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Multicasting in MANET's Through Scalable Mobility-Aware Virtual Tree based Geographic routing protocol

[1]B. V. V. S. Prasad, M.C.A., M.Tech., (Ph.D) is a research scholar in Pacific University,
[2]Dr.G.Manoj Someswar, B.Tech., M.S.(USA), M.C.A., Ph.D.

Abstract: Mobile ad-hoc networks became a popular subject for research in recent years, and various studies have been made to increase the performance of ad hoc networks and support more advanced mobile computing and applications. Multicasting is an useful operation that facilitates group communications in MANETs. The key problems of the existed mobile computing applications are multicast group membership management, zone construction and efficient forwarding of packets to all the group members over the dynamic network topology for a large group size or network size. To overcome the above problems in this paper we proposed a new Scalable Virtual structures based Geographic Multicasting (SVGM) protocol. A perfect two-tier virtual zone system and GPS information is used to maintain the multicast group membership management and virtual tree like efficient paths are used to forward the multicast data packets to all the group members in a MANET. Our simulation results demonstrate that SVGM has high packet delivery ratio, low control overhead and multicast group joining delay under all test scenarios, and is scalable to both group size and network size.

Keywords: SVGM protocol, Multicasting, Virtual trees, GPS systems, Routing Protocols

1. INTRODUCTION

A mobile ad hoc network is a collection of wireless nodes that can dynamically be set up anywhere and anytime without using any pre-existing network infrastructure. It is an autonomous system in which mobile hosts connected by wireless links are free to move randomly and often act as routers at the same time. The traffic types in ad hoc networks are quite different from those in an infrastructure wireless network. Due to its popularity and wide advantages MANET are applied to different applications including battlefield communications, emergency relief scenarios, law enforcement, public meeting, virtual class room and other security-sensitive computing environments. Multicasting is a powerful scenario in MANET's environment. The design of the multicast scheme in MANET is more complex because of the dynamic change in the network topology and the limited bandwidth availability. Previous researches designed some ad hoc network routing protocols LAM [3], MZRP [5] and ODMRP[6] are to enable the membership management and transport of data packets from one point to another. But all of these protocols can have their own inherent limitations due the nodes dynamism, increasing group members and maintaining the complex group structure. Another main challenge in MANET is to design the robust security solution that can protect MANET from various routing attacks.

In order to address the issues in multicasting over MANETs, we propose a Scalable Virtual structures based Geographic Multicasting (SVGM) Protocol, which can extent to a large group size and large network size and this Protocol will provide efficient multicast packet transmissions in a dynamic mobile ad hoc network environment. In SVGM protocol, there is no need of maintaining state information at each network node for robust and scalable packet transmission in dynamic environment. We introduce several virtual architectures for more robust and scalable membership management and packet forwarding in the presence of high network dynamics due to unstable wireless channels and frequent node movements. Both the data packets and control messages will be transmitted along efficient tree-like paths, however, different from other tree-based protocols, there is no need to explicitly create and maintain a tree structure. A virtual-tree structure can be formed during packet forwarding with the guidance of node positions. Furthermore, SVGMP makes use of position information (GPS) to support reliable packet forwarding. The main intension of SVGMP is to improve the performance of the network and also SVGMP achieves a significantly higher data packet delivery ratio.

2. LITERATURE WORK

In order to support more reliable and scalable communications, recently several conventional location-based multicasting protocols are introduced in MANET. In this section we present and classify existing multicast routing protocol for MANETs. A brief overview of a few existing multicast protocols that are relevant to our work is provided. Conventional topology-based multicast protocols include tree-based protocols (e.g., [3],[5]]) and mesh-based protocols (e.g., [4], [6]). Tree-based protocols construct a tree structures for more efficient forwarding of packets to

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all the group members. Mesh-based protocols expand a multicast tree with additional paths that can be used to forward multicast data packets when some of the links break. The tree-based protocols construct a tree structure for more efficient multicast packet delivery, and the tree structure is known for its efficiency in utilizing network resources. 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.

The mesh-based protocols are proposed to enhance the robustness with the use of redundant paths between the source and the set of multicast group members, which incurs a higher forwarding overhead. There is a big challenge to support reliable and scalable multicast in a MANET with these topology-based schemes, as it is difficult to manage group membership, find and maintain multicast paths with constant network topology changes. A topology-based multicast protocol generally has the following three inherent components that make them difficult to scale: Group membership management, Creation and maintenance of a tree or mesh-based multicast structure, Multicast packet forwarding. Besides the three components included in conventional topology-based multicast protocols, a geographic multicast protocol also requires a location service to obtain the positions of the members. The geographic multicast protocols presented in [7] and [2] need to put the information of the entire tree. The Position Based Multicast Protocol [8] which uses the geographic position of the nodes to make forwarding decisions. PBM neither requires the maintenance of a distribution structure nor resorts to flooding. The Location-Guided Tree [4] is applicable for small communication group. In this protocol an upper overlay packet delivery tree is created on top of the underlying unicast protocol.

3. SVGM PROTOCOL

3.1 Overview of SVGM Protocol

SVGM supports scalable and reliable membership management and multicast packet forwarding through a two-tier virtual zone- based structure. First the entire network region is divided into zones based on the GPS information. Each zone will act as a separate environment to maintain the mobile nodes structure. These zones are arranged at lower level of two tier architecture and managed by the zone leader. Zone Leader maintains the local group membership (node position, group id) efficiently. At the upper tier, the leaders of the member zones(zone which contain the group members) 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. 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, and packet forwarding. The zone-based tree is shared for all the multicast sources of a group.

3.2 Virtual Zone Construction and Leader election

In SVGM first we can divide the entire network region into the virtual zones based on the network reference point. The constructed zones are shape independent and managed by the zone leaders. These virtual zones are used as references for the nodes to find their zone positions in the network region. The zone is set relative to a virtual origin located at (x_o,y_o) which is set at the network initialization stage as one of the network parameters. The length of a side of the zone square is defined as zone size. Each zone is identified by a zone ID (zID). These zone IDs are useful to locate a zone in network region and to forward the data packets to the destination points (multicast member nodes).

To maintain the zone and its contained group members information we need a node that is called as a zone leader (ZLdr).This zone leader is any member node to maintain the other members information of that zone. At lower level of out protocol zone leader will maintain the communication with source home of upper layer. In this protocol we are not maintaining the neighbor node information at each node due to its maintenance overhead problem. Each node is equipped with the node GroupId, zId, ZLdr info and its current location information through the in-built GPS information system. When a node n_1 wants to join to a zone z_1, it will enquires the neighbor about the zone leader. Neighbor node will gives the ZLdr information to node n_1.Now at a certain refresh interval time n_1 will forwards the joining request along with GroupID and the positional information to ZLdr to maintain the n_1 information at leader. If there is no ZLdr found in that zone then n_1 as itself announced as a ZLdr and spread that information to all other nodes in that zone at next interval time. This will overcome the empty-zone

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problem which is a problem in previous works. ZLdr contained information can be updated at each refresh interval time to maintain the node joining and leavings information up-to-date.

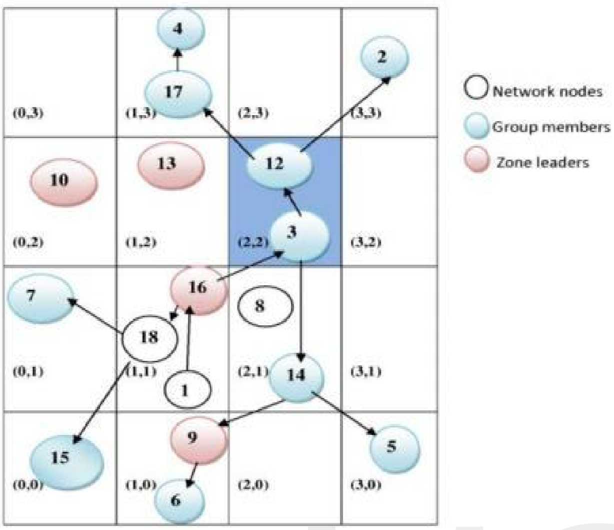

Figure 1. Zone structure

3.3 Efficient Membership management at two layers

In SVGM protocol group membership is managed at two tiers. At first level the local group members are efficiently managed by the zone leader. SVGM takes advantage of the virtual-zone-based structure to efficiently track the group membership and member positions. In order to maintain the nodes information at zone level we can use the multicast group (G), Data Source(S) and group member variable (M).

1)Low(Zone) level membership management: The group membership is first aggregated in the local zone and managed by the zone leader. All the mobile nodes can have the mobility nature, so they can frequently change from one location to another. Due to this reason maintaining the membership became complex for previous protocols. In SVGM the nodes when they have to join to or leave from a group they will send a message to the zone leader. All the member nodes will sends its Group id, position, flag information to zone leader at each refresh interval time to maintain the updated nodes data and to handle the dynamic changes in group membership. For example if a node N_1 has to move from zone Z_1 to Z_2 first it will sends a leave request to the zone leader of Z_1 and a join request to zone leader of Z_2 at a certain refresh time. Then it initiates the changing from zone Z_1 to zone Z_2. Suppose the zone leader is unable to receive the leave request it will never create the problem, because A member record will be automatically removed by the zone leader if not refreshed within 2 refresh intervals.

2) Higher (network) level Membership management: At higher level of this protocol layer all the member zones information is used by sources to initiate the multicast packets to the destination nodes. Zone leader is the responsible node to track all the member nodes information in that zone and sending that information to sources. When the source has to transfer the multicast data then it will consider all the zones and tracks the ID's of the member zones that have multicast group members. When a zone changes from a member zone to a non-member zone of G or vice versa, the zone leader sends a REPORT message immediately to Source to notify the change. Zone leader obtains the source information from Source Home, which is one of the zone in network region to maintain all the sources information. Like zone members, Zone leader sends the zone members information to the source at each refresh interval time. This process remains the zone information at source up-to-date. In the case that S is the source of more than one multicast group, instead of sending a REPORT to S for each group, the leader sends one REPORT carrying all corresponding group IDs. If any zone leader is fail to send the zone information to source after 2 continuous intervals the zone information is removed by the zone leader. This process will overcome the empty zone and zone checking problems.

3.4 Scalable Packet forwarding through virtual tree like paths

A source needs to send the multicast packets reliably to the group members. With the membership management, the member zones are recorded by source S, while the local group members and their positions are recorded by the zone leaders. Multicast packets will be sent along a virtual distribution tree from the source to the member zones, and then along a virtual distribution tree from the zone leader to the group members. A virtual distribution tree is formulated during transmission time and guided by the destination positions. The multicast packets are first delivered by S to member zones towards their zone centers. S sends a multicast packet to all the member zones, and to the member nodes in its own zone through the zone leader. In our 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 (D1; D2; D3; :), it decides the next hop node towards each destination using

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the geographic forwarding strategy. After deciding the next hop nodes, N inserts the list of next hop nodes. and the destinations associated with each next hop node in the packet header. An example list is (N1: D1; D3; N2: D2; :), where N1 is the next hop node for the destinations D1 and D3, and N2 is the next hop node for D2. Then N broadcasts 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. For example, in fig. 1, after node 3 receives the packet from zone (1, 1) it will forward the packet to downstream zones (2.1), (1, 3) and (3, 3). It determines the next hop node for destination and insert the list (12: (1, 3), (3, 3); 14: (2, 1)) in the packet header. After broadcasting the packet its one-hop node 12, 14 and node 8 will drop this packet, while node 12 and 14 will continue forwarding. Node 12 replaces the list carried in the packet header with (17: (1, 3); 2: (3, 3)) and broadcast the packet. Node 14 finds group information from its multicast table and broadcast the packet with a header (9: (1, 0); 5: (3, 0)). Only one copy needs to be sent when packets for different destinations share the same next hop node. Thus the packets are forwarded along a tree-like path without the need of building and maintaining the tree in advance. For robust transmissions, geographic unicast is used in packet forwarding. The packets can also be sent through broadcast to further reduce forwarding bandwidth, at the cost of reliability.

4. PERFORMANCE EVALUATION

In this section, we study the performance of SVGP by simulations. We are mainly interested in the protocol's scalability and efficiency in a dynamic environment. We implemented the SVGP protocol using NS2 Simulation. A multicast source broadcasts Join-Query messages to the entire network periodically. We focus on the packet delivery ration and normalized control overhead to present the effectiveness of a protocol, on the average hop count and the unicasting delay to prove the virtual tree paths cost value, and on the normalized forwarding overhead to express the data traffic load on the network.

We first examine the message delivery ratio from source to each node that runs with SVGM protocol propagation model. Then later we concentrated on the packet delivery ratio results between the various protocols like AODV, MAODV, ODRMP, and SVGM. The above results in fig 2 shows that at average SVGM protocol can have the best packet delivery ratio among all other previous protocols and it is easy implement, maintain and less overhead problem.

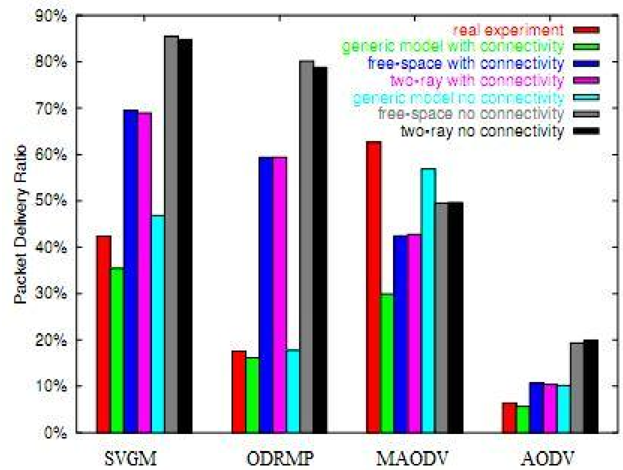

Fig.2. Simulation results of various protocol packet delivery ratio.

5. CONCLUSION

In this paper, we propose an efficient and scalable geographic multicast protocol, SVGM, for MANET. The scalability of SVGM is achieved through a two-tier virtual-zone-based structure, which takes advantage of the geometric information to greatly simplify the zone management and packet forwarding. A zone-based bidirectional multicast tree is built at the upper tier for more efficient multicast membership management and data delivery, while the intra zone management is performed at the lower tier to realize the local membership management. The position information is used in the protocol to guide the zone structure building, multicast tree construction, maintenance, and multicast packet forwarding. Compared to conventional topology based multicast protocols, the use of location information in SVGM significantly reduces the tree construction and maintenance overhead, and enables quicker tree structure adaptation to the network topology change.

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8. Authors

Author 1:

B. V. V. S. Prasad (Ph.D) is a Research Scholar in Pacific Academy of Higher Education and Research University under the Guidance of Dr.G.Manoj Someswar, and completed M.Tech in Computer Science & Engineering. He is presently working as an Asst. Prof. in Malineni Lakshmaiah Women's Engineering College, Pulladigunta, Guntur, India. He is having about 5years of teaching experience in different Engineering Colleges and an associate member of CSI and life member of ISTE, Member in IEEE. Undergone CIT program conducted by IIIT Hyderabad and published more than 5 international journals in the area of Data Mining and Image Processing and Present one international conference on Fuzzy logic in IRNET. Recently attended a National Seminar conducted by GITAM University Vizag, on Cloud Computing.Mail id: vvsprasad.author@gmail.com.

Author 2:

Dr. G. Manoj Someswar, B.Tech., M.S.(USA), M.C.A., Ph.D. is having 20+ years of relevant work experience in Academics, Teaching, Industry, Research and Software Development. At present, he is working as PRINCIPAL and Professor CSE Department Anwarul-uloom College of Engineering & Technology, Yennepally, Vikarabad - 501101, RR Dist., A.P., and utilizing his teaching skills, knowledge, experience and talent to achieve the goals and objectives of the Engineering College in the fullest perspective. He has attended more than 100 national and international conferences, seminars and workshops. He has more than 10 publications to his credit both in national and international journals. He is also having to his credit more than 50 research articles and paper presentations which are accepted in national and international conference proceedings both in India and Abroad. He received National Awards like Rajiv Gandhi Vidya Gold Medal Award for Excellence in the field of Education and Rashtriya Vidya Gaurav Gold Medal Award for Remarkable Achievements in the field of Education. He can be contacted at: manojgelli@yahoo.co.in.