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Scalable Receiver Based Multicast Protocol for Mobile Ad-Hoc Network

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Abstract: In recent years due to the vast availability of handheld devices, it stimulates the researchers to do work on self organizing network. But in topology based multicast protocols maintenance of group members, creation and maintenance of tree/mesh is somewhat difficult. In this study, we introduced a zone based virtual isometric structure. Virtual architectures are used without need of maintaining state information. Here, we use the concept of Artificial Bee Colony algorithm for splitting up of zones for quick transmission of data. Scalable receiver based multicast routing protocol is a stateless multicast routing protocol significantly reduces the tree or mesh management overhead. It is more efficient, robust and a dynamic protocol under all the circumstances and it gives higher packet delivery ratio.

Key words: MANET, multicast routing, zone based routing, Artificial Bee Colony (ABC) algorithm, wireless networks

INTRODUCTION

Mobile Ad-Hoc network consists of many mobile nodes connected by wireless links. Each node operates as an end-system also as a router. In MANET, the network topology may change frequently due to the movements of the nodes. A routing protocol should always forward packets along or close to the shortest path from source to destination and be able to adapt quickly to topology changes. A number of routing protocols have been proposed in the Mobile Ad-Hoc environment. But, the multicast distribution tree cannot be controlled by transport and application layers (Ji and Corson 2001). In (Chen and Nahrstedt, 2002), they introduced small group multicasting scheme based on packet encapsulation in MANET which uses two novel tree construction algorithms to construct an efficient packet distribution tree. Two effective tree construction algorithms are LGK and LGS. But, it is also a tree based multicast. It effectively forwards the packets to all group members. But, it is difficult to maintain if there is mobile node and breakage in link. In RSGM protocol, they have designed a robust and scalable geographic multicast protocol for MANET (Lee *et al*., 2000). In RSGM, uses simple management and robust forwarding stateless virtual transmission structure. Both data packets and control messages are transmitted without creating and maintaining a tree structure. It uses virtual-zone-based two-tier infrastructure. A source home is defined to track the locations and addresses of the multicast sources. In this study, we propose a novel Robust and Scalable Geographic Multicast protocol (RSGM) scale to a large group size and a large network size and can more efficiently support multiple multicast groups in the network. But, it has low packet delivery ratio, high delay and source zone maintaining problems. Due to the hierarchical structure and maintenance of source home it is not possible to track the node if it fails. Thus to avoid the routing inefficiency, the source home does not serve as the gateway for data forwarding between the source and the group members.

ODMRP is a multicast routing protocol designed for ad hoc networks with mobile hosts (Xiang *et al*., 2010). ODMRP is a mesh-based, multicast scheme and uses a forwarding group concept. It uses on-demand procedures to dynamically build routes and maintain multicast group membership. The ODMRP is well suited for ad hoc wireless networks with mobile hosts where bandwidth is limited, topology changes frequently and rapidly and power is constrained. It uses joint query and joint reply packets for the mesh formation. But it also gives overhead and consumes power for the mesh formation. Position-Based Multicast routing for Mobile Ad-Hoc Networks (Xie *et al*., 2002) is a position-based unicast routing, the forwarding node selects one of its neighbors as a next hop such that the packet make progress towards

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the geographical position of the destination. It uses a multicast routing algorithm for mobile ad-hoc networks. It demonstrates by means of simulation that it achieves very high packet delivery rates even under high mobility. Its key weakness is that it requires position and membership information at the sending node. It is not a scalable solution which uses the fact that the sender needs only to know in which direction receivers are located. Information about individual receivers is not necessary. TORA (Temporally Ordered Routing Protocol) is a distributed highly adaptive routing protocol designed to operate in a dynamic multihop network. TORA uses an arbitrary height parameter to determine the direction of link between any two nodes for a given destination. Consequently, multiple routes often exist for a given destination but none of them are necessarily the shortest route. To initiate the route, the node rebroadcasted a query packet then broadcast the update packet which lists its height with respect to the destination. When, this packet propagates in the network each node that receives the update packet sets its height to a value greater than the height of the neighbor from which the update was received. This has the effect of creating a series of directed links from the original sender of the query packet to the node that initially generated the update packet. When, it was discovered by a node that the route to a destination is no longer valid, it will adjust its height so that it will be a local maximum with respect to its neighbors and then transmits an update packet. If the node has no neighbors of finite height with respect to the destination, then the node will attempt to discover a new route as described above. When, a node detects a networks partition, it will generate a clear packet that results in reset of routing over the Ad-Hoc network. TORA supports multiple routes. It retains multiple route possibilities for a single source/destination pair. Bandwidth is conserved because of the fewer route rebuilding. TORA also supports multicasts. TORA'S reliance on synchronized clocks limits in applicability. If the external time source fails, the algorithm ceases to operate. Also, route rebuilding may not occur as quickly due to oscillations. During this period this can lead to lengthy delays while for the new routes to be determined.

Forwarding Group Multicast Protocol (FGMP) provides a simple and efficient way for multicasting in multihop, mobile wireless networks (Mauve *et al*., 2003). It is more suitable to the wireless broadcast channel than the conventional notion of upstream/downstream links. This leads to a more prompt adjustment to topology changes and to a reduction of redundant transmissions, resulting in higher throughput and multicast efficiency. Storage overhead savings extend the scalability to large multicast group nodes. The drawback is that it uses more bandwidth, communication overhead and not energy efficient.

In Geographic Multicast routing Protocol (GMP) (Chiang *et al*. 1998) for WSN uses a protocol is fully distributed and stateless. The transmitting node first constructs a virtual Euclidean Steiner tree rooted itself and including the destinations, using efficient reduction ratio heuristic called STR. Based on this locally computed tree and the information regarding the locations of its immediate neighbors, the transmitting node then splits the destinations into a set of groups and calculates a next hop for each of these groups. A copy of the packet and the locations of the corresponding group of destination nodes are directed towards the corresponding hop. It uses the concept of partitioning the destination and Euclidean Steiner trees construction. It consumes memory and not energy efficient.

SPBM (Scalable Position-Based Multicast) routing is based on quad-tree structure, which is used to aggregate membership information by region. In SPBM each participating node should be aware of the geographical dimensions of the network area. In SPBM, the network is split into smallest square to communicate directly with another directly. Each node periodically sends its vector to the nodes within its own lowest-level square. It is propagated to next higher level by sending one packet to all the nodes within the square on that level. The frequency of these propagation messages decreases with the level of aggregation. Multicast forwarding is done using the information collected by group management packets overhead by each node. When forwarding a packet, the forwarder stores the information about the remaining receiver nodes inside the packet header. SPBM should provide interfaces for incoming and outgoing data packets. The delivery ratio of SPBM decreases with increase in the mobility of the nodes. In SPBM, when mobility increases, its periodic multi-level membership update mechanism cannot catch quick membership changes of the lower squares in time, its higher control overhead results in much more transmission collisions. Hence, the delivery ratio of SPBM is reduced.

Literature review In MANET there are many multicast protocols. These includes, tree based and mesh based protocols. In tree based structure (Corson and Batsell, 1995; Ji and Carson, 1998; Royer and Perkins 1999; Wu *et al*., 1998), there is only one path for each destination; multiple destinations may share parts of their paths. However, it is very difficult to maintain the tree structure in mobile ad hoc networks and the tree connection is easy to break and the transmission is not reliable. In mesh-based structures (Garcia-Luna-Aceves and Madruga, 1999; Zhang and Jacob, 2003) there may be multiple paths from a given source to each destination. Unfortunately, change in topology any node failures and group membership changes can render the communication and reconfiguration overheads of maintaining a distributed tree or mesh structure unacceptably high.

To address these problems we propose a Scalable Receiver Based Multicast (SRBM) routing protocol. The results demonstrate that SRBM is scalable to large group size, network size and it provides optimal path. Compared to exiting protocols ODMRP, RSGM and AODV, SRBM gives minimum end to end path length delay, minimum control overhead and high packet delivery ratio. SRBM is a stateless multicast routing protocol significantly reduces the tree or mesh management overhead, more efficient, robust and a dynamic protocol under all the circumstances like node densities, zone size, network size and various speed of nodes gives higher packet delivery ratio. We introduce a zone based Virtual Isometric Structure (VIS). Virtual architectures are used without need of maintaining state information.

The AODV Routing protocol uses an on-demand approach for finding routes that is a route is established only when it is required by a source node for transmitting data packets. It employs destination sequence numbers to identify the most recent path. AODV offers quick adaptation to dynamic link conditions, low processing and memory overhead, low memory utilization and determines unicast routes to destinations within Ad-Hoc network. The message types defined by the AODV protocol are Route Requests (RREQs), Route Replies (RREPs) and Route Errors (RERRs). However, in AODV, the source node and the intermediate nodes store the next-hop information corresponding to each flow for data packet transmission. Neighbors receive the RREQ message the nodes have two choices; if they know a route to the destination or if they are the destination they can send a RREP message back to node 1, otherwise, the nodes will rebroadcast the RREQ to their set of Neighbors. The message keeps getting rebroadcasted until its lifespan is up. If Node 1 does not receive a reply in a set amount of time, it will rebroadcast the request except at this time the RREQ message will have a longer lifespan and a new ID number. In AODV, the network is silent until a connection is required. The network node that needs a connection broadcasts a request for connection. Other AODV nodes forward this message and record the node that they received it from, creating an explosion of temporary routes back to the node which requires the connection. This node then begins using the route that has the least number of hops through other nodes. Unused entries in the routing tables are recycled after a time. In AODV the network is silent until a connection is needed. AODV requires more time to establish a connection and initial communication to establish a route is heavier.

The ODMRP (Lee *et al*., 2000; Junhai *et al*., 2008, 2009; Lee *et al*., 2002) has a problem of excessive flooding when number of multicast senders is more. In wireless networking, ODMRP is a protocol for routing multicast and unicast traffic throughout Ad hoc wireless mesh networks. The ODMRP creates routes on demand, rather than proactively creating routes. This suffers from a route acquisition delay. The delivery ratios of ODMRP drop significantly when there is a large number of groups in the network or when the network size is large.

RSGM Stands for Robust and Scalable Geographic Multicast Protocol. RSGM is used in the mobile Ad-Hoc network area. It can scale to a large group size and network size and provide robust multicast packet transmissions in a dynamic environment. RSGM uses more efficient zone-based structure to allow nodes to quickly join and leave the group. Additionally, RSGM introduces Source Home to facilitate quick source discovery and avoid network wide, flooding of source information. The RSGM does not use any periodic network-wide, flooding and uses stateless virtual-tree-based structures for control and data transmissions. The RSGM supports a two-tier membership management and forwarding structure. At the lower tier, a zone structure is built based on position information and a leader is elected on demand when a zone has group members. A leader manages the group membership and collects the positions of the member nodes in its zone. At the upper tier, the leaders of the member zones report the zone membership to the sources directly along a virtual reverse-tree based structure. If a leader is unaware of the position or addresses of the source, it could obtain the information from the Source Home. With the knowledge of the member zones, a source forwards data packets to the zones that have group members along the virtual tree rooted at the source. After the packets arrive at a member zone, the leader of the zone will further forward the packets to the local members in the zone along the virtual tree rooted at the leader. In RSGM, 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. Virtual zones are used as references for the nodes to find their zone positions in the network domain. In Receiver Based Multicast protocol (RBMP) destination nodes are considered as stationary. This created a problem of breaking the links between sources to destination.

MATERIALS AND METHODS

Scalable Receiver Based Multicast (SRBM) protocol overview: SRBM is a stateless multicast routing protocol which significantly reduces the tree or mesh management overhead, it is more efficient, robust and a dynamic protocol. Under all the circumstances like node densities, zone size, network size and various speed of nodes gives higher packet delivery ratio. Tree based multicast is a very well established concept in wired networks. But, Tree based is not an effective one in the MANET's, since the network topology keeps on changing which is difficult to maintain if there is mobile node and breakage in link. Also, the network is vulnerable as it is wholly dependent on the central hub. If the network become extremely large it becomes difficult to manage. Thus in contrast to a tree- based approach, mesh based multicast protocols may have multiple path between any source and the destination pair but it is not suitable for MANET's, since there is chance for change in topology, for any node failures and the member of the group may change. In SRBM the network size can be scaled to larger size, during packet transfer in dynamic mobile network. Thus in this protocol, we are making use of virtual isometric structure. It overcomes the disadvantages of mesh and tree networks where in mesh based the total cost of the network is very high and set up and maintenance is very difficult. Virtual architectures are used without need of maintaining state information which is easier to maintain and to implement. In order to obtain higher efficiency hybrid protocols such as ZRP was introduced. Current zone based multicast routing protocols in MANET are based on number of nodes, geographical area, hops count, gateway nodes and clusters. SRBM is scalable to large group size, network size and it provides optimal path. In SRBM, the network's minimum traffic load does not increase faster than the network rate. Compared to exiting protocols ODMRP, RSGM and AODV, SRBM gives minimum end to end path length delay, minimum control overhead and high packet delivery ratio. SRBM is a stateless multicast routing protocol significantly reduces the tree or mesh management overhead, more efficient, robust and a dynamic protocol under all the circumstances like node densities, zone size, network size and various speed of nodes gives higher packet delivery ratio. A robust virtual isometric structure is used in packet forwarding with the help of node positions. We introduce the zone based protocol for the efficient handling of the members of the group and also take the advantage of tracking the locations of group members. The zone structure is also formed virtually and thus the zone where a node is located can be calculated based on the node position and its reference origin. Hence, like others in VIS, there is no need to involve the complicated structure which is hard to create and maintain.

Zone constructions and maintenance: The SRBM is based on group management and consists of upper zone and lower zone, where different zones are created in both tier based on position information. Each tier has its own leader to manage the group and share information to source directly via VIS tree structure. At upper tier, the leader of member zones sends report to source. Both in upper and lower tier the leaders should keep track of nodes entering and leaving the network. This is how group management is done by leaders in upper and lower tier. SRBM makes use of threshold value, hence by using the ABC algorithm if the number of nodes in a network increases above the threshold value; the zone is split into two halves. Since the zone is divided with the increase in network size (number of nodes), the transmission of packets from source to destination is made easier and the end to end delivery ratio is reduced. SRBM makes use of VIS structure which reduces the time delay and forwarding bandwidth.

In SRBM, the source sends RREQ (Route Request) signal to the leader, then the leader receives information regarding the routes to multiple destinations and its schedule regarding routing. Once the route to specified destination is free, the leader sends ACK (acknowledgment) to the source. The source, then sends the packets to the multicast module and from that module the packets are transmitted to various destinations. Since, the packets are transmitted in virtual isometric form the end to end delay is reduced .Virtual architectures are used without need of maintaining state information. In SRBM the packets are transmitted with greater speed and reduced control overhead in an optimal continuous path.

Zone construction: In SBRM, the zone structure is virtual and calculated based on the reference point. Therefore the construction of the zone structure does not depend on the shape of the network region and it is very simple to locate and maintain the zone. Thus, to manage the group zone members elects its leader. We use virtual zones as references for the nodes to find the zone position in the network domain.

$$\left.\begin{aligned} a &= [\, x - x_0/\text{zonesize} \,] \\ b &= [\, y - y_0/\text{zonesize} \,] \end{aligned}\right\} \quad (1)$$

Where (x_0, y_0) is the position of the virtual origin. The length of a side of a zone square is defined as zone size. For simplicity, we assume the entire zone IDs is positive. The zID will also help locate a zone. In our scheme, a packet destined to a zone will be forwarded towards its center. The center position (x_0, y_0) of a zone with zID (a,b) can be calculated as shown in Eq. 1 and 2:

$$\left.\begin{aligned} x_c &= x_0 + (a + 0.5) \times \text{zonesize} \\ y_c &= y_0 + (b + 0.5) \times \text{zonesize} \end{aligned}\right\} \quad (2)$$

Leader election: A zone leader is elected through the cooperation of nodes and maintained consistently in a zone, a leader will be elected in a zone only when the zone has group members in it to avoid unnecessary management problems. It shows a node appears in the network, it sends out a beacon announcing its existence. It waits for an Intval_{max} period for the beacons from other nodes. Every Intval_{max} a node will check its neighbor table and determine its zone leader under different cases:

- The neighbor table contains no other node in the same zone; it will announce itself as a leader, i.e. Let us assume a multicast group member M which moves to a new zone if the zone leader is unknown, hence, M queries the neighbor node in the zone for the leader. If it fails to get the leader information then, M will announce itself as leader by flooding leader message into the zone
- The flags of all the nodes in the same zone are unset, its 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
- About >1 node in the same zone have their leader flags set, the one with the highest node ID is elected, i.e. In case two leaders in same zone which may be due to slight difference of leader queries and announcement. In this case, the leader with large ID will be elected as leader
- Only one of the nodes in the zone has its flag set and then the node with the flag set is the leader

A zone leader floods a LEADER in its zone every time interval $\text{Intval}_{refresh}$ to announce its leadership until that zone becomes empty with no members. M (Member) needs to send REFRESH message to its zone leader in equal time intervals $\text{Intval}_{refresh}$ which is used to update its position and membership information. A membership record will be removed by the leader itself if its fail to update its position and membership information within $2\times\text{Intval}_{refresh}$. When, M moves to a new zone its REFRESH message will be sent to the leader of new zone. It will announce itself as a leader of the new zone if there is no leader. Hence, by the Baye's theorem and its conditional probability the leaders of the zone are elected using Eq. 3:

$$P(A/B) = [P(B/A)P(A)]/P(B) \quad (3)$$

Management of group members: The group membership is first clustered in the local zone and is managed by its own zone leader while a member M joining or leaving the group sends a message as REFRESH along with its group ID represents the addresses of the group where the member M is present and Pos_M is the position of the member in zones. After the aggregation of the zone member's information, it is the duty of the source to track the ID's of the group members in its zone.

Handling of empty zone: A zone may become empty when all the nodes move away. When a member zone of the group G is becoming empty , the leader moving out of the zone must notify S to immediately stop the sending of the data packets to the empty zone. In case if the moving out leader fails to notify S about the empty zone which may happen if the leader dies suddenly without passing the information about the empty zone, in these cases the packet forwarded to the empty zone will finally dropped without being delivered.

Zone Routing Protocol (ZRP): Routing protocols for mobile ad-hoc networks have to face the challenge of frequently changing topology, low transmission power and asymmetric links. Both proactive and reactive routing protocols prove to be inefficient under these circumstances. Proactive routing uses excess bandwidth to maintain routing information while reactive routing involves long route request delays. Reactive routing also inefficiently floods the entire network for route determination. The Zone Routing Protocol (ZRP) combines the advantages of the proactive and reactive approaches by maintaining an up-to-date topological map of a zone centered on each node. Within the zone, routes are immediately available. For destinations outside the zone, ZRP employs a route discovery procedure which can benefit from the local routing information of the zones. ZRP exploits the characteristics of both proactive and reactive protocol. For routing across the network, the reactive part of the protocol is used. This is where, it is different from the proactive part which has its existence limited to a relatively smaller area of the node. So this number of control messages as well.

Thus, ZRP reduces the control overhead for longer routes that would be necessary if using proactive routing protocols throughout the entire route while eliminating the delays for routing within a zone that would be caused by the route discovery processes of reactive routing protocols.

Route maintenance: Route maintenance is especially important in ad-hoc networks, where links are broken and established as nodes move relatively to each other with limited radio coverage. In purely reactive routing protocols, routes containing broken links fail and a new route discovery or route repair must be performed. Until, the new route is available, packets are dropped or delayed. In ZRP, the knowledge of the local topology can be used for route maintenance. Link failures and sub-optimal route segments within one zone can be bypassed. Incoming packets can be directed around the broken link through an active multi-hop path. Similarly, the topology can be used to shorten routes, for example, when two nodes have moved within each other's radio coverage, for source-routed packets, a relaying node can determine the closest route to the destination that is also a neighbor. Sometimes, a multi-hop segment can be replaced by a single hop. If next-hop forwarding is used, the nodes can make locally optimal decisions by selecting a shorter path.

Artificial Bee Colony (ABC) algorithm: If the number of nodes increases above the threshold value in the network then SRBM uses the ABC algorithm to split the zones into two halves. After the zone division, the transmission of packets from source to destination is made easier and have reduced end to end delivery ratio.

RESULTS AND DISCUSSION

Step 1: In ABC algorithm first, we have to initialize the parameters shown in Table 1. In ABC algorithm the Bees denote the number nodes. Once the Onlooker Bees (leader) finds the nectar by the waggle dance it gives information to other Bees and based upon the fitness of the Bee nectar will be collected.

In SRBM, the source node sends request to the leader, the leader then collects information regarding the routes and finds the best route to send the packet to the different members. The leader then sends ACK to the source node, that the route is free and the packets can be transmitted. The leader keeps track of the nodes entering and leaving the zone.

Table 1: Parameters and its description

Parameters	Description
N	No. of employed bees (nodes)
0.1×n	No. of scout bees
M	No. of onlooker bees (m>n)
Iteration	Maximum iteration number
α_j	Initial value of penalty parameter for jth agent
EC length	Length of ejection chain neighborhood

Step 2: Then, we have to construct initial employed Bee colony solutions by using Greedy Randomized Adaptive search Heuristic (GRAH).

Step 3: Using Eq. 4, we evaluate fitness value for each bee. Fitness function for minimization

$$\sum_{j=1}^{m}\sum_{i=1}^{n} c_{ij}x_{ij} + \alpha\sum_{j=1}^{m}\max\left\{0, \sum_{i=1}^{n} b_{ij}x_{ij} - a_j\right\} \tag{4}$$

Step 4: Initially I = 0.

Step 5: Repeat.

Step 6: Initially N=0

Step 7: Repeat

- Apply shift neighborhood (this type of neighbor is obtained from original solution by changing the agent assignment of one task)
- Apply double shift neighborhood (this neighborhood structure is the special case of the long chain neighborhood. Since, the two shift move are performed in double shift this is the (EC-length = 2) state of the long chain)
- Then, calculate probabilities related to fitness value
- Assign Onlookers Bees to Employed Bees according to probabilities as in Eq. 5:

$$p_i = \frac{\sum\left(\frac{1}{fit}\right)^{-1}}{fit_i} \text{ for minimization} \tag{5}$$

- For all onlooker bees:
  - Ejection-chain neighborhood
  - N_i= Number of Onlooker Bees sent to ith sites (P_i*m)
  - O_{ij}, jth Onlooker Bee of ith solution (j = 1, 2, 3, ..., N_i)
  - $\{O_{i1}, O_{i2}, ..., O_{iNi}\}$ = Ejection chain (σ^i)

- Find best onlooker bees replace with respective employed bee
  - If fit (Best onlooker)<fit (Employed)
  - If the amount of nectar increases, the research of collecting the nectar is divided between various Bees and in this way the nectar will be transferred to its hive. Once, the nectar is fully used by the bees, again the bees will continue to find new nectar

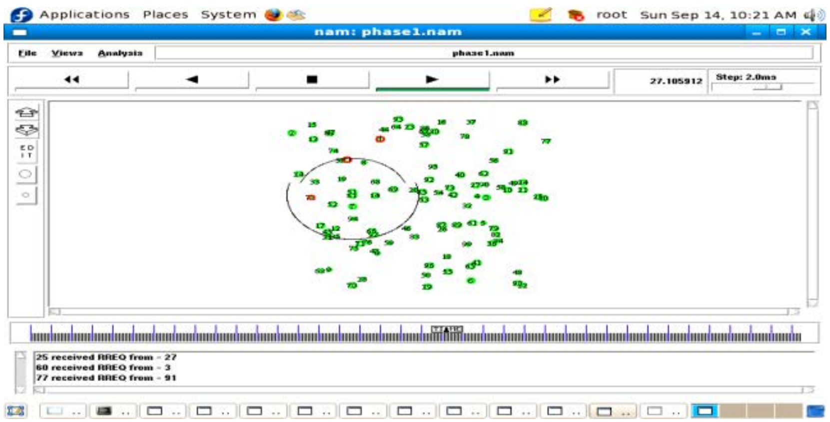

Fig. 1: Node formation

If the number of node increases the above the threshold value, the zone get split to two halves for quick transmission of data packets as the other bees splits its work among various Bees.

If (min (fit(Oij)<fit (σ^i)) then (σ^i = Oij)

- Find best feasible Onlooker, replace with best solution
  - If fit (Best feasible Onlooker) <fit (Best)
  - If fit (best $_{cycle-1}$)>min (fit (σ^i)) I = 1, 2, ..., n, then best $_{cycle}$ = σ^i
  - Else best $_{cycle}$= best $_{cycle-1}$
  - ntil (i = 1)
- N = N+1.

Step 8: Until (N = Employed bee)

Initialize scout bees with GRAH algorithm; if the scout solution is better than the employed solution, employed solution is replaced with Scout solution. Else employed solution is transferred to the next cycle without any change

Step 9: I = I+1; Cycle = Cycle+1

Step 10: Until (I = Max iteration); cycle = Iteration

Thus, in ABC algorithm the position of a food source represents a possible solution to the optimization problem and the nectar amount of a food source corresponds to the quality of the associated solution. In SRBM the packets are transmitted with greater speed and less delay.

Performance evaluation: The performance of SRBM by simulations is shown below. The main concept is scalability and robustness in a dynamic environment. We evaluate and compare the performance of SRBM with RSGM, AODV and ODMRP. This Performance is simulated using NS-2 software. Continuous and efficient path is obtained and the data is transmitted without any delay and with very high delivery ratio. Results show that SRBM has a high success rate packet delivery ratio, low latency when compared with AODV, RSGM and ODMRP protocols. Results show that SRBM performs better than all the other existing protocol. This principle states that multicast routing from source to destination is efficient, continuous and has a high packet delivery ratio. Figure 1 shows the node formation. In this Fig. 1, >90 nodes are formed to compare the performance of different protocols.

Average packet delay: It is sum of the times taken by the successful data packets to travel from their sources to destination divided by the total number of successful. The average packet delay is measured in seconds. In Fig. 2 shows the comparison of four different protocols using NS-2 simulator. Figure 2 shows that average delay of SRBM is less when compared to other protocol.

Routing overhead: This metric describes how many routing packets for route discovery and route maintenance need to be sent so as to propagate the data packets. In Fig. 3, SRBM there is no need to maintain state information the routing overhead is reduced in SRBM when compared to other protocol.

Throughput: This metrics represents the total number of bits forwarded to higher layers per second. It is measured in bps. It is the ratio of the total amount of data that reaches a receiver from a sender to the time it takes for the receiver to get the last packet. When comparing the

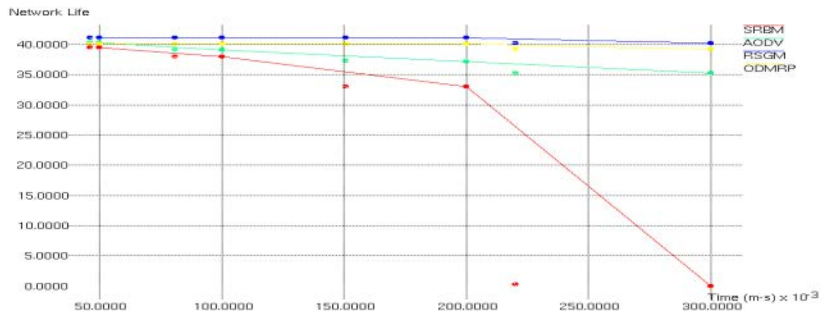

Fig. 2: Average delay

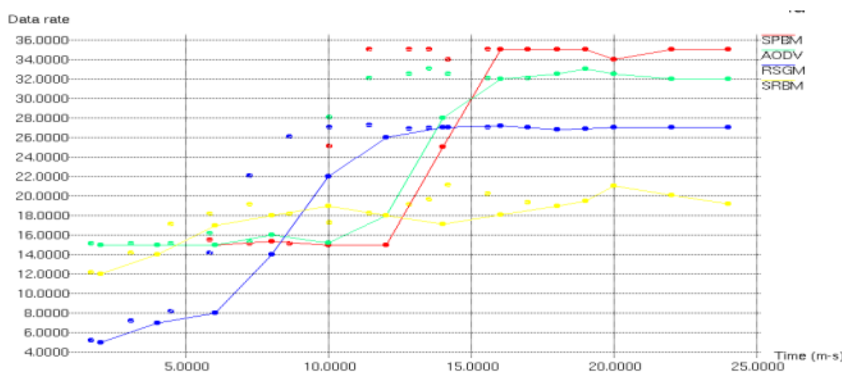

Fig. 3: Routing load

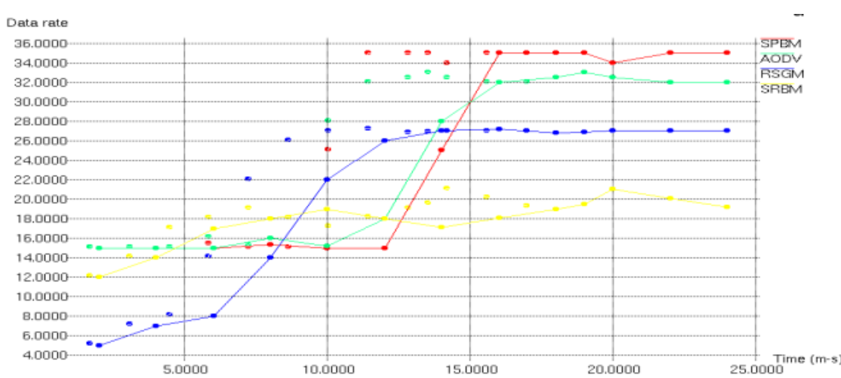

Fig. 4: Average throughput

routing throughput by each of the protocols, SRBM has the high throughput. The throughput value of AODV slowly increases initially and maintains its value when the time increases.

In Fig. 4, the throughput value of SRBM increases at lower pause time and grows as the time increases. Hence, SRBM shows better performance with respect to throughput among these three protocols. Figure 4 shows that the throughput of SRBM increases with time.

Energy consumption: It is the ratio of total network energy consumption to the number of data packet successfully delivered to destination. In Fig. 5 shows that the energy consumption during the transmission is reduced in SRBM when compared to other protocol.

Average node density: The node density impacts routing evaluations since it determines, together with the mobility model, how many neighbors a node has. Figure 6 shows the average node density of SRBM is reduced when compared to other protocol.

Control overhead: This is one of a primary factor, total number of control packets needed to establish a stable

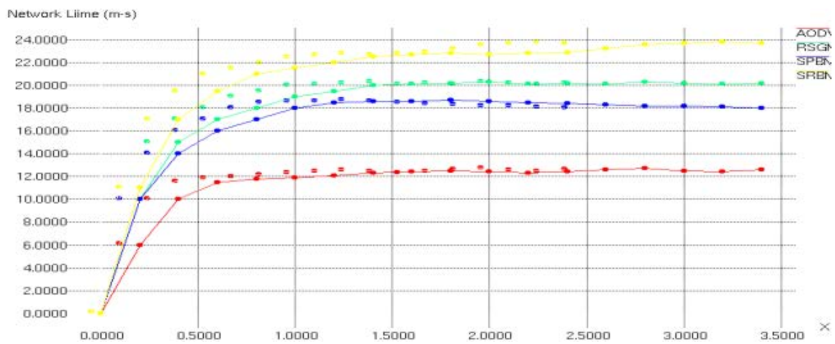

Fig. 5: Energy efficient

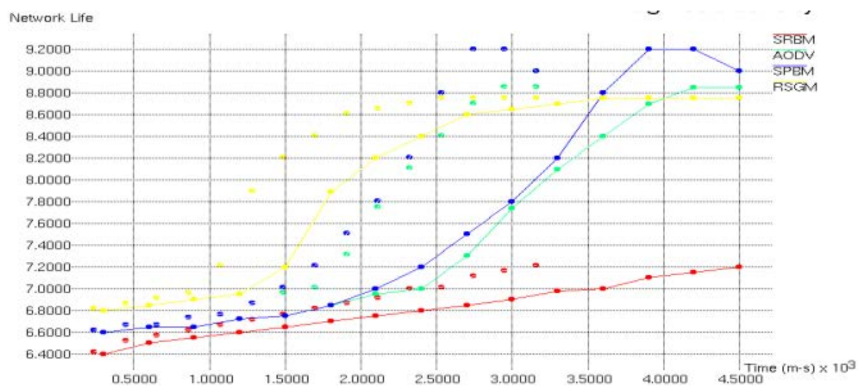

Fig. 6: Average node density

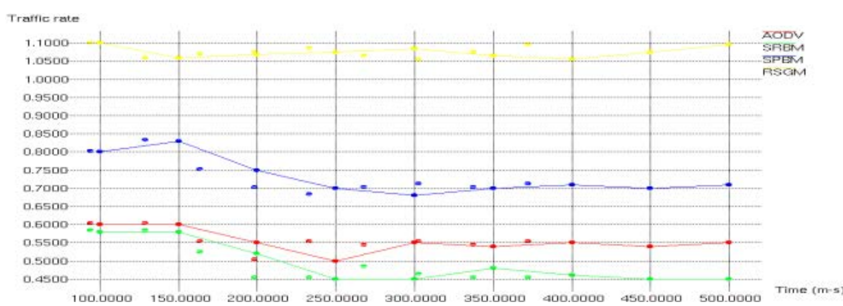

Fig. 7: Control overhead

route from source to the multicast receiver. In Fig. 7, the control overhead of SRBM is improved using this bee algorithm when compared to other protocol.

Average end-to-end delay: End-to-end delay or one-way delay refers to the time taken for a packet to be transmitted across a network from source to destination. The packet end-to-end delay is the average time that a packet takes to traverse the network.

Figure 8 shows that the End to End delay of SRBM is reduced when compared to other protocol using VIS structure. This is the time from the generation of the packet in the sender up to its reception at the destination's application layer and it is measured in seconds. It therefore, includes all the delays in the network such as buffer queues, transmission time and delays induced by routing activities. Average end-to-end delay is the delay experienced by the successfully delivered packets in reaching their destinations. This is a good metric for comparing protocols. This denotes how efficient the underlying routing algorithm is, because delay primarily depends on optimality of path chosen.

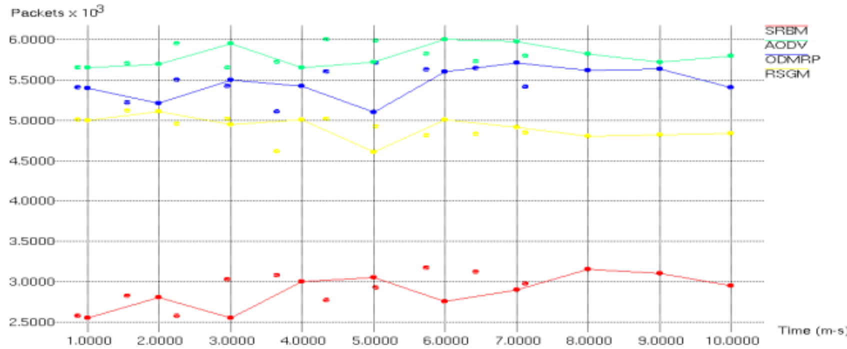

Fig. 8: End to end delay

CONCLUSION

Current multicast protocols generally rely on various trees or mesh structures and hence intermediate nodes need to maintain their states. In this study, the performance of the 3 MANET routing protocols such as AODV, RSGM and ODMRP was analyzed using NS-2 Simulator along with SRBM. We have simulation results of average end-to-end delay, throughput and packet delivery ratio over the routing protocols SRBM, AODV, RSGM and ODMRP. Comparing SRBM, AODV, RSGM and ODMRP protocol, byte overhead in each packet will increase whenever network topology changes but in SRBM due to Virtual Isometric Structure there is no need to maintain state information, hence control overhead is reduced. Hence by using VIS there is no need to maintain the state information which results in long battery life. Also, the data sent will be always reliable. By using the ABC algorithm in SRBM, where the number of node increases above the threshold value, the zone get split to two halves for quick transmission of data packets as the Bees splits its work among various Bees. As AODV routing protocol needs to find route on demand, End-to-End delay will be higher than other protocols. SRBM produces low end-to-end delay compared to other protocols. When the network load is low, AODV performs better in case of packet delivery ratio but it performs badly in terms of average End-to-End delay and throughput. Overall, SRBM outperforms AODV because it has less routing overhead when nodes have high mobility.

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