Analysis of Scalable and Energy Aware Multicast Routing Protocols for MANETs

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Abstract - Mobile ad hoc networks (MANETs) are used for group communication in situation where other means of communication are difficult to deploy. But the unique characteristics of MANETs like limited battery power, shared bandwidth, high mobility and dynamic topology poses many challenging issues in achieving quality of service (QoS) oriented communication. Energy and scalability are among few important QoS parameters of multicast algorithm in MANETs. Energy efficiency refers the capability of multicast algorithm to use the node's limited battery for a longer communication. While scalability refers the strength of network in terms of accommodating varying density of nodes in varying timeline without affecting ongoing communications. Many researchers are working on these issue to achieve scalable and energy efficient multicast routing protocols. In this paper,an extensive analysis of scalability behavior of MAODV under varying node density and group size has been done. Preliminary analysis of energy consumption by MAODV and PUMA for transmission and receiving of packets has also been done. Further, the future directions to tackle these issues have been given to carry out more work these open issues.

Index Terms- Mobile ad hoc network (MANET), Wireless networks, Quality of services (QoS), MAODV, PUMA,Energy efficient, and Scalability.

1. Introduction

Mobile ad hoc networks (MANET) have become an emerging wireless technology for group communication in various crucial applications like military operations, rescue operations, disaster management and other applications where other means of communication system are difficulty to deploy. MANETs are collection of battery operated autonomous mobile nodes without any centralized infrastructure support.A node in mobile ad hoc network may be laptop with wireless LAN cards, Palmtop, Personal Digital Assistants (PDA), or any other wireless or mobile devices [1]. In fig. 1, layout of MANET has been shown in which a set of mobile devices is connected together to form amobile ad hoc network. The device with high computation capability and more battery power can be elected as the group leader which is responsible the overall management of group communication within the network.

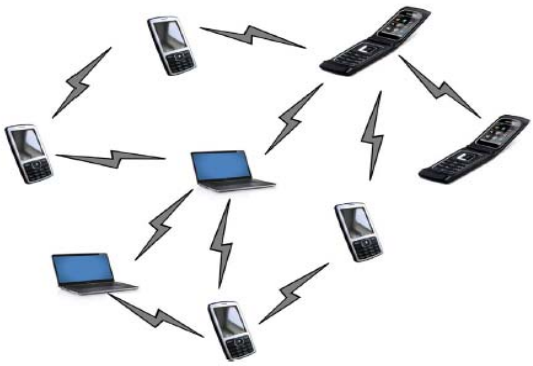

Fig. 1 Structure of Mobile ad hoc network

In MANET, it is very important to search a path from source to multiple destinations for sending data packet that satisfies various Quality of Service (QoS) parameters, such as throughput, packet delivery ratio, end-to-end delay and routing loadetc[2].These QoS parameters are highly affected by energy and scalabilityissues of the MANET which needs to be tackled wisely for a better and longer communication. In other words, routing a packet between source to destination pairs requires an adequate number of well energized nodes in between to

forward the packets [3].In MANET nodescan operate in one of four different modes. (a) Transmission mode, (b) Receiving mode, (c) Idle or standby mode, and (d) Sleep mode. Energy is consumed by nodes in all the mentioned modes. But energy consumption by a node in sleepstate is very less as compared to node in transmission mode [4].An application like military operations requires a high degree of energy optimization, as communication failure may become a security breach for the enemy [5].Another challenging and open issue of MANET is scalability support for multicast algorithm. It is difficult to achieve group management in MANET due to its dynamic topology and varying motion of nodes. Nodes are free to join or leave the group at any moment, joining a new member leads to update in multicast table and the protocol should be robust enough to manage new members. Similarly if a node leaves the group, its entry must be deleted from the multicast table. In this way lot of control overhead involved to maintain the uninterrupted communication as the group size increase or decreases. Further when a node joins or leaves a group, different procedures and actions are taken by different multicast algorithm. Therefore it is not possible to propose a single scalable solution for tree based as well as mesh based algorithm.In this paper an extensive survey on energy and scalability aware multicast routing protocols have been done to find the further scope of work in this direction.

The organization of rest of the paper is as follows: section 2 gives brief overviews about work done in this direction; section 3 gives the simulation and analysis of energy and scalability issues; section 4gives the future directions to carry out energy efficient multicast algorithms; section 5 gives the future directions to carry out scalability aware multicast; section 6 discusses the conclusion and future scope.

2. RELATED WORK

Most of the existing multicast routing protocols for MANET can be broadly classified into two categories, namely tree-based multicast protocols and mesh -based multicast protocols. Tree based routing strategies are further can be of source rooted tree or core rooted tree. Core rooted multicast strategies are optimal as compared to source rooted tree. Mesh based protocols are not energy efficient due to excessive control overhead as it depends on flooding technique within the mesh. On the other hand tree based protocols are good in terms of energy utilization as compared to mesh based protocols [6, 7]. In this paper our aim to study several routing schemes in MANETs that have recently been proposed to optimize these two major issues and to simulate few of them to observe the behavior in term of energy and scalability. Literature review is divided in to two section i.e. first we discuss about the work done to achieve energy efficient multicast algorithms followed by scalability aware multicast algorithms in MANET.

2.1 Literature review of energy efficient multicast algorithms

In a network, node's energy is consumed during transmission and receiving of packets. Most of the energy aware multicastalgorithms are broadly categorized into six categories as shown in fig 2: (1) Source-initiated-based (2) Link state-based (3) Load-balancing approach (4) Multicast-based approach (5) Location-based and (6) Power control based approach.

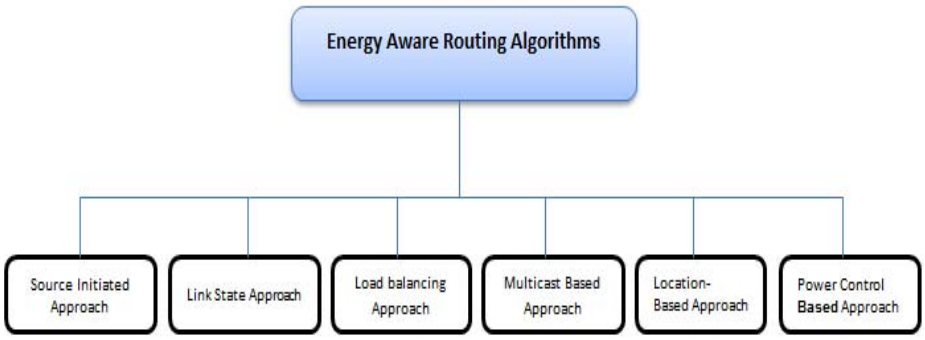

Fig. 2Categories of Energy aware routing algorithms [2]

Dingde Jiang et al.[8] proposed an energy efficient multicast algorithm for multi-hop wireless network. They used the concept of network coding and sleeping scheme to minimize the energy consumption. They worked to reduce the energy consumption by using appropriate coding, thus lowering the transmission time.MitraAhmadi et al. [9] proposed an energy and delay aware routing algorithm that improved the network life and end-to-end delay. Their proposed method used the cellular automata and genetic algorithm to achieve better QoS and found better PDR and node lifetime.Santosh Kumar Das et al. [10] used Fuzzy Based Energy Efficient Multicast Routing (FBEEMR) for ad-hoc network that select the path which consumes less energy. Thismethod increased the life time of the network by selecting energy efficient rout.Ahyoung Lee et al. [11] proposed an adaptive-gossiping routing algorithm to save energy consumption and network bandwidth at each node by reducing the

duplicated routingcontrol packets.They used the concept of selective flooding instead of normal flooding, thus reduces the control overhead. Their proposed model is found to be better in terms of energy conservation, routing overhead and in conserving network resources. KavithaSubramaniam et al. [12] worked on buffer management to reduce the energy consumption of network by efficient management of buffers. Efficient management of buffers leads to reduced energy consumption and increasing packet delivery ratio.J Sandeep et al. [5] worked on energy optimization for military operation by distributing the load among multiple nodes and by identifying the critical nodes. Simulation results proved that the proposed scheme is better in terms of energy consumption and packet delivery ratio.K. SeshadriRamana et al. [13] proposed a tree based Heuristics to Multicast Route Discovery (HMRD) model. They used heuristic to determine the intermediate node with maximum residual energy and minimal energy usages. The proposed model is found better in terms of maximal residual energy and minimal energy consumption.S. BeskiPrabaharan et al. [14] presents a metaheuristic based routing algorithm that use to find the energy efficient intermediate node. They also optimized the energy consumption by an efficient load distribution and random path selection among network. Santosh Kumar Das et al. [15] proposed an Intelligent Energy-aware Efficient Routing protocol for MANET (IE2R) that used Multi Criteria Decision Making (MCDM) technique based on entropy and Preference Ranking Organization METHod. The proposed method have shownbetter result in terms of several network metrics.S.K. NagulaMeeraet. al [16] proposed a tree based Minimal Energy usage Competent Multicast Steiner Tree based Route Discovery (ECMST) that use genetic algorithm to calculate the maximal residual energy and minimal energy usages of intermediate nodes. The experimental results proved that the performance ECMST is the best of in its class to discover multicast route.

2.2 Literature review of scalability aware multicast algorithms

The highly dynamic topology and uncertain behavior of mobile ad hoc networks poses significantchallenges for group management. As the group size increases throughput, packet delivery ratio, end to end delay and control overhead start diminishing. Node's unpredictable motion often change the structure of multicast tree, results in, frequent updates in routing tables to refresh the multicasttree for uninterrupted communication. Scalability support in multicast is still an unexplored area and needs a better attention for uninterrupted communication in MANET. Ben Newton et al. [17] exploit the position of the nodes to forward the packets to the destination,thus reduced the number of hops andcontroloverhead carried by packet header. Their proposed Topology Aware Geographic Routing (TAG) outperforms over previous algorithms of similar nature.KasunSamarasinghe et al. [18] proposed a Greedy Zone Routing (GZR) that assigns greedy coordinates to the whole zone (collection of nodes) rather than the individual nodes within zone. In GZR communication is done in two levels: greedy geographic routing is used to carry out inter zone communication and conventional tree based routing is performed within zone. This scheme has small routing tables and found to be superior as control overhead reduced up to 50% as compared to other greedy approaches.Jaspreet Singh et al. [19] propose a scalable multicast by distributing the traffic among different available path rather than flooding on few paths. In order to keep the scheme light weighted they use to vary the degree of distribution among alternate path. Simulations results show its superiority in terms of scalability.

D.SrinivasaRao et al. [20] proposed a poly mesh routing protocol (PMRP) for efficient management of cluster. This scheme also use two different approaches to find the route: inter cluster route use on demand whereas intra cluster use table driven approach to find the route.BhartiSharma et al. [21] proposed a fast and fault tolerant scheme to choose the group leader on the basis of local information. This scheme is based on layered architecture based on cluster formation followed by ring formation of cluster heads and finally the leader election algorithm. This scheme found to be better in terms of maintainingscalability and throughput.PramitaMitra, Christian Poellabauer [22] presents a group communication algorithm that uses the velocity and location of moving nodes to provide bandwidth efficientmulticast between a source and its destinations (i.e., group members) by utilizing the concept of location awaremobile environments. They also proposed a model that is able to predict the movement of mobile group members for a better communication.

3. Simulation and analysis

3.1 Energy consumption analysis of MAODV and PUMA algorithms

Here we have analyzed the energy consumption by the nodes in MAODV and PUMA algorithm using NS-2 simulator. Following will be the simulation parameters:

Table 1: Simulation configuration

Simulation Parameters	
Node(s)	30
Sender	1
MAC Protocol	802.11
Terrain	1200x1200
Ad Hoc Multicast Routing Protocol(s)	MAODV, PUMA
Simulation Time	10 Seconds
Group Size	1
Propagation Model	TwoRayGround
Simulator	NS-2
Node's Speed	120ms
Queue Type	DropTrail/Priority Queue
Initial Energy	10.0j
Traffic Type	CBR
Packet Size	512 Bytes
IFQ Length	50
Simulation Scenario(s)	Normal Execution Environment: MAODV PUMA

Each node in the network is defined with initial level of energy in beginning of simulation, termed as initial energy. In simulation, initial level of energy is passed as an input. A node consumes a specific amount of energy in transmission and receiving of every packet. As a result, the value of initial level of energy in a node starts decreasing. When the result between the initial energy and current energy reaches to zero, nodes become dead and stops transmission and receiving. The graph represents that PUMA is more efficient in terms of energy consumption as compared to MAODV, due to low control overhead.

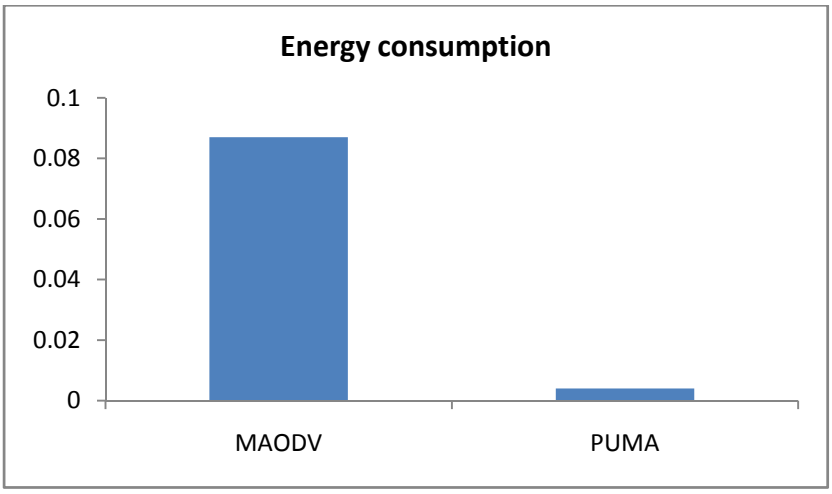

Fig. 3 Energy consumption by MAODV and PUMA

3.2 Scalability Analysis of MAODV algorithm

Here we have analyzed the normal behavior of MAODV in term of its scalability by increasing the node density. Analysis is done to observe the impact of node density and group size over throughput, PDR, routing load and end to end delay. Simulation analysis is done in NS-2 simulator under the following configuration:

Table 2: Simulation configuration

Simulation Parameters	
Node(s)	30
Sender	1
MAC Protocol	802.11
Terrain	1200x1200
Ad Hoc Multicast Routing Protocol(s)	MAODV
Simulation Time	10 Seconds
Group Size	1, 2,4
Propagation Model	TwoRayGround
Simulator	NS-2
Node's Speed	120ms
Queue Type	DropTrail/Priority Queue
Initial Energy	10.0j
Traffic Type	CBR
Packet Size	512 Bytes
IFQ Length	50
Simulation Scenario(s)	**Group Size-1-Node(s)-30** **Group Size-2-Node(s)-30** **Group Size-4-Node(s)-30** **Group Size-1-Node(s)-60** **Group Size-2-Node(s)-60** **Group Size-4-Node(s)-60** **Group Size-1-Node(s)-90** **Group Size-2-Node(s)-90** **Group Size-4-Node(s)-90**

Group Size-1,2,4 Node(s)-30

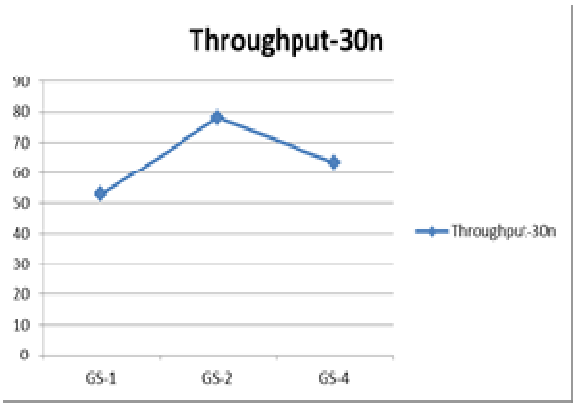

Fig. 4 Throughput

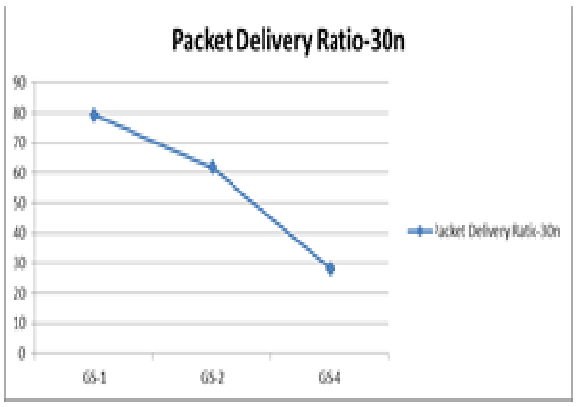

Fig. 5 Packet Delivery Ratio

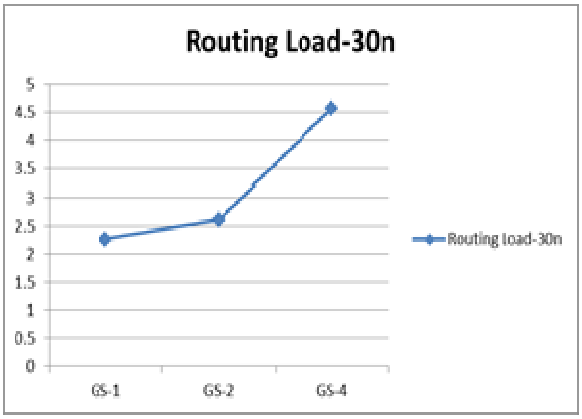

Fig. 6 Routing Load

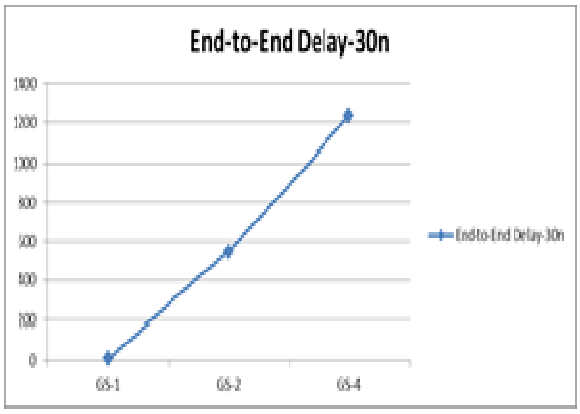

Fig. 7 End-to-End-Delay

Group Size-1,2,4 Node(s)-60

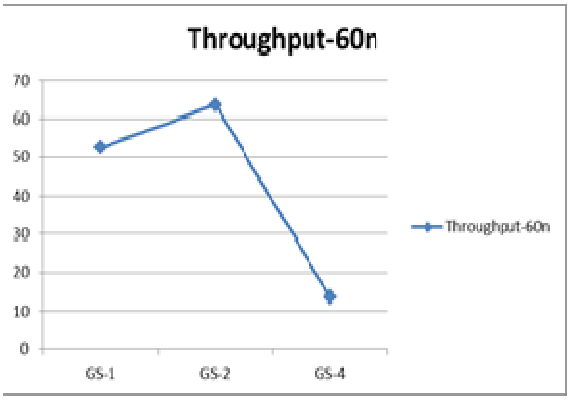

Fig. 8 Throughput

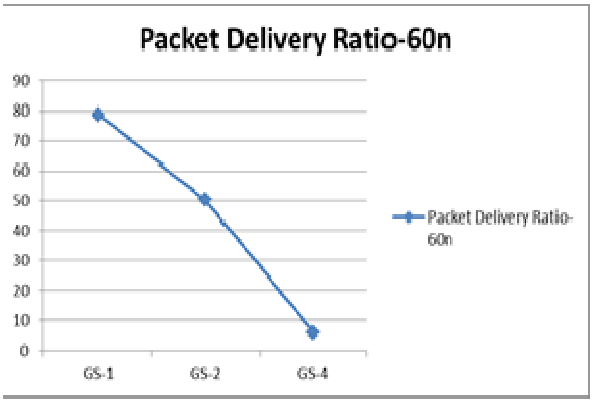

Fig. 9 Packet Delivery Ratio

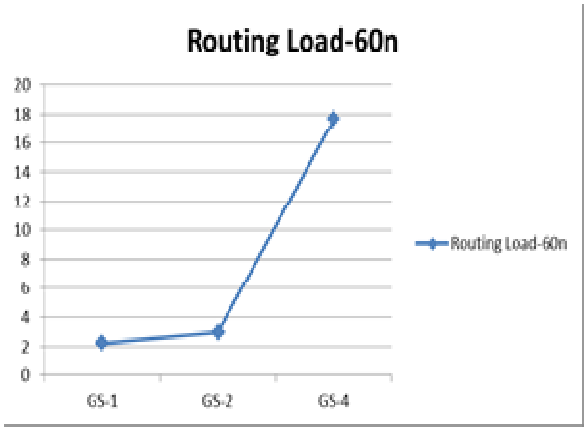

Fig. 10 Routing Load

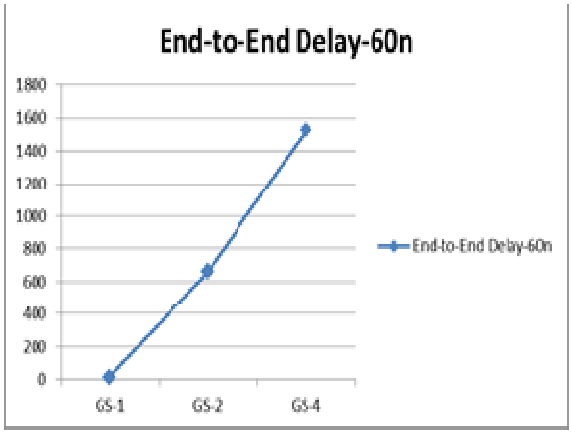

Fig. 11 End-to-End-Delay

Group Size-1,2,4 Node(s)-90

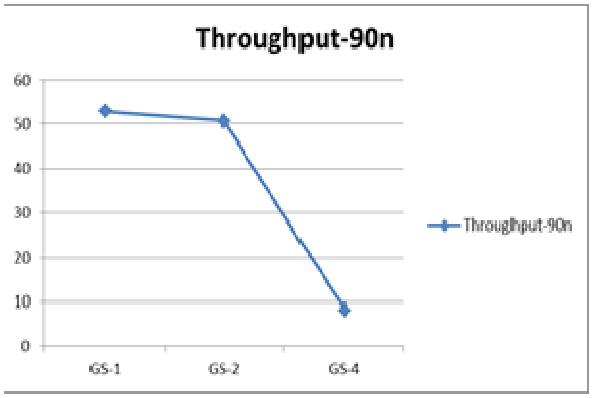

Fig. 12 Throughput

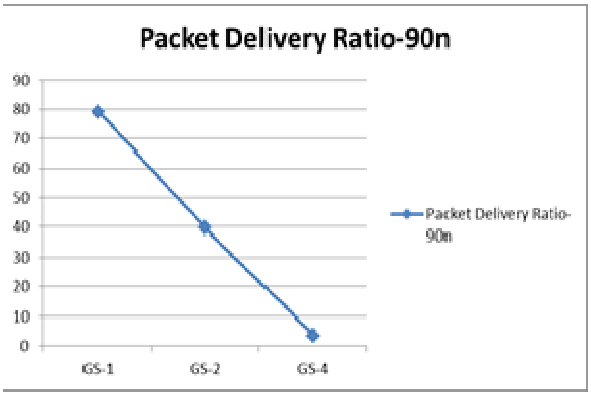

Fig. 13 Packet Delivery Ratio

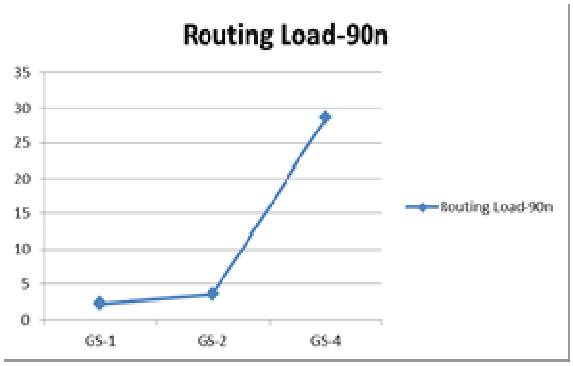

Fig. 14 Routing Load

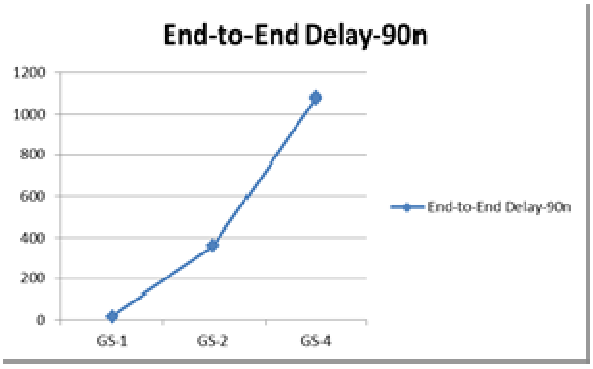

Fig. 15 End-to-End-Delay

From simulation results it has been observed that MAODV perform better in moderate group size. As the number of nodes and group size increases the throughput and packet delivery start decreasing, while the routing load and end to end delay start increasing. Therefore scalability aware multicast algorithm is an important issue need to be addressed in future to accommodate more number of mobile nodes without performance degradation.

4. FUTURE DIRECTIONS FOR ENERGY EFFICIENT MULTICAST

1. Load sharing of an individual node in situation of high traffic can increase the life time of heavily loaded node. Many researchers are working on this open and challenging issue in MANET.
2. Buffer management of an individual node can be another technique to optimize the limited battery power in MANET. Buffer management can be achieved by regulating the transmission and receiving of packets.
3. High residual energy (RE) of node can be used as metric for the selection of next node. Residual energy refers to the remaining energy available in the node after the transmission. It can be calculated with the help of mathematical formula:

$$\text{RE} = Pt \times Ep$$

   Where Pt is number of packet transmitted.

   Ep is energy required for transmitting one data packet.

   In these protocols, next hop is chosen on the basis of residual energy.
4. Efficient management of mesh and tree structure can reduce the control overhead that lead to energy saving of the node.
5. Congestion control mechanism can be devised to overcome the issue of energy of a node. Congestion occurs when there are limited resources to satisfy the demand of the network. There are many existing congestion control algorithms in MANET that can be extended further to optimize the energy issues.

6. Mesh based protocols can be optimized by opting selective flooding rather than normal flooding may reduce the unnecessary control overhead, thus reduce the node's energy consumption.
7. Route discovery can be optimized within cluster and inter cluster to reduce the control overhead involved in path finding from source to destination. This will help us in saving the battery power of a node.

5. FUTURE DIRECTIONS FOR SCALABLE MULTICAST

1. Efficient cluster or zone management can be done to reduce the size of routing table and control overhead to achieve the scalable multicast routing.
2. Position of a node can be used as a metric for better forwarding decision, thus reducing the number of hops and control overhead to maintain scalability.
3. Quick and fault tolerant election of group leader will be helpful in achieving better scalability.
4. Load balancing techniques can be explored and used to achieve better scalability by reducing the control overhead.
5. Optimized node insertion techniques and route list table update techniques can be developed to achieve better scalability.
6. Dynamic topology and node mobility behavior of nodes can be utilized to propose better results in terms of scalability with improved QoS parameters.
7. Scalability can be increased by limiting the numbers of error forwarding nodes.

6. CONCLUSION AND FUTURE SCOPE

MANETs supported applications are gaining over other group communication techniques due its low cost and quick deployment. But its advantages are associated with many challenges issues due to its unique characteristics. Energy efficient and scalable multicast algorithms are among most open and challenging QoS parameter that needs to address by research fraternity. In this paper, an extensive analysis and literature survey of work done in this direction has been done to provide a better roadmap to pursue research on these issues. We further conclude that, MAODV performs better with moderate network size. PUMA is better than MAODV in terms of energy consumption at preliminary stage. Each multicast algorithm has its own set of rules that triggers when a node join or leave the group, therefore a single solution for allmulticast is an open and challenging issues.In next papers we will propose some scheme for better energy consumption and scalability support in multicast algorithms over MANET.

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