET) is a self-configuring network of mobile nodes which communicate with each other without any fixed infrastructure. Multicast routing is extremely difficult in MANET dues to its limited resources such as bandwidth and battery power. Energy management techniques are necessary to improve the performance of the routings protocol. Efficient energy management is necessary in MANET due to its dependency on battery power. Routings protocols in MANET, establish the path between the source and the destination based on the numbers of hops. Establishment of the shortest path alone is not sufficient to prolong the network life–time. Energy consumption reduction techniques are necessary as the nodes in MANET are limited by battery supply. Energy is drained whereas the MANET nodes transmit and receive the data. Energy consumption in MANET also depends on the residual battery capacity, distance between the nodes, retransmission and overhearing. EDR-MRP protocol attempts to construct the energy efficient path by addressing the power consumption during the transmission and reception of the data, signal strength and the residual battery capacity of the nodes.

B. *Multicasts Ad hocs On Demand Distance Vector (MAODV)*

MAODV protocol is extended from AODV. It is a shared-tree-based multicast routing protocol. Each multicast group maintains a shared tree, which consists only of receivers and relays (forwarding nodes). On demand, a multicast route is determined by using a broadcast route discovery mechanism. The first member which joins with the multicast group becomes the leader of that group. The multicast group leaders maintains the multicast group sequence number and broadcast this numbers to the multicast group by a group HELLO message. The nodes update their request table using the groups HELLO information. MAODV maintains threes tables unicast Routing table, Multicast Routings Table and Group Leader Table. Multicast Routing Table is maintained for each multicast group. Group leaders table maintains the multicast group address along with its group leader address and the next hop towards the group leader. There are four types of packets are MAODV: RREQ, RREP, MACT and GRPH. RREQ and RREP are also packets in AODV. A node broadcasts a RREQ when 1) it is a member node and want to join the tree, or 2) it is as non-member node and has a data packet targeted to the group. When a node in the tree received RREQ, it responses with RREP using unicast. Since RREQ is broadcasted, there may be multiples RREPs received by the originating node. The originating node should select one RREP that has the shortest distance to the tree and uncast a MCAT along the path to sets up as new branch to the tree. GRPH is the group hello packet, it is periodically broadcasted by group leader to let the nodes in the tree to update its distance to the group leaders

C. *Related Work*

PAMPMAODV selects multiple routes based on hop count, end-to-end delay and residual battery capacity to utilize the battery effectively. It is discussed below.

1) *Multiple Path -s Multicast Ad hoc On-demand Vector (MP-MAODV)*

MP-MAODV is a multipath routing protocol extension based on MAODV In this extension MAODV is based on three aspects: multipath selection and establishment, multipath route maintenance and load distribution for distributing traffic among node-disjoint paths. They add two control messages and one backup routing table for the MPMAODV, and extend it from three aspects: multipath selection and establishment, multipath routing maintenance and load distribution. The flag S with value 1 is added to control message MACT-S and RREP-S for selecting and establishing disjoint paths.

MAODV [7] and MP-MAODV creates bi-directional shared multicast trees connecting multicast sources and receivers. MAODV is a shortest routing, that is, the least hops routings and MP-MAODV is creating multiple routes from a source to a destination is used to provide a backup route. When the primary route fails to delivers the packets in some way, the backup is used. This provides a better fault tolerance in the sense of fasters and efficient recovery from route failures. Multiple paths cans also provide load balancing and route failure protection by distributing traffic among a set of disjoint paths, which do not consider the energy aware problem. However, the portable communication devices in Ad Hoc networks are untethered, batteries operated and have limited energy, so the network is an energy constrained system. How to preserve the nodes energy and prolong the lifetime of the system gradually plays an important role on evaluating the performance of Ad Hoc network routing protocols. The energy conservation of the network system is a key problem especially in the situations such as military areas, disaster relief, classrooms and conferences, where the times and the devices are constrained.

2) Power-Aware Multiple Path Multicast AODV (PAMP-MAODV)

In PAMP-MAODV, a different strategy has been proposed for route selection and route maintenance in order to utilize the battery effectively. The route selection process has been designed to select multiple routes based on hop count, end-to-end delay and residual battery capacity.

a) Determination of Threshold

The threshold for the residual battery capacity has been calculated based upon the numbers of total packets to be transferred and the maximums transmit powers used for each packet.

b) Multipath Selection and Establishment

MAODV relies on broadcast based on-demands routes discovery. Whens a source node wants to send a packet or joins a multicast group, it broadcasts a route request (RREQ) Packet, it is often likely to receive more than ones responses packet since any node in the multicast tree can responds to the packet. Each intermediate node, which receives RREQ, calculates the signal strength and battery capacity needed to transfer the packets. When the residual battery (RB) capacity is greater than the threshold, then each neighbor node calculates the distances between itself and the previous node which has sent RREQ. If the calculated distance is less than the distance for safe threshold which is set to 25m, then the intermediates node forwards RREQ further. Whens an RREQ packet arrives at its any member, the received RREQs are stored in RREQ table. All the member nodes are wait for a particular times RREQ_TIMER (which is set to 3 seconds), receives all the incoming RREQ packets and maintains them in a RREQ TABLE. Upon RREQ_TIMERs expiry, Member node assigns rank for each path based on the hop count and link quality and sends corresponding reply, which travel backs to the source retracing the path. The member generates a RREP packet that contains the node list of the whole route and unicast it back towards the source that originated the RREQ packet along the reverse route. When an intermediate node receives a RREP, its updates its multicast routing table to add an entry towards member node by using the nodes list of the whole routes contained in the RREP. If the source node receives one or more RREP messages in this time, it queries the multicast table and check if the route is activated to confirm which one is the first arrival. The source node unicasts a MACT to the node which RREP is the first arrival for activating the route and sends packets through the path due to the first path has the shortest latency. The intermediates nodes, which received MACT, activate the related entry in m-cast routing table, and sets mpath fields as 1, then forward the MACT to next hop until one group member receives MACT. If the RREP received by the sources node is not the first arrival, the source node replies MACT-S to the next hop. The intermediate nodes, which received MACT-S, query the multicast table and checks if the route is activated. If the route is activated, the intermediate nodes discards this MACT-S, if not , it will add an entry to the backup route table to establish reverse route ins backup route table and send MACT-S to the next hop until this MACT-S forward to a group member. The multicast group node received the MACT-S then unicasts a RREP-S to the source node. The intermediates node that received MACT-S adds an entry to the mcast routing table to establish forwarding route and set math field as 2, then forwards it to the source node. So this mechanism can guarantee two node disjoint paths and avoided loops. Sources node is likely to receive one or more RREP-S messages during this time, but it selects the routes with largest sequences number and smallest hops by checking the RREP-S messages as the second path, and adds an entry to the mcast route table with mpath field as 2. Maintaining more than two backup paths cannot evidently improve route performance. So we selects only two paths in order to reduce resource consumption and improve calculation efficiency. If the source nodes does not receive a RREP-S message before timeout, it uses the one path to send data packets.

c) Load Distribution

Once the source node activates the first path, it sends all packets through the path in order to reduce latency caused by route discovery. When two paths has been selected, the source node starts to send packets through two paths in turn, that is, send a packet through the first path, then send the next packet through the second path. This simple method can balance the network load and relieve the networks congestion.

d) Multipath Routes Maintenance

The wireless link is easy to breaks because of nodes mobility or other reasons. When a node does not receive any message from the adjacent node or cannot send any packet to the next hop, it thinks the link is broken. If the broken node on the tree, it is will be treated according to the MAODV. If not, the upstream node unicasts a routes error message (RERR) to the source node which notifies the source node that link is broken. When the intermediate nodes ins this path receive RERR, they delete the entry in the routes table, and continue to forwarding RERR until the source nodes receives RERRs message. When the source node receives the RERR, it deletes the related entry in the route table, searches backup route table and checks whether both paths are invalid. If the two paths are broken 3ry ratio increases by choosing minimum energy paths in routing the packets. This approach lays emphasis on residual battery capacity thereby aiding load balancing, minimal power consumption, minimal packet loss; minimal packet delays .It also prevents unnecessary control messages.

The others related papers on Powers Aware Routing select the less congested route to maximize the network life span. They are discussed below.

D. Power Aware Routing Schemes

Several power aware routing schemes have been proposed for mobile ad hoc networks. In Power Aware on Demand Multipath Routings, an energy efficient shortest path is established between a given source and destination pair. The proposed schemes maintains the information about the nodes on a given route along with theirs corresponding residual energy levels. It maintains multiple routes simultaneously, so the switching from one route to another route does not create additional delay and packet loss. During routes discovery, the duration of a path is estimated as the minimums residual energy of a links along the givens route and is used as a cost function in paths selection. During packet forwarding, the amount of conserved energy is updated by subtracting the energy consumed for forwarding a packet. If an active route breaks, an alternate route is selected for data transmissions. The QoS Based Power Aware Routing Scheme finds an energy efficient route, which meets QoS constraints along an established path. If the application doesn't require QoS guarantees, the protocol finds a path consisting of high energy nodes. If the QoS constrained path is required, the protocol considers nodes energy and links capacity as route selections metrics. During route discovery, the sources node specifies the minimum energy and minimum bandwidth required along the established route. Each node inserts its residual energy and available bandwidth information into the route selection packets. The destinations node finds and establishes the route which meets the energy and bandwidth constraints of the user application. If an active route breaks due to links failure or battery power depletion, the local route repair is used to find a new route. The Power Aware Routing Algorithm maximizes the network lifetime and minimizes the power consumption by establishing an energy efficient and congestion free route. The proposed scheme takes into consideration the accumulated energy of a path, status of battery life time and type of data to be transferred (real time and non-real time). During route discovery, the source node specifies the traffic type, total battery status and total traffic level in the routing packets. The traffic level of a node represents the number of packets buffered in the node's interface queue. Each node updates the relevant information in the routings packets and forwards them towards the destination node. The destination node buffers the routing packets for certain time interval and selects the route which meets the required power and link status ratio.

The Power Aware Routing Protocol establishes an efficient, stable and long lasting path under large network size and high node mobility for a variety of data traffic. The power status of each node is periodically monitored and stored. The power level of a node is categorized as Active, Critical and Danger. The protocol comprises of Route Construction, Route Error and Recovery, and Route Erasers phases. During Route Construction, a stable path having all Active nodes is selected. If the link breaks occurs, the intermediate node performs local routes repairs to find an alternate Active route. Once the established Actives route is undesired, the Route Eraser phase is initiated, where each node updates its routing table information by removing Active route entries. The Power Aware QoS Multipath Routing Protocol establishes a path, which meets the bandwidth and energy requirements of the application. If the application does not require QoS guarantees, the nodes with high energy level are selected along the established route. The proposed scheme comprises of Route Discovery, Route Selections and Route Maintenance phases. During Route Discovery, the application specifies the required bandwidth and required energy in the routing packets. If the intermediate node meets the bandwidths and energy requirements of the application, it forwards the packets to its nexthop and discards otherwise. The destination node replies back to the sources node through maximum of 3 different routes. During Route Selection, the source nodes receives information regarding multiple routes to the destination and selects the best path by sorting multiple routes in descending order of node's residual energy and bandwidth. The route with maximal nodal residual energy is selected for data transfer. If the energy level of a node decreases than the required energy, the link is assumed to be broken and a new route setup is initiated. The Variable Range Location Aided Routing reduces the network energy consumption by using variable transmission power control. Each mobile node is equipped with a GPS device and the source node specifies the required energy in the route selection packets. The energy factor at each nodes is calculated, which is used to find an energy efficient path. The path energy factors is obtained by multiplying the energy factor of all nodes along a givens path. The Energy Aware Variables Transmission Range Routings reduces the network energy consumption by varying the transmission range of nodes dynamically. During route discovery, each node specifies its current location in the routing packets generated by the destination node. Each intermediate node receives multiples routing packets from its downstream nodes, calculates the distances between itself and all its downstream nodes and selects the nearest node. The transmission energy is estimated based on the distance between current node and its nearest downstream node. This process continues until the routes is established and data transmission takes place. The Fuzzy Based Power Aware Routing estimates the power consumed at a node for a particular data transmission through received signal strength. The battery cost function of each route is calculated and appended ins the routing packets along with the node's power consumption. The destination nodes applies fuzzy logic and selects the route among all available routes having low power consumption. During mobility, if the nodes on an established route start moving away from each other, the probability of link break increases and an alternate route is established through route maintenance process. The Locations Based Power Aware Routing finds an optimal path in terms of bandwidth and power consumption. The proposed scheme divides the network into Expected Zone and Request Zone. The Expected Zone is the region, where the destination nodes can move randomly. The Request Zone is the region, where the routing packets are broadcasts to find as route to a given destination. During route discovery, ifs an intermediate node receives routing packet and it lies within the Request Zone, it rebroadcasts the packet and drops the packet otherwise. This process continues until the destination node receives routing packets and finds an energy and bandwidth efficient path.

The Residual Energy Based OLSRs Protocol selects an MPR node based on its residual energy and reachability. The proposed scheme aims at avoiding the selection of power deficient nodes as MPRs. During MPR selection, as node calculates the residual energy and reachability of all its one-hop neighbors, who are the candidates for MPRs. If a candidate MPR node possesses the highest residual energy among all its competitors and its reachability is also greater than zero, it is included in the MPR list.

E. Energy Drain Reduction using Multicast Routings Protocols (EDR-MRP)

The proposed multicast routing protocol EDR-MRP addresses the issues of energy drain to establish the path. The energy drain mays occur due to the transmission and reception of control and data packets. The protocol also concentrates the residual battery capacity and the distance between the nodes to manage the energy consumption. EDR-MRP protocol establishes the energy efficient path in the multicast routing protocol MAODV, by managing the energy drain in the transmission and reception of data. Energy Drain Reduction Multicast algorithm addresses the following issues in reducing the energy consumptions of the nodes and to extend the network life-time.

1) Computation of the residual battery capacity of the nodes.
2) Computation of the energy needed to transmit and receive the data and Control packets and the distance between the nodes.
3) Computation of signal strengths to minimize the link breakage.

1) Routes Discovery-Computation of Residual battery capacity

Source node initiates a RREQ to the multicast address, if it has data to send to as multicast group and there exists no route. RREQ packet contains the field‘s battery level of the node, sequence number and hops count. Residual battery capacity is used as a predictive measure to select the routes with the possibility of more remaining life-time. The battery level of the node is set in the RREQ packet before it is forwarded. If the intermediate nodes receives multiple RREQ packets, it selects the packet with highest sequence number, lowest hop count and the battery level greater than 60%.Selected RREQ alone is forwarded else rejected. After the reception of the RREQ packets, RREP is unicast to the requesting node. Since only the selected RREQ is forwarded, the control overhead is reduced and the networks life times is extended.

2) Computation of Energy

The algorithm computes the energy expended in the transmission of the control and data packets and also its reception. The distance of the replying nodes from the group leader to the requesting node is determined and stored in the RREP packet before it is unicasted to the requesting node. The power required to transmit from the replying nodes to the receiving node is computed stored in the RREP packet. RREP packets update the powers in the unicast routing table while traversing along the path. Further, the current sequences number of the multicast group is also updated. More than one RREP packets received by the receiving nodes is forwarded. The RREP packet which has the minimum energy value selected by the source node is the paths that requires minimum energy. This path is used to transmit data, in turn to reduce the energy consumption. The energy is computed based on the parameters signal strength and the distance between the nodes.

3) Signal Strength

Signal strength (ss) = Pr / RXThresh

Pr is the receiving powers of a signal at a distances ds meters. The receiving power of a signal (Pr) and rxthresh is calculated using the equations 1 and 2 respectively.

Pr = Pt *Gt*Gr*lambda 2 / (4*pi *d) 2 * L.

1 rxthreshs = Prs * pow (10.0, threshdb/10.0). 2

threshdb is calculated using the values average power loss, path loss exponent, shadowing deviation and the correct reception rate. Pr is computed in mobile/shadowing.ccs and rxthresh is computed in indep-utils/propagation /threshold.cc in ns2. The signal strength ranges from the minimum value of 0 and maximum value of greater than 255. Based on this value, signal strength is classified as follows.

1) SS > 255 – high
2) SS > 200 and SS < 255 – medium
3) SS >175 and SS < 200 – low
4) Otherwise very low.

4) Computation of distance between the nodes

Maximum default energy of 0.283 watts is consumed to transmit data irrespective of the distance between the nodes. The proposed protocol estimate the distance between the nodes to compute the required power to transmit the data. The transmission range of the nodes is set as 250m.

If the distance between the nodes less than 100m, D-level = less Else If the distance between the nodes is 100s to 200m, D-level = mediums Else If these distance between the nodes is 200 to 300m, D-level = highs Else If the distance between the nodes is greater than 300m, D-level = very high.

5) Required Power

1) If the signal strength is high and the distance between the nodes is less, less powers (0.22 w) is required.
2) If the signal strength is highs or medium and the distances between the nodes is medium or high, mediums power (0.24w) is required.
3) If the signal strength is low and is the distance between the nodes is very high, highs power (0.26w) is required. The computer power is used to select the path which requires minimum energy

6) Simulation Results

The proposed protocol is simulated and evaluated using ns-2. It is compared with the MAODV [19] to analyze the performance. 60 nodes were simulated in an area of 1000m × 1000m.The simulation durations is of 1000s.The mobility model is the random way point mobility model and the MAC protocol used is IEEE 802.11.The initial energy of the node is 1000 joules and the channel capacity is 2Mbps. The metrics packet delivery ratio, throughput and energy consumption are used to analyze the performance of the protocol.

a) PDRs vs. Numbers of Receivers

Figure 3.1.compare the packet delivery ratio of the protocol EDR-MRP with MAODV. Packet delivery ratio of EDR-MRP is measured with the variation in the number of receivers and senders as 10. PDR is significantly increased when compared with MAODV. The increase is due to the selection of the path which needs minimum energy to transmit the data which in turn reduces the number of control packets to find out the neighbor, if any of the nodes are dead due to the scarcity of power.

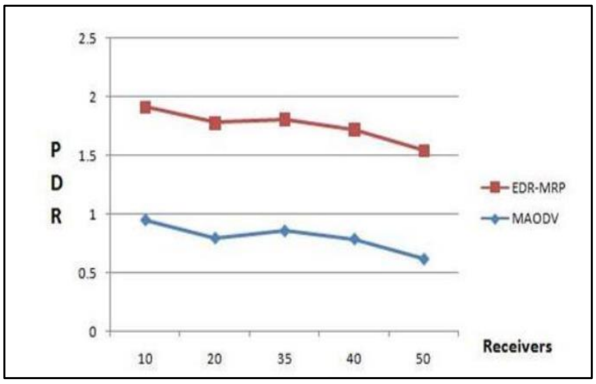


Fig. 3.1. Comparisons of PDRs vs. Number of Receivers of MAODV and EDR-MRP

b) Energy Consumed

Figure 3.2 shows the energy consumed by the node after the occurrence of the transmission and reception of the data. The initial energy of the node is 0.277 watts. Energy consumed by EDR- MRP is less when compared to MAODV. This is due to the selections of the minimum energy path based on the metric link quality, received signal strength and the distance between the nodes. But MAODV transmit and receive the packet with the default maximum energy of 0.277 watts irrespective of the distance, link quality and hence consumes more energy. The energy consumption of MAODV is 0.003 watts to 0.007 watts more when compared to EDR-MR.

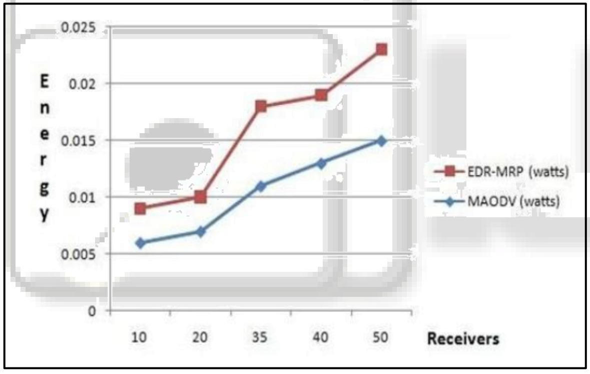


Fig. 3.2: Comparison of energy consumed for MAODV and EDR-MRP

c) Throughput

Figure 3.3 shows the increase in the throughput of EDR-MRP against the number of receivers. The path which needs minimums energy is chosen to transmit and receive the data. Hence the life- times of the nodes may be increased and hence reduce the control overhead which leads to increase in the throughput.

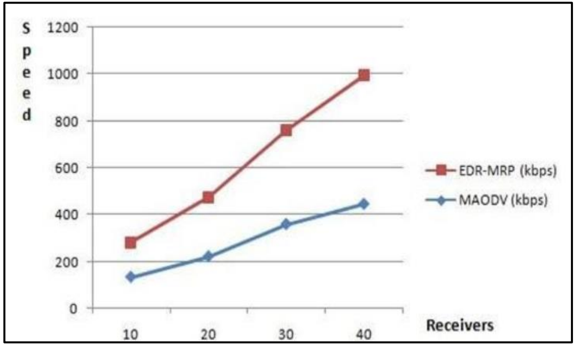


Fig. 3.3: Comparison of Throughput for MAODV and EDR-MRP

The mobile devices depend on battery power to communicate over the wireless medium. This creates the need to conserve the battery powers to maximize its life. Hence, it is necessary to find the path which consumes minimums energy to transmit and receive the data. The performance of the protocol is enhanced. PDRs and throughput is increased when compared with MAODV. The energy consumption is reduced by .007 watts compared to MAODV, if the number of receivers is 50 with the senders as 10. EDR-MRP may be useful for any applications of Wireless Ads Hoc Networks.

IV. ANALYSIS OF PROPOSED WORK

A. *Simulation Model and Results*

Figure 4.1 shows the network creation in which the nodes are deployed in the network having length of 500 meters in length and 500 meters in width and shows the total area of 1000 meters. The simulation is achieved using MATLAB programming:

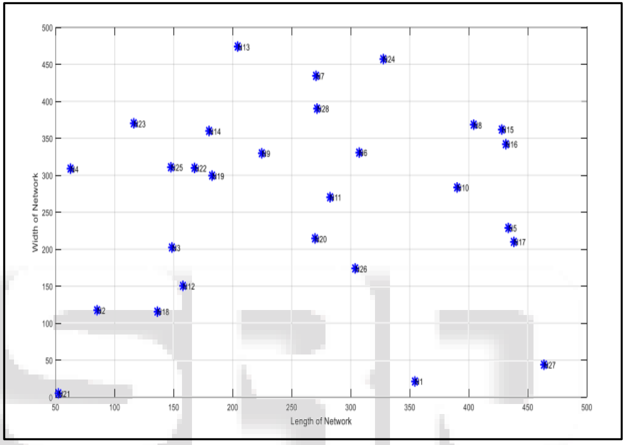


Fig. 4.1: Network Creation

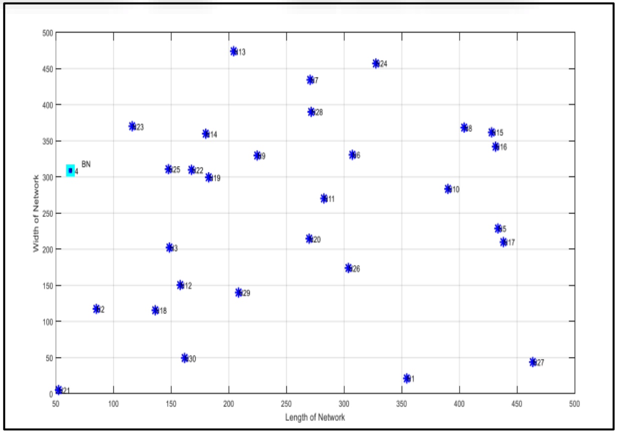
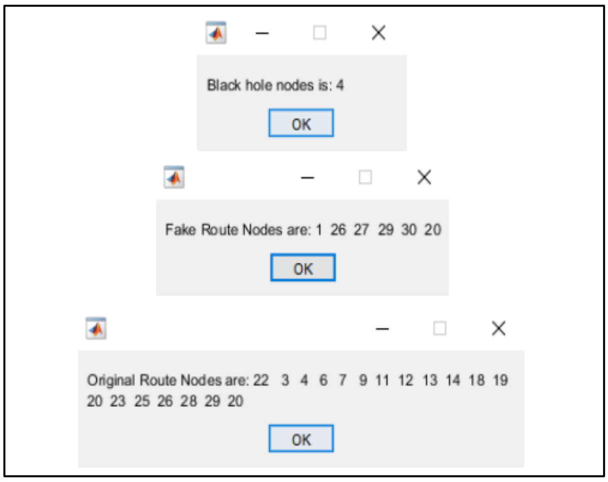


Fig. 4.2: Identification of Black Hole

The figure 4.2 shows the black hole node in the cyan color and also it acts as a malicious node which will generate the fake route path.



Black hole nodes is: 4

Fake Route Nodes are: 1 26 27 29 30 20

Original Route Nodes are: 22 3 4 6 7 9 11 12 13 14 18 19 20 23 25 26 28 29 20

Fig. 4.3: Node ids (Black Hole node, Fake Rout, Original Route after Mitigating)

The figure 4.3 shows the node ids for the black hole node and also the fake route node ids which is done by the malicious node in the presence of attack and also the original node ids which is achieved after mitigating the effect of attack in the sensor network

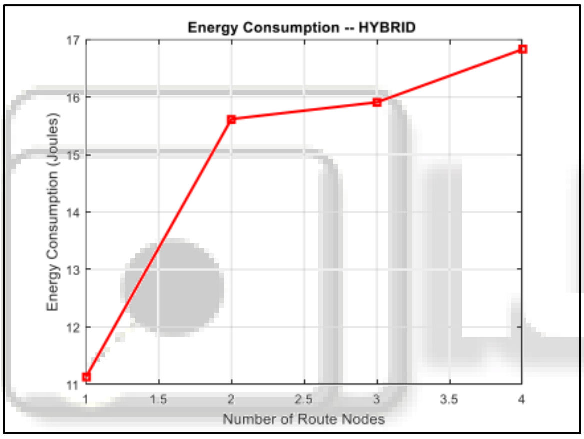


Fig. 4.4: Energy Consumption

Figure 4.4 shows the energy consumption with respect to the total number of nodes which are performing or participating in the route and shows that the hybrid approach is able to achieve less energy consumption which will increase the lifespan of the nodes.

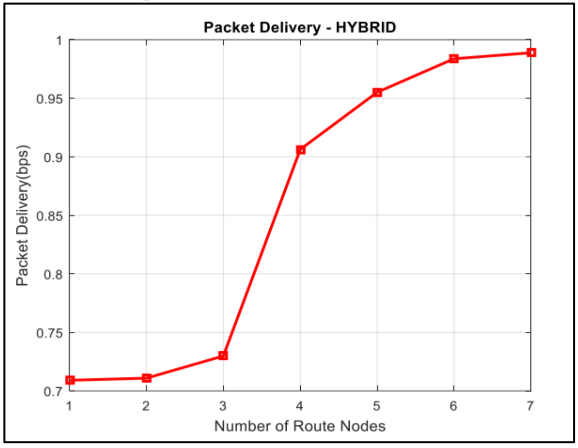


Fig. 4.5: Packet Delivery

Figure 4.5 shows the packet delivery of the network in terms of probability which shows that the proposed approach is able to achieve high packet delivery in terms of successful packet deliveries and it is showing closest to the 1 which shows that the proposed system is able to achieve high packet deliveries.

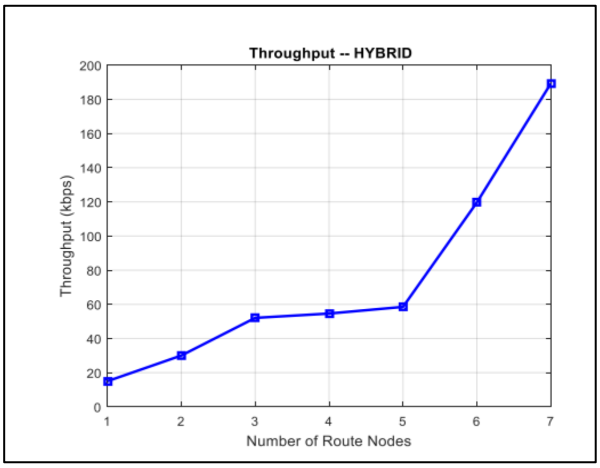


Fig. 4.6: Throughput versus Number of Nodes

Fig 4.6 shows the throughput in kilobits per second and shows the proposed approach is able to achieve high throughput of the network which shows the network is delivering packets from source to the destination in attack free environment which is done in the efficient manner by our proposed approach

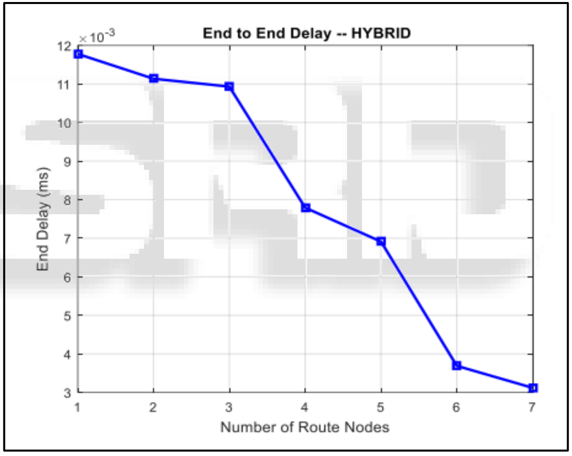


Fig. 4.7: End-To-End Delay

Figure 4.7 shows the end delay of the network which must be low for high packet deliveries and less packet losses which shows that the proposed system is able to achieve less end delay from the source to the destination.

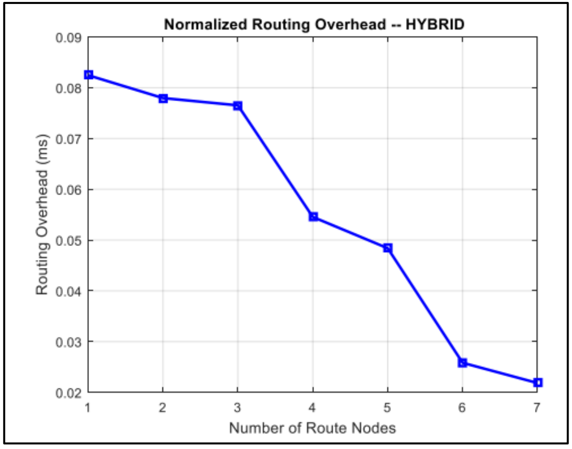


Fig. 4.8: Routing Overhead

Figure 4.8 shows the routing overhead of the network which is one of the important parameter in the sensor network which must be less for the low efficient overhead for the less collisions of the packets between the nodes in the sensor networks. This parameters must be less as the number of routing nodes increases.

Section 5 analyses the results with those of earlier authors and concludes the dissertation. It also gives a brief outline of the scope of future work.

V. CONCLUSION AND FUTURE SCOPE

A. Conclusion

Q-MAODV established a route to the destination satisfying the QoS constraints delay, and bandwidth. The QoS constraints are used to optimize the path. Depending on the application, the application requirements could be transformed to QoS requirements. The performance is enhanced compared to the protocol MAODV. PDRs and throughputs is significantly increased. Delay is also reduced which is due to the selection of the path that satisfies the QoS requirements.

Thus, this Paper focused on the issues of energy efficiency in multicast routing protocols for MANETs and successfully addressed the following challenges, namely,

1) Energy Drain Reduction using Multicast Routings Protocol
2) Improved Energy Efficiency using Distributed Swarm Intelligence (DSI) in Wireless Mobile Networks
3) Design and Implementation of a Novel Energy Efficient Multicast Routing Protocol for MANET
4) QoS enabled MAODV for Mobile Ads hoc Network

B. Future Work

In the future, the above proposed protocols could be extended to analyze the QoS metrics in a distributed network with increased numbers of nodes. Further, additional QoS metrics could be analyzed based on the proposed protocols and results could be observed for further improvement of the protocols.

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