Performance Analysis of Efficient and Geographic Multicast Routing Protocol for Mobile Adhoc Networks using NS-2

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Abstract

Group Communication has become important in Mobile Adhoc Network (MANET). But because of its dynamic topology it is difficult to implement group communication in MANET. In order to implement group communication, Efficient Geographic Multicasting Protocol (EGMP) came into existence, the efficiency and scalability of the protocol was already tested using Global Mobile Simulation (GloMoSim), but this paper test the Bandwidth utilization, performance and delay in packet transmission by using Network Simulator-2 (NS-2), as NS-2 helps in finding the functionality of the protocol in real time environment, at lower cost. In this EGMP uses a MAC layer protocol IEEE 802.15.4 SSCS with the data rate of 250kbps and the radio frequency 2.4GHz. Here a network wide Zone based bidirectional tree is constructed to achieve the efficient group membership management. Every node is aware of its own position which efficiently reduces the overhead for route searching and also comparing EGMP with AODV (Adhoc On-Demand Distance Vector Routing Protocol), EGMP has high Bandwidth utilization, lower delay in packet transmission, and higher performance. And EGMP has constant overhead irrespective of increase in number of nodes.


1 Introduction

Mobile ad hoc network (MANET) consists of many mobile nodes which are connected by a wireless links. Each node will not only act as end system but also as a router for transmitting the data. In MANET the network topology may change frequently due to the nodes movements. A efficient routing protocol will always route the packets along or close to shortest path from source to destination and will be able to adopt the dynamic topology. A number of unicast routing, geographic routing protocol have been proposed in mobile ad hoc network [2], [3], [4], [5]. The existing geographic routing protocol generally assume mobile nodes are aware of their own position through certain positioning system (for example GPS) and source can obtain the destination position through some type of location service [6], [7]. An intermediate node makes its forwarding decisions based on the destination position inserted in the packet header by the source and the positions of its one-hop neighbors learned from periodic beaconing of the neighbors. By default, the packets are greedily forwarded to the neighbor that allows for the greatest geographic progress to the destination. When no such a neighbor exists, perimeter forwarding is used to recover from the local void, where a packet traverses the face of the planarized local topology subgraph by applying the right hand rule until the greedy forwarding can be resumed. Similarly to reduce the overhead and support more reliable multicasting, position information is used to guide the multicast routing. However, there are many challenges in implementing an efficient and scalable geographic multicast scheme in MANET. For example, in unicast geographic routing, the destination position is carried in the packet header to guide the packet forwarding, while in multicast routing, the destination is a group members. A straightforward way to extend the geography –based transmission from unicast to multicast is to put the addresses and positions of all the members into the packet header, however, the header overhead will increase, which constrains the application of geographic multicasting only to a small group[8], [9], [10]. Besides requiring efficient packet forwarding, a scalable geographic multicast protocol also needs to efficiently manage the membership of a possible large group, obtain the positions of the members and build routing paths to reach the members distributed in a possibly large network terrain. The existing small-group-based geographic multicast protocol [8], [9], [10] normally address only part of these problems. Efficient geographic multicast protocol, EGMP [30], can scale to a large group size and large network size. The protocol is designed to be comprehensive and self-contained, yet simple and efficient for more reliable operation. Instead of addressing only a specific part of the problem, it includes a zone-based scheme to efficiently handle the group membership management structure to efficiently track the locations of all the group members without resorting to an external location server. The zone structure is formed virtually and the zone where a node is located can be calculated based on the position of the node and reference origin. In topology-based cluster construction, a cluster is normally formed around a cluster leader with nodes on hop or K-hop away, and the cluster will constantly change as network topology changes. In contrast, there is no need to involve a big overhead to create and maintain the geographic zones proposed in this work, which is critical to support more efficient and reliable communications over a dynamic MANET. By making
use of the location information, EGMP could quickly and efficiently build packet distribution paths, and reliably maintain the forwarding paths in the presence of network dynamics due to unstable wireless channels or frequent node movements. This work also includes: (I) the use of the position information to design a scalable virtual-zone-based scheme for efficient membership management, which allows a node to join and leave a group quickly. Geographic unicast is enhanced to handle the routing failure due to the use of estimated destination position with reference to a zone and applied for sending control and data packets between two entities so that transmission are more robust in the dynamic environment. (II) Supporting efficient location search of the multicast group members, by combining the location service with the membership management to avoid the need and overhead of using a separate location server. (III) Introducing an important concept zone depth, this is efficient in guiding the tree branch building and tree structure maintenance, especially in the presence of node mobility. With nodes self-organizing into zones, zone-based distribution paths can be built quickly for efficient multicast packet forwarding. (IV) Addressing the empty zone problem, this is critical in a zone-based protocol, through the adoption of tree structure. (v) Evaluating the performance analysis through NS-2 simulator. We organize the rest of this paper as follows: We present a detailed design of the EGMP protocol in Section 2 as given by the work in [30]. Finally we give our simulation results in Section 4 and conclude the paper in Section 5. Since this protocol is already tested using golobosim. This paper analysis EGMP using a NS-2, it will very ful to know the working of protocol in real time environment at cheaper cost.

2.1 Protocol overview

This section deals with the work of EGMP [30] that supports scalable and reliable membership management and multicast forwarding through a two-tier virtual-zone-based structure. At the lower layer, in reference to a predetermined virtual origin, the nodes in the network self-organize themselves into a set of zones as shown in Fig. 1, and a leader is elected in a zone to manage the local group membership. At the upper layer, the leader serves as a representative for its zone to join or leave a multicast group as required. As result, a networkwide zone-based multicast tree is built. For efficient and reliable management and transmissions, location information will be integrated with the design and used to guide the zone construction, group membership management, multicast tree construction and maintenance, packet forwarding. The zone-based tree is shared for all the multicast sources of a group. To further reduce the forwarding overhead and delay, EGMP supports bidirectional packet forwarding along the tree structure. That is instead of sending the packets to the root of the tree first; a source forwards the multicast packets directly along the tree. At the upper layer, the multicast packets will flow along the multicast tree both upstream to the root zone and downstream to the leaf zones of the tree. At the lower layer, when an on-tree zone leader receives the packets, it will send them to the group members in its local zone.

2.2 Issues need to be addressed to make the protocol fully functional and scalable

The issues related to zone management include: the schemes for more efficient and robust zone construction and maintenance of a zone leader with minimum overhead, zone partitioning as a result of severe wireless channels or signal blocking, potential packet loss when multicast when there is a movement of multicast members. There are also issues related to packet forwarding which include: the efficient building of multicast paths with the zone structure, the handling of empty zone problem, the efficient tree structure maintenance during node movements, the reliable transmissions of control and multicast data packets an obtaining location information to facilitate our geometric design without resorting to external location server.

2.3 Terminologies

This section gives the terminologies used in the paper[30]. In EGMP [30], every node is aware of its own position through some system (e.g. GPS [28]) or the other localization schemes. The forwarding of data packets mostly depend on GPSSR [4] but EGMP however does not depend upon specific geographic unicast protocol. Some of the notations used:

- **Zone**: The network is divided into square zones as shown in fig. 1.
- **r**: Zone size, the length of a side of zone square. The zone size is set to $r \leq r_{t}/2^{1/2}$, where $r_{t}$ is the transmission range of the mobile nodes. To reduce intrazone management overhead, the intrazone nodes can communicate directly with each other without the need of any intermediate relays.
- **Zone ID**: The identification of a zone. A node can calculate its zone ID $(a, b)$ from its position coordinates $(x, y)$ as: $a = \lfloor(x-x_0)/r\rfloor$, $b = \lfloor(y-y_0)/r\rfloor$, where $(x_0, y_0)$ is the position of the virtual origin, which can be a known reference location or determined at network setup time. A zone is virtual and formulated in reference to a virtual origin and all zones ID are assumed as positive.
• **Zone center**: for a zone with ID \((a, b)\), the position of its center \((x, y)\) can be calculated as: 
\[
x = a + 0.5 \times r, \quad y = b + 0.5 \times r
\]
A packet destined to a zone will be forwarded toward the center of the zone.

• **ZLdr**: zone leader. A ZLdr is elected in each zone for managing the local zone group membership and taking part in the upper tier multicast routing.

• **Tree zone**: the zones on the multicast tree. The tree zones are responsible for the multicast packet forwarding. A tree zone may have group members or just help forward the multicast packets for zones with members.

• **Root zone**: the zone where the root of the multicast tree is located.

• **Zone depth**: the depth of a zone is used to reflect its distance to the root zone. For zone with ID \((a, b)\) its depth is
\[
\text{Depth} = \max(|a_a, a|, |b_b, b|)
\]
where \((a_0, b_0)\) is the root-zone ID. In fig. 1, the root zone has depth zero, the eight zones immediately surrounding the root zone have depth one, and the outer seven zones have depth two.

In EGMP, the zone structure is virtual and calculated based on a reference point. Therefore, the construction of zone structure does not depend on the shape of the network region, and it is very simple to locate and maintain a zone. The zone is used in EGMP to provide location reference and support lower-level group membership management. A multicast group can cross multiple zones. With the introduction of virtual zone, EGMP does not need to track individual node movement but only needs to track the membership change of zones, which significantly reduces the management overhead and increases the robustness of the proposed multicast protocol. In EGMP designing of zone is done without considering node density so it can provide more reliable location reference and membership management in a network with constant topology changes.

### 2.4 Neighbor Table Generation

For efficient management of states within a zone, a leader is elected with a minimum overhead. As a node employs periodic BEACON broadcast to distribute its position in the underneath geographic unicast routing [4], to facilitate leader election and reduce overhead, EGMP inserts a message with a BEACON, a flag indicating whether the sender is zone leader. With zone size, a broadcast message will reduce the beaconing overhead, instead of using fixed-interval beaconing, the beaconing here is done by sending a beacon by a nonleader node at period of Intval_{max} and a leader node will send a beacon in the period of Intval_{min} to announce its leadership role. When a node is

<table>
<thead>
<tr>
<th>Table 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>The neighbor table of node 18 in fig.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>nodeID</th>
<th>Position</th>
<th>flag</th>
<th>zoneID</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>((x_{16}, y_{16}))</td>
<td>1</td>
<td>((1, 1))</td>
</tr>
<tr>
<td>1</td>
<td>((x_{1}, y_{1}))</td>
<td>0</td>
<td>((1, 1))</td>
</tr>
<tr>
<td>7</td>
<td>((x_{7}, y_{7}))</td>
<td>1</td>
<td>((0, 1))</td>
</tr>
<tr>
<td>13</td>
<td>((x_{13}, y_{13}))</td>
<td>1</td>
<td>((1, 2))</td>
</tr>
</tbody>
</table>

receiving a beacon from its neighbor it will record its node ID, position, and flag contained in the message in its neighbor table. Table 1 shows the neighbor table of node 18 Fig. 1. To avoid routing failure due to outdated topology information, an entry will be removed if not refreshed within a period Timeout_{NT} or the corresponding neighbor is detected unreachable by the MAC layer protocol.

### 2.5 Zone Leader Election

A zone leader is elected through the cooperation of nodes and maintained consistently in a zone. When a node appears in the network, it sends out a beacon announcing its existence. Then, it waits for an Intval_{max} period for the beacons from other nodes. Every Intval_{min} a node will check its neighbor table and determine its zone leader under different cases: 1) the neighbor table contains no other node in the same zone; it will announce itself as a leader. 2) the flags of all the nodes in the same zone are unset, which means that no node in the zone has announced the leadership role. If the node is closer to the zone center than other nodes, it will announce its leadership role through a beacon message with the leader flag set. 3) More than one node in the same zone have their leader flags set, the one with the highest node ID is elected. 4) only one of the nodes in the zone has its flag set, then the node with the flag set is the leader.

### 2.6 Zone Supported Geographic Forwarding

With a zone structure, the communication process includes an intrazone transmission and an interzone transmission. In our zone structure, as nodes from the same zone are within each other’s transmission range and are aware of each other’s location, only one transmission is required for intrazone communications. Transmissions between nodes in different zones may be needed for the network-tier forwarding of control messages and data packets. As the source and the destination may be multiple hops away, to ensure reliable transmissions, geographic unicasting is used with the packet forwarding guided by the destination position. However, in normal geographic unicast routing, location service is required for the source to obtain the destination position. In EGMP, to avoid the overhead in tracking the exact locations of a potentially large number of group members, location service is integrated with zone-based membership management without the need of an external location server. At the network tier, only the ID of the destination zone is needed. A packet is forwarded toward
the center of the destination zone first. After arriving at the destination zone, the packet will be forwarded to specific receiving node or broadcast depending on the message type. Generally, the messages related to multicast group membership management and multicast data will be forwarded to the zone leader to process. In the above design, for scalability and reliability, the center of the destination zone is used as the land mark for sending an packet to the group members in the zone although there may be no node located at the center position. This however may result in failure of geographic forwarding. To avoid this problem, we introduce a zone forwarding mode in EGMP when the underlying geographic forwarding fails. Only when the zone mode also fails, the packet will be dropped. In zone mode, a sender node searches for the next hop to the destination based on its neighbor table, which can more accurately track the local network topology. The nodes selects as its next hop the neighboring node whose zone is the closest to the destination zone and closer to the destination zone than its own zone. It multiple candidates are available, the neighbor closest to the destination is selected as the next hop. To compare the distance of different zones to the destination zone, the node can calculate the distance zone the node can calculate the distance value dis(a,b) of a zone (a,b) to the destination Zone (a_dstd, b_dstd) as given in [30]

\[
\text{Dis}(a, b) = (a-a_{dstd})^2 + (b-b_{dstd})^2
\]

A zone with a smaller dis value is closer to the destination zone and to avoid possible routing loop and intermediate node only forwards a packet that is received for the first time.

### 2.7 Multicast Tree Construction

This section deals with the Multicast session Initiation and Termination, Joining, and Leaving.

#### 2.7.1 Multicast Session Initiation and Termination

When a multicast session G is initiated, the first source node S announces the existence of G by flooding a message NEW_SESSION (G, Zone IDs) into the whole network. The message carries G and the ID of the zone where S is located, which is used as the initial root-zone ID of group G. When a node M receives this message and is interested in G, it will join G. A multicast group member will keep a membership table with an entry (G, root_ZID, is Aced), where G is a group of which the node is a member, root_ZID is the root-zone ID, and is Aced flag indicating whether the node is on the corresponding multicast tree. A zone leader maintains a multicast table. When a ZLdr receives the NEW_SESSION message, it will record the group ID and the root-zone ID in its multicast. Table 2 is an example of one entry in the multicast table of node 16 in fig. 1. The table contains the group ID, root zone ID, upstream zone ID, downstream zone list, and downstream node list. To end a session G, S floods a message END_SESSION(G). When receiving this message, the nodes will remove all the information about G from their membership table and multicast tables.

<table>
<thead>
<tr>
<th>Group ID</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root-zone ID</td>
<td>(2,2)</td>
</tr>
<tr>
<td>Upstream zone ID</td>
<td>(2,2)</td>
</tr>
<tr>
<td>Downstream Zone list</td>
<td>(0,1), (0,0)</td>
</tr>
<tr>
<td>Downstream node list</td>
<td>1</td>
</tr>
</tbody>
</table>

#### 2.7.2 Multicast Group Join

When a node M wants to join the multicast group G, if it is not a leader node, it sends a JOIN_REQ (M, PosM, G, \{M_old\}) message to its ZLdr, carrying its address, position, and group to join. The address of the old group leader M_old is an option used when there is a leader handoff and a new leader sends an updated JOIN_REQ message to its upstream zone. If M did not receive the NEW_SESSION message or it just joined the network, it can search for the available groups by querying its neighbors. If a ZLdr receives a JOIN_REQ message is received from a member M of the same Zone, it will compare the depth of the requesting zone is closer to the root zone than the requesting zone, it will add the requesting zone to its downstream zone list; otherwise, it simply continues forwarding the JOIN_REQ message toward the root zone. If new nodes or zones are added to the downstream list the leader will check the root-zone ID and the upstream zone ID. If it does not know the root zone, it starts an expanded ring search. As the zone leaders in the network cache the root-zone ID quickly obtained. With the knowledge of the root zone, if its upstream zone ID is unset, the leader will represent its zone to send a JOIN_REQ message toward the root zone; otherwise, the leader will send back a JOIN_REPLY message to the source of the JOIN_REQ message. When the source of the JOIN_REQ messages receives the JOIN_REPLY, it is a node, it sets the isAced flag in its membership table and the joining procedure is completed. If the leader of a requesting zone receives the JOIN_REPLY message, it will set its upstream Zone ID as the ID of the zone where the JOIN_REPLY messages to unacknowledged downstream nodes and zones. Through the joining process, the group membership management is implemented in a distributed manner. An upstream zone only need to manage its downstream zones and the group membership of a local zone is only managed by its leader. The zone depth is used to guide efficient tree construction and packet forwarding.

#### 2.7.3 Multicast Group Leave

When a member M wants to leave G, it sends LEAVE (M, G) message to its zone leader. On receiving a LEAVE message, the leader removes the source of the LEAVE message from its downstream node list or zone list depending on whether the message is sent from an intrazone node or a downstream zone. Besides removing a branch through explicit LEAVE, a leader will remove a
node from its downstream list if does not receive the beacon from the node exceeding $2 \times \text{Interval}_{\text{max}}$. If it’s downstream zone list and node list of G are both empty and it is not a member of G either, the leader sends a LEAVE (zoneID, G) message to its upstream zone. Through the leave process, the unused branches are removed from the multicast tree.

2.8 Multicast Packet Delivery

2.8.1 Packet Sending from the Source

After the multicast tree is constructed, all the source of the group could send packets to the tree and the packets will be forwarded along the tree. EGMP assumes a bidirectional-tree-based forwarding strategy [29], with which the multicast packets can flow not only from an upstream node/zones down to its downstream nodes/zones, but also from a downstream node/zones up to its upstream node/zones. A source is also a member of the multicast group and will join the multicast tree. When a source S has a data to send and it is not a leader, it checks the isAcked flag in its membership table to find out it is on the tree. If it is, i.e., its zone has joined the multicast tree, it sends the multicast packets to its leader. When the leader of an on-tree zone receives multicast packets, it forwards the packets to its upstream zone and all its downstream nodes and zones except the incoming one. When a source node S is not on the multicast tree, for example, when it moves to a new zone, the isAcked flag will remain unset until it finishes the joining process. To reduce the impact of the joining delay, S will send packets directly to the root zone until it finishes the joining process.

2.8.2 Multicast Data forwarding

In EGMP protocol, only zLdrs maintain the multicast table, and the member zones normally cannot be reached within one hop from the source. When a node N has a multicast packet to forward to a list of destinations ($D_1$, $D_2$, $D_3$, …), it decides the next hop node toward each destination using the geographic forwarding strategy described in section 3.6. After deciding the next hop nodes and the destinations associated with each next hop node in the packet header. An example list is ($N_1$; $D_1$; $D_2$; $N_2$; $D_2$; $D_2$; …), where $N_1$ is the next hop node for the destinations $D_1$ and $D_3$, and $N_2$ is the next hop node for $D_2$ Then, N broadcast the packet promiscuously. Upon receiving the packet, a neighbor node will keep the packet if it is one of the next hop nodes or destinations, and drop the packet otherwise. When the node is associated with some downstream destinations, it will continue forwarding packets similarly as done by node N.

2.9 Multicast Route Maintenance and Optimization

In dynamic network, it is critical to maintain the connection of the multicast tree, and adjust the tree structure upon the topology changes to optimize the multicast routing. In the zone structure, due to the movement of nodes between different zones, some zones may become empty. It is critical to handle the empty zone problem in a zone-based protocol. Compared to managing the connections of individual nodes, however, there is much lower overhead in maintaining the zone-based tree. As the tree construction is guided by location information, a disconnected zone can quickly reestablish its connection to the tree. In addition, a zone may be partitioned into multiple clusters due to fading and signal blocking. In this section we discuss our maintenance schemes.

2.9.1 Moving between Different Zones

When a member node moves to a new zone, it must rejoin the multicast tree through the new leader. When a leader is moving away from its current zone, it must handover its multicast table to the new leader in the zone, so that all the downstream zones and nodes will remain connected to the multicast tree. Whenever a node M moves into a new zone, it will rejoin a multicast group G by sending a JOIN_REQ message to its new leader. During this joining process, to reduce the packet loss, whenever the node broadcasts a BEACON message to update its information to the nodes in the new zone, it also unicasts a copy of the message to the leader of its previous zone to update its position. Since it has not sent the LEAVE message to the old leader, the old leader will forward the multicast packets loss and facilitates seamless packet transmissions during zone crossing. When the rejoining process finishes, M will send a LEAVE messages to its old leader. To handle leader mobility problem, if a leader finds its distance to the zone border is less than a threshold or it is already in a new zone, it assumes it is moving away from the zone where it was the leader, and it starts the handover process. To look for the new leader, it compares the positions of the nodes in the zone it is leaving from and selects the one closest to the zone center as the new leader. It then sends its multicast table to the new leader, which will announce its leadership role immediately through a BEACON message. It will also send a JOIN_REQ message to its upstream zone. During the transition, the old leader may still receive multicast packets. It will forward all these packets to the new leader when the handover process is completed. If there is no other node in the zone and the zone will become empty, it will use the method introduce in the next section to deliver its multicast table. In the case that the leader dies suddenly before handing over its multicast table, the downstream zones and nodes will reconnect to the multicast tree through the maintenance process described in section 3.9.4.

2.9.2 Dealing with Empty Zones

A zone may become empty when all the nodes move away, the tree zone may become empty, and the multicast tree will be adjusted correspondingly to keep the multicast tree connected. When the leader is moving away from a nonroot tree zone and the zone is becoming empty, it will send its multicast table to its upstream zone. The upstream zone leader will then takes over all its
downstream zones, and delete this requesting zone from its downstream zone list. The new upstream zone needs to send JOIN_REPLY messages to all the newly added downstream zones to notify them the change. When receiving the JOIN_REPLY messages, these downstream zones will change their upstream zone ID accordingly. If the empty zone is the root zone, since the root zone has no upstream zone, the leader will check its neighboring zones and choose the one closest to the root zone as the new root zone. The leader then forwards its multicast table to the new zone, and floods a NEW_ROOT message to announce the change.

2.9.3 Handling Multiple Clusters per Zone

EGMP handles the zone partitioning problem as follows: If there are multiple clusters in a zone, because these clusters are not aware of the existence of each other, each cluster will elect a leader. When an upstream zone leader receives JOIN_REQ messages from multiple leaders of the same zone and the new message is not sent as a result of leader handover, it detects that the downstream zone has partitioned into multiple clusters. It identifies a cluster by its ZID and the leader address. When sending a packet to the cluster, it uses the leader position instead of the zone center as the transmission reference. Even though the leader may move, its position carried in JOIN_REQ message can still be used as reference. A cluster leader can learn that multiple clusters exist within its zone. In case that not all the clusters of a partitioned zone send JOIN_REQ messages, the upstream zone leader may not be aware of the partitioning of the downstream zone. When a cluster leader receives a packet destined to its zone but does not match its status, it will send an update message to its upstream zone. For example, when a cluster leader receives a JOIN_REPLY message or a multicast packet but did not send JOIN_REQ message, it will send a LEAVE messages to the upstream zone. When receiving messages from multiple leaders of the same zone, the upstream leader can detect zone partitioning. It will resend the previous message to the target cluster with the position of the zone leader as the destination. When the leader of a cluster changes, if the cluster is on-tree, the new leader sends a JOIN_REQ message to its upstream zone immediately. This also carries the old leader address. With multiple clusters in its upstream zone, the JOIN_REQ message from a zone leader will generally be intercepted by one of the clusters, which will be responsible for forwarding the packets to the zone. Some clusters may merge later into a larger cluster, and through the leader election procedure, only one of the leaders will win as the new cluster’s leader. The new leader will send a JOIN_REQ message to the upstream zone to refresh the cluster’s information. The leaders of the other merged-in clusters will also send LEAVE messages to the upstream zone, which will remove their information from the multicast table.

2.9.4 Tree Branch Maintenance

To detect the disconnection of tree branches in time, if there are no multicast packets or messages to deliver for a period of Intval_active, the leader of a tree zone will send an ACTIVE message to its downstream nodes and zones to announce the activity of the multicast branches. The message is sent through multicast to multiple downstream entities. When a member node or a tree zone fails to receive any packets or messages from its leader or upstream zone up to a period of 2*Intval_active, it assumes that it loses the connection to the multicast tree and restarts a joining process.

2.9.5 Route Optimization

Sometimes a zone leader may receive duplicate multicast packets from different upstream zones. For example, as described in the above section, when failing to receive any data packets or ACTIVE messages from the upstream zone for a period of time, a tree zone will start a rejoining process. However, it is possible that the packet and message were lost due to collisions, so the old upstream zone is still active after the rejoining process, and supplicate packets will be forwarded by two upstream zones to the tree zone. In this case, the one closer to the root zone will be kept as the upstream zone. If the two upstream zones have the same distances to the root zone, one of them is randomly selected.

3 Performance Evaluations

On comparing the performance of EGMP with AODV, EGMP has low control overhead and high bandwidth utilization, and higher performance. Further in AODV when there is a existence of collision, it cannot repair it locally but in EGMP when there is existence of collision the packets can travel through any other shortest path and reduces delay in packet transmission to the destination. Figure 2, 3, 4 gives the comparison EGMP and AODV. In all the graphs the X-Axis is taken as Number of Nodes and Y-Axis is taken as Packet Transmission.
Fig. 5.1 Screenshot of NAM Output

Fig. 5.2 Comparison of Packet Loss between AODV & EGMP

Fig. 5.3 Comparison of performance between AODV & EGMP
4 Conclusion

In this paper performance of EGMP is tested using NS-2. The simulation result demonstrate that EGMP has higher Bandwidth Utilization, Better performance, and higher packet delivery ratio and lower control overhead. Since NS-2 can considered as tool that shows the performance of the protocol in real time application the simulation results show that EGMP can be implements in real world application. The future work can further enhance the efficiency of the protocol.

5 References