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Study of Zone Based Multicast Routing Protocols in MANETs

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Abstract - ***Ad hoc wireless networks in which nodes that can move freely have become key research areas in past and continue to dominate now also. This paper introduces and classifies several protocols in the field of constructing multicast concept in ad hoc wireless networks (MANETs). Classification is performed according to several points of view such as underlying topology structure, topology maintenance approaches, initialization of multicast session, zone management and dependency on unicast routing protocols.***

Keywords: Mobile Ad hoc Networks; Multicasting; Routing Protocols; Zone; Mesh topology; Tree topology

I. INTRODUCTION

Ad hoc networks are characterized by frequent change. Nodes may join the network at any time, get disconnected as they run out of power, or alter the physical network topology by moving to a new location. Link characteristics, such as bit error rates and bandwidth, change frequently due to external factors like interference and radio propagation fading. Traffic patterns in the network can shift drastically as applications modify their behavior and redistribute load within the network. Consequently, a primary challenge in ad hoc networks is the design of routing protocols that can adapt their behavior to rapid and frequent changes at the network level.

Ad hoc routing protocols proposed to date fall between two extremes based on their mode of operation. *Proactive protocols*, such as DSDV, TBRPF, and OLSR, exchange routing information periodically between hosts, and constantly maintain a set of available routes for all nodes in the network. In contrast, *reactive protocols [1]*, such as AODV, DSR, and TORA, delay route discovery until a particular route is required, and propagate routing information only on demand. There are also a few hybrid protocols, such as ZRP, HARP, and ZHLS that combine proactive and reactive routing strategies. There is a fundamental trade-off between proactive dissemination and reactive discovery of routing information. While proactive protocols can provide good reliability and low latency through frequent dissemination of routing information, they entail high overhead and scale poorly with increasing numbers of participating nodes. In contrast, reactive protocols, can achieve low routing overhead, but may suffer from increased latency due to on-demand route discovery and route maintenance. Since the characteristics of a practical network vary dynamically with time, choosing an appropriate routing protocol is an important design and implementation decision [1].

II.MULTICAST ROUTING PROTOCOLS.

A. *Zone Routing Protocol (ZRP)*

The Zone Routing Protocol (ZRP) [4, 5] is a hybrid routing protocol for mobile ad hoc networks. The hybrid protocols are proposed to reduce the control overhead of proactive routing approaches and decrease the latency caused by route search operations in reactive routing approaches. In ZRP, the network is divided into routing zones according to distances between mobile nodes [13]. In ZRP, different routing

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approaches are exploited for inter-zone and intra-zone packets. The proactive routing approach, i.e., the Intra-zone Routing protocol (IARP), is used inside routing zones and the reactive Inter-zone Routing Protocol (IERP) is used between routing zones, respectively. The IARP maintains link state information for nodes within *d*. Therefore, if the source *A Survey of Mobile Ad Hoc Network Routing Protocols [6][13]* and destination nodes are in the same routing zone, a route can be available immediately. Most of the existing proactive routing schemes can be used as the IARP for ZRP. The IERP reactively initiates a route discovery when the source node and the destination are residing in different zones. The route discovery in IERP is similar to DSR with the exception that route requests are propagated via peripheral nodes[13].

B. Multicast Zone Routing Protocol (MZRP)

MZRP[11] is a source-initiated multicast protocol that combines reactive and proactive routing approaches. Every node has a routing zone. A proactive approach is used inside this zone and a reactive approach is used across zones. First, a source node constructs a multicast tree inside its routing zone, and then it tries to extend the tree outside the zone (the entire network)[11]. A node (which is already a multicast forwarding node for that group), wishing to join a multicast group, changes its status from multicast forwarding node to multicast group member. Any other node sends a multicast route request (*MRREQ*) message. There are two kinds of *MRREQ*, unicast or broadcast, depending on the information the source node has. If the source node has a valid route to any node on the tree and it wants to join that group, it sends a unicast *MRREQ* along the route to the multicast tree and waits for a multicast route reply, *MRREP*.

The intermediate nodes forward the unicast *MRREQ* and reverse paths are set in their multicast routing tables. When the destination receives the *MRREQ*, it sends an *MRREP*. If the unicast *MRREQ* fails or the source node does not have a valid route to that group, it initiates a bordercast [3] *MRREQ*, which is sent via the bordercast tree of the source node. When the bordercast *MRREQ* reaches the peripheral nodes, they will check whether or not they have a valid route to that multicast group or group leader. If so, they will send unicast MRREQs instead of bordercast MRREQs and wait for the MRREPs. Otherwise, bordercast MRREQs will be sent via the bordercast tree of the peripheral nodes, and so forth. Reverse paths will be established among the intermediate nodes. When a destination node receives an MRREQ for a multicast group, and if it is a multicast tree member of that multicast group, it will send an MRREP to the source and wait for the multicast route activation MRACT message from the source node to activate the new branch of the multicast tree. The MRREP is sent to the source along the reverse path.

A multicast group member wanting to leave the group will, if it is a leaf node on the multicast tree, prune itself from the tree by sending a multicast prune message *MPRUNE* toward an upstream node. The upstream node also will prune itself from the tree if it is not a group member, and becomes a leaf node. Otherwise, the pruning procedure will stop. MZRP scales well for different group sizes [3]. MZRP runs over the Zone Routing Protocol (ZRP), so the two can exchange information, which means that MZRP has less control overhead than ODMRP. One of the main drawbacks of this protocol is that a node outside a source routing zone will wait a considerable time to join the group. Compared with the Shared-Tree-based approach, MZRP creates many more states at nodes involved in many groups, each with multiple sources [3]

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C. RSGM Protocol

RSGM [2] 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. It is assumed that every node is aware of its own position. The forwarding of data packets and most control messages is based on a geographical unicast routing protocol [17]. A zone ID will help the node to locate a zone[12]. Zone leaders are elected to avoid unnecessary management overhead [17]. When a member moves in to a new zone, if the leader is unknown it floods query messages to its neighbour nodes in the zone. In case two leaders exist in a zone, e.g., due to the slight time difference of leader queries and announcements, the one with the larger ID will win and be selected as the leader [12].

A zone leader floods a LEADER message in its zone for every time interval to announce its leadership, until the zone no longer has any members. The group membership is first aggregated in the local zone and managed by the zone leader. When joining or leaving a group, a member M sends a REFRESH message immediately to its zone leader to notify its membership change. After the membership information is aggregated in the local zone, a source only needs to track the IDs of the member zones that have 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 S to notify the change. When a member zone of G is becoming empty, the moving out zone leader will notify S immediately to stop sending packets to the empty zone. If the moving out leader fails to notify S, the packet forwarded to the empty zone will finally be dropped without being delivered. In order to join or leave the multicast group, the nodes in the network need to have the source information. [2] As a source can move in a MANET, it is critical to quickly find the source.

RSGM incorporates mechanisms for session creation and efficient source discovery. With a source home, there is no need to flood the source information periodically or search for source throughout the network, which greatly reduces the management overhead and multicast group joining delay. 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 source to the member zones, then from the zone leader to the group members [2].

D. Dense Multicast Zone Routing Protocol (DMZ)

DMZ [33] based on adaptive mesh structures; it makes use of dense zone approach. A high concentration of multicast members in the specific place in the network, each dense zone has a connection to the multicast group. There are special nodes in the multicast group placed on the upper level named leader's node. This approach provides more robustness and scalability for multicast data transmission in ad-hoc networks.

E. Hybrid Ad hoc Routing Protocol (HARP)

The Hybrid Ad hoc Routing Protocol (HARP) [9] is a hybrid routing scheme, which exploits a two-level zone based hierarchical network structure. Different routing approaches are utilized in two levels, for intra-zone routing and inter-zone routing, respectively. The Distributed Dynamic Routing (DDR) [9] algorithm is exploited by HARP to provide underlying supports. In DDR, nodes periodically exchange topology messages with their neighbours.

A forest is constructed from the network topology by DDR in a distributed way. Each tree of the forest forms a zone. Therefore, the network is divided into a set of non-overlapping dynamic zones. A mobile node keeps routing information for all other nodes in the same zone [9].

The nodes belonging to different zones but are within the direct transmission range are defined as gateway nodes. Gateway nodes have the responsibility forwarding packets to neighbouring zones. In addition to routing information for nodes in the local zone, each node also maintains those of neighbouring zones. As in ZRP, the intra-zone routing of HARP relies on an existing proactive scheme and a reactive scheme is used for inter-zone communication.

Depending on whether the forwarding and the destination node are inside the same zone, the respective routing scheme will be applied.

F. Zone-based Hierarchical Link State routing (ZHLS)

The Zone-based Hierarchical Link

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State routing (ZHLS) [8] is a hybrid routing protocol. In ZHLS, mobile nodes are assumed to know their physical locations with assistance from a locating system like GPS. The network is divided into non-overlapping zones based on geographical information. ZHLS uses a hierarchical addressing scheme that contains zone ID and node ID. A node determines its zone ID according to its location and the pre-defined zone map is well known to all nodes in the network. It is assumed that a virtual link connects two zones if there exists at least one physical link between the zones. A two-level network topology structure is defined in ZHLS, the node level topology and the zone level topology. Respectively, there are two kinds of link state updates, the node level LSP (Link State Packet) and the zone level LSP. A node level LSP contains the node IDs of its neighbours in the same zone and the zone IDs of all other zones.

A node periodically broadcast its node level LSP to all other nodes in the same zone. Therefore, through periodic node level LSP exchanges, all nodes in a zone keep identical node level link state information. In ZHLS, gateway nodes broadcast the zone LSP throughout the network whenever a virtual link is broken or created. Consequently, every node knows the current zone level topology of the network. Before sending packets, a source firstly checks its intra-zone routing table. If the destination is in the same zone as the source, the routing information is already there. Otherwise, the source sends a location request to all other zones through gateway nodes. After a gateway node of the zone, in which the destination node resides, receives the location request, it replies with a location response containing the zone ID of the destination.

The zone ID and the node ID of the destination node will be specified in the header of the data packets originated from the source. During the packet forwarding procedure, intermediate nodes except nodes in the destination zone will use inter-zone routing table, and when the packet arrives the destination zone, an intra-zone routing table will be used.

III. COMPARISON OF ZRP, HARP AND ZHLS [10]

As zone based mobile ad hoc network routing protocols, ZRP, HARP and ZHLS use different zone construction methods, which have critical effect on their performance. In ZRP, the network is divided into overlapping zones according to the topology knowledge for Neighbouring nodes of each node. In HARP, the network is divided into non-overlapping zones dynamically by DDR through mapping the network topology to a forest. For each node in HARP, topology knowledge for neighbouring nodes is also needed and the zone level stability is used as a QoS parameter to select more stable route.

ZHLS assumes that each node has a location system such as GPS and the geographical information is well known, and the network is geographically divided into non-overlapping zones[10]. The performance of a zone based routing protocol is tightly related to the dynamics and size of the network and parameters for zone construction. However, because zones heavily overlap, ZRP in general will incur more overhead than ZHLS and HARP[11].

All three zone-based routing protocols presented in this subsection use proactive routing for intra-zone communication and reactive routing for inter-zone packet forwarding. Performance of a zone based routing protocol is decided by the performance of respective proactive and reactive routing protocols chosen and how they cooperate each other [7].

IV. COMPARISON OF MULTICAST ROUTING PROTOCOLS.

	ZRP	DMZ	RSGM	MZR	ZHLS	HARP
Multicast delivery structure routing	Mesh		Virtual tree structure	Multicast delivery tree		Tree
Info acquirement	Hybrid	Hybrid	Hybrid	Hybrid	Hybrid	
Maintenance loop free	Yes	Yes	Geograohic routing protocol	Zone routing protocol	Non-overlapping zone using geographical information	Yes
Control packet flooding	Yes	Yes	Source control mechanism	Querying mechanism		yes
Periodic messages requirement	Yes	Yes	Announce message	Advertisement packets	Yes	No
Routing hierarchy			Hierarchy	Hierarchical		Hierarchical
Scalibility	Fair	More	Suitable for both network & group sizes, avoids network wide flooding	Suitable for both network and group sizes		Fair

IV. CONCLUSION

This paper presents survey of multicast routing protocols designed for MANETs stating their advantages and drawbacks. A comparison of their characteristics according to several distinct feature and performance parameters. There are still many issues which have not been considered in this report In addition, the operation of each protocol is portrayed.

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