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Energy-Efficient Coverage and Prolongs Networks Lifetime of MANNET using MTMP

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Abstract: In this study we have proposed a new energy efficient routing protocol is MTMP (Mesh and Tree based Multicast Protocol). It is a combination of the routing scheme of tree and Mesh. The main mission of this protocol is minimized the Energy dissipation in Mobile Ad-hoc network. The Previous routing protocols use knowledge of past encounters to forecast future contacts, this problem is trounced by MTMP. It is established and maintain an active multicast tree surrounded by a passive mesh within a mobile ad hoc network. The multicast mesh is created by using the route discovery concept. Pruning mechanism is used to eliminate the redundancies of mesh that is created by the route discovery approach and it creates the multicast tree. The proposed protocol is achieved to efficient storage, lifetime of the node is increased to maximum. It achieves not only higher delivery rates but shorter delivery delays. The performance of the MTMP scheme is simulated over a large number of nodes in the MANET with a wide range of mobility. The efficiency of the proposed scheme is superior compare to other leading multicast routing protocol.

Keywords: Energy efficiency, MANET, multicast group member node, multicast mesh, multicast tree, multicasting, packet delivery ratio, relay node, routing

INTRODUCTION

An ad-hoc network is the cooperative engagement of a collection of mobile nodes without requiring intervention of any centralized access point or existing infrastructure. To provide the optimal communication ability, a routing protocol for such dynamic self-starting network must be capable of unicast, broadcast and multicast in a wireless ad hoc network environment some nodes may want to communicate with other nodes outside their maximum transmission range, thus requiring other nodes to forward packets on behalf of source nodes. In general, there will be none, one, or several intermediate forwarding nodes between source-destination pairs. Route-discovery is responsible for finding new routes between active source-destination pairs whereas route maintenance is responsible for updating existing routes in the presence of node mobility. Multicasting is a communication process in which the transmission of packets (message) is initiated by a single user and the message is received by one or more end user of the network (Chen and Wu, 2003).

A MANET is an autonomous collection of mobile nodes forming a dynamic network and communicating over wireless links. Users are allowed to communicate with each other in a temporary manner with no centralized administration and in a dynamic topology that changes frequently. Due to the limited propagation range of the wireless environment, routes in ad hoc networks are multi-hop and mobile nodes in this network dynamically establish routing among themselves to form their own network "on the fly" (Broach *et al*., 2008). Each participating node acts both as a host and a router and must therefore be willing to forward packets for other nodes. Nodes in such a network move arbitrarily, thus network topology changes frequently, unpredictable and may consist of unidirectional links as well as bi-directional links. Moreover, wireless channel bandwidth is limited. The scarce bandwidth decreases even further due to the effects of signal interference and channel fading. Network hosts operate on constrained battery power, which will eventually be exhausted. MANETs strictly depend on radio links. Actually, a wireless link is the most variable and unpredictable communication channel. In addition, ad hoc networks are vulnerable to attacks and have limited physical security. The increased possibility of eavesdropping, spoofing and denial-of-service attacks should be carefully considered. Because ad hoc networks do not typically allow the same aggregation techniques that are available to standard Internet routing protocols, they are vulnerable to scalability problems. These drawbacks lead to define a set of underlying assumptions and performance concerns for protocol design (Tony and Nicklas, 1998).

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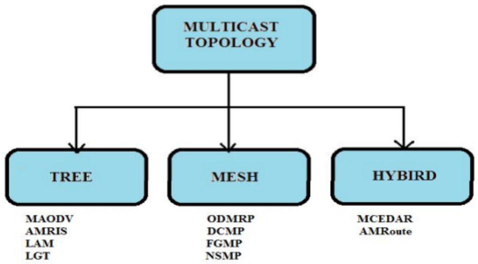

Fig. 1: Various multicast routing protocols in MANET

The multicast protocols are mainly classified as: tree-based and mesh-based protocols. In tree-based protocols, only one route exists between a source and a destination and hence these protocols are efficient in terms of the number of link transmissions. There are two major categories of tree-based protocols: source tree-based (the tree is rooted at the source) and shared tree-based (the tree is rooted at a core node and all communication from the source nodes to the receiver nodes is routed through this core node). Even though shared tree-based multicast protocols are more scalable with respect to the number of sources, these protocols suffer under a single point of failure, the core node. On the other hand, source tree-based protocols are more efficient in terms of traffic distribution (Das *et al*., 1998).

In mesh-based multicast routing, multiple routes exists between the source node and each of the receivers of the multicast group. A receiving node receives several copies of the data packets, one copy through each of the multiple paths. Mesh-based multicast routing protocols provide robustness in the presence of node mobility; however, at the expense of a larger number of link transmissions leading to inefficient bandwidth usage. The mesh-based protocols are classified into source-initiated and receiver-initiated protocols depending on the entity (the source node or the receiver nodes) that initiates mesh formation (Wu and Tay, 1999).

In this study, our work focuses on one critical issue in MANETs that is multicast routing. Indeed, the advantages mainly expected were provided efficient saving in bandwidth, reducing communication cost, supplying efficient data delivery with highly unpredictable node's mobility and supporting dynamic topology with unreliable wireless links. Until now, only a few multicast routing protocols have been proposed. Consequently, we propose a novel multicast routing protocol. The various multicast protocol in MANET is shown in Fig. 1.

Our proposed scheme named MTMP (Mesh and Tree based Multicast protocol). It minimizes both routing and storage overhead in order to provide efficient robustness to host mobility, adaptability to wireless channel fluctuations and optimization of network resource use.

LITERATURE REVIEW

In a source-rooted tree-based multicast routing protocol, source nodes are the roots of multicast trees and execute algorithms for distribution tree construction and maintenance. This requires a source to be aware of the topology information and addresses of all its receivers in the multicast group. Therefore, source-rooted tree-based multicast routing protocols suffer from high traffic overhead when used for dynamic networks.

A tree-based multicast routing protocol establishes and maintains a shared multicast routing tree to deliver data from a source to the receivers of a multicast group. A well-known example of tree-based multicast routing protocols are the Multicast Ad hoc On-demand Distance Vector routing protocol (MAODV) (Guo and Yang, 2007). It is a multicast extension to AODV protocol. MAODV based on shared trees on-demand to connect multicast group members. MAODV has the capability of unicast, broadcast and multicast. MAODV protocol can be route information obtained when searching for multicast; it can also increase unicast routing knowledge and vice- versa. When a node wishes to join a multicast group or it has data to send to the group but does not have a route to that group, it originates a Route Request (RREQ) message. Only the members of the multicast group respond to the join RREQ. If an intermediate node receives a join RREQ for a multicast group of which it is not a member or it receives a route RREQ and it does not have a route to that group, it rebroadcasts the RREQ to its neighbors. But if the RREQ is not a join request any node of the multicast group may respond.

ODMRP is an on-demand mesh based, besides it is a multicast routing protocol, ODMRP protocol can make use of unicast technique to send multicast data packet form the sender nodes toward the receivers in the multicasting group. To carry multicast data via scoped flooding it uses forwarding group concept. The source, in ODMRP, establishes and maintains group membership. If the source wishes to send a packet to a multicast group but has no route to that group, it simply broadcasts a JOIN_DATA control packet to the entire network. When an intermediate node receives the JOIN_DATA packet it stores source address and sequence number in its cache to detect duplicate. It performs necessary routing table updates for reverse path back to the source (Lee *et al*., 2002).

E-ODMRP is source initiated mesh based hard state multicast routing protocol. It is same as ODMRP but it uses dynamic broadcasting to reduce the control overhead in ODMRP. This protocol also performs local route discovery by using ERS. ERS requires more processing. It's not suitable for low end mobile devices. Packet delivery will be same as in ODMRP. The advantage is it reduces control overhead. The disadvantage is it suffers from scalability and nodes will perform ERS that leads to malicious activities. It requires more processing overhead (Gerla *et al*., 2005).

NSMP (Lee and Chongkwon, 2000) is another mesh-based protocol that tries to re-deuce flooding. Like ODMRP, NSMP operates independently of the unicast routing protocol. It reduces the routing overhead by localizing route discovery and maintenance operations. For an initial route establishment or a network partition repair, NSMP performs flooding route discovery in which control messages are broadcast by all nodes. Since routine path maintenance usually occurs much more frequently than the initial path establishment, the saving by localized path maintenance could be sizable.

On Location-Based Multicast protocol (Young-Bae and Nitin, 1999), location information is used to limit the flooding in the network. This thus necessitates the use of a global positioning system or similar tools. Based on the location of the multicast region, forwarding zones are defined. Only nodes in the forwarding zone forward a multicast packet.

MTMP

In this study we have proposed a Multicast Routing protocol MTMP (Mesh and Tree based Multicast Protocol). It is a combination of Tree and Mesh. Its active multicast backbone is a highly pruned tree. However, the tree branches are cushioned within a passive outer crust formed by the nodes passively monitoring the backbone and any collapse in the active tree is rapidly repaired or replaced by the passive nodes, which form a condensed mesh around the active tree. Thus, MTMP multicasting can be interpreted as an integration of tree- and mesh-based approaches.

Tree formation phase: In MTMP, a receiver node joins the multicast tree through a member node that lies on the minimum hop path to the source. A potential receiver wishing to join the multicast group broadcasts a Route-Request message. If a node receives the RREQ message and is not part of the multicast tree, the node broadcasts the message in its neighborhood and also establishes the reverse path by storing the state information consisting of the group address, requesting node id and the sender node id in a temporary cache. If a node receiving the RREQ message is a member of the multicast tree and has not seen the RREQ message earlier, the node waits to receive several RREQ messages and sends back a Route-Reply message on the shortest path to the receiver. The member node also informs in the RREP message, the number of hops from itself to the source. The prospective receiver receives

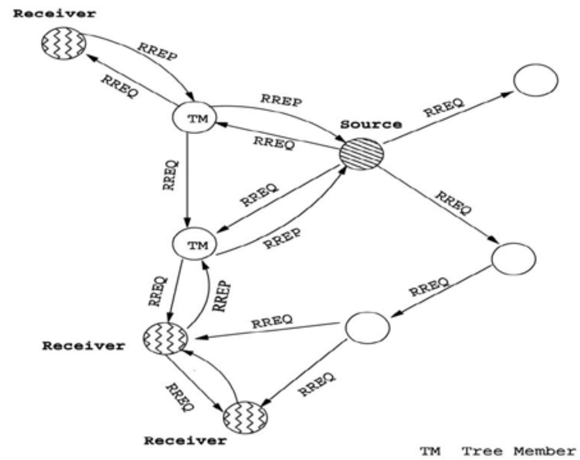

Fig. 2: Packet delivery ratio of multicast group size

several *RREP* messages and selects the member node which lies on the shortest path to the source. The receiver node sends a Multicast Activation message to the selected member node along the chosen route. The route from the source to the receiver is set up when the member node and all the intermediate nodes in the chosen path update their multicast table with state information from the temporary cache.

Data transmission: A multicast source starts its transmission via selecting one of the routes stored in its Routing Table. The Data packet includes information of the corresponding upcoming data packet is announced so that the nodes that have already received the data packet do not waste energy receiving a previously received data packet. Channel access is automatically renewed by the continuous use of a reserved data slot. This leads to an attractive feature in MTMP, preventing packet transmission through stale routes and minimizing traffic overhead. The process continues until reaching all multicast receivers. A multicast receiver, receiving a data packet for the first time, creates an entry in Routing table. To guarantee data transmission to all multicast receivers, nodes duplicate transmission if the selected route leads directly to the multicast group.

The route-discovery process is initiated by the source node. The source node specifies the entire path in a packet-header itself to the destination node. The route discovery process allows the nodes to discover a path to the destination by using the Route Request (RREQ) packet. A source node initiates a session by broadcasting packets to its one-hop neighbors. Nodes that receive a data packet contend for channel access and the ones that obtain channel access retransmit the data they received. The Packet delivery ratio as a function on multicast group size is shown in Fig. 2.

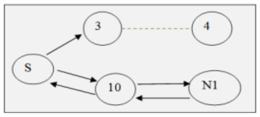

Fig. 3: Operation of the pruning mechanism

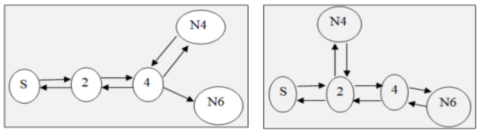

Fig. 4: Multicast group member node, (a) before movement, (b) after moving

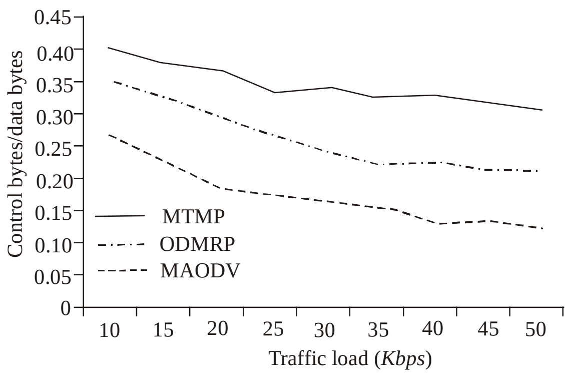

Fig. 5: Routing overhead as a function of traffic load (10 senders and 20 receivers)

Pruning mechanism: The redundancy introduced by Route discovery is pruned by the pruning mechanism using receiver based and transmitter-based feedbacks. After the route discovery process, all the nodes receive the data packets and they determine their predecessor and successor nodes. Multicast relays are also determined. Pruning uses the multicast relays to create an efficient multicast tree. A multicast relay node that does not receive any predecessor or successor ACK for any time ceases to be a multicast relay.

In Fig. 3, Nodes 10 and N1 along with S are multicast relays. However, nodes 3 and 4 are not multicast relays because there is no multicast group member connected to that branch of the network. Node 4 will cease retransmitting the packets that it receives from its successor node 3 because no node is acknowledging its data transmissions. Thus, the redundant upper branch is pruned. Unlike the upper branch, the lower branch is not pruned due to the fact that the lower branch has a multicast node as the leaf node. Route discovery and PRN mechanisms are not always capable of maintaining the multicast tree in a mobile network. Thus, there is a need for additional maintenance mechanism techniques to repair broken branches. Maintain Branch, Repair Branch and Create Branch mechanisms are utilized to maintain the multicast tree.

Refreshment mechanism: It follows a simple mechanism making use of data packet propagation and requiring no extra control overhead. Each time the source transmits a data packet, it is updated in its cache the timer of the used route. Typically, a multicast node forwarding this packet scans the packet header and refreshes in its cache the corresponding route entry timer. Furthermore, a multicast receiver scans the header of each received data packet, refreshing its corresponding table entry timer to the source. Periodically, each node checks its timers and purges out expired multicast group entries, preventing stale route storage. In addition, it checks its neighbor table, deleting from its cache routes to multicast groups for which it possesses no more members.

Maintenance mechanism: Route maintenance concerns with reporting and recovering routing problems, keeping the lifetime of a route as long as possible. MTMP addresses two mechanisms.

Maintain branch: The initial multicast tree formed by pruning is broken in time due to node mobility. Tree branches broken primarily due to leaf node (multicast group member node) mobility are repaired by this mechanism. Some of the multicast group members are not multicast relays.

In Fig. 4, Multicast node N4 is a multicast relay, as indicated by the two-way arrows; whereas node N6 is not a multicast relay. Node N6 has just received packets from the successor node 4. Hence, node N6 do not acknowledge node 4. Any node can acknowledge only one predecessor and one successor node with a single MS packet.

A multicast group member node N4 move away from node 4's transmit range and enters node 2's transmit range as shown in Fig. 5. Then N4 receives the data packets from node 2 and begins to acknowledge node 2 as its successor node. In this case, node 4 does not receive any ACK from node N4 due to the mobility of multicast member node N4. Node 4 starts to set its successor node ID as the null ID. However, node 4 does not cease retransmitting data packets that it receives from its successor node 2 instantly because a multicast relay does not reset its status for some time and thus, continues to retransmit data packets. Although none of the other multicast nodes acknowledge any node, they monitor their successor node through IS and data packets. The successor node of one or multiple multicast group member node (s) announces the null ID as its successor node ID.

In this scenario, the multicast node N6 starts to acknowledge the successor node by announcing the ID of the successor node 4 in its IS packet. Thus, node 4 continues to be a multicast relay and a successor multicast node N6 becomes a multicast relay after receiving a successor ACK from its successor node 4. Node N6 forms a redundant passive outer mesh for the tree branch. Passive nodes in the neighborhood of the

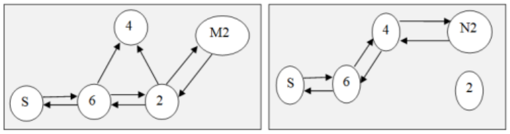

Fig. 6: (a) Multicast relay node-before movement, (b) after moving

tree breakage created an active mesh, which is quickly pruned down to a single path after the tree branch is repaired.

Repair branch: The multicast tree formed by pruning is broken in time due to node mobility. Tree branches broken primarily due to relay node mobility are repaired by this mechanism. After a node marks itself as a multicast relay, it continuously monitors its Successor node to detect a possible link break between it and its predecessor multicast relay node, which manifests itself as an interruption of the data flow without any prior notification. If such a link break is detected, the successor node uses the repair branch mechanism to fix the broken link.

Figure 6 illustrates an example of a network topology, where a branch of the multicast tree is broken due to the mobility of a multicast relay. Figure 6a shows a multicast tree formed by the source node S, multicast relay nodes 6 and 2 and the multicast group node N2, which is a multicast relay as well. Node 4 is neither a multicast relay node nor a multicast group member; however, it receives the MS packets from nodes 6 and 2 (i.e., nodes 8 is in the receive ranges of these two nodes).

After some time, as illustrated in Fig 6b, node 2 moves away from its original position and nodes 6 and 2 cannot hear each other; thus, the multicast tree is broken. At this point, node 2 realizes that the link is broken (i.e., it does not receive data packets from its successor node anymore) and the repair branch mechanism is used to fix the broken tree. Thus, temporarily, the path between node 6 and node N2 are created (i.e., the path via node 4). Node 4 replaces node 2 as a multicast relay node and the multicast tree branch is repaired. Multicast group member node N2 acknowledges node 4 as its successor node.

PERFORMANCE EVALUATION

The performance evaluation is carried out as a simulation study using NS2. We use the following metrics in evaluating the performance of the different multicast routing protocols.

The packet delivery ratio is computed as the ratio of total number of unique packets received by the receivers to the total number of packets transmitted by all sources times the number of receivers.

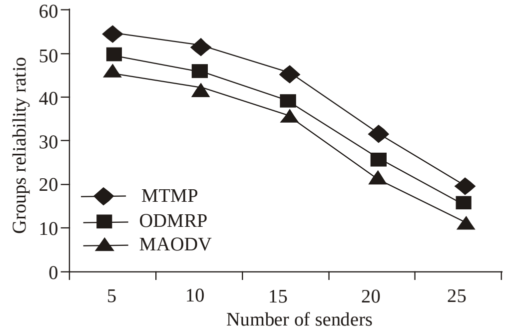

Fig. 7: Packet delivery ratio as a function of traffic load

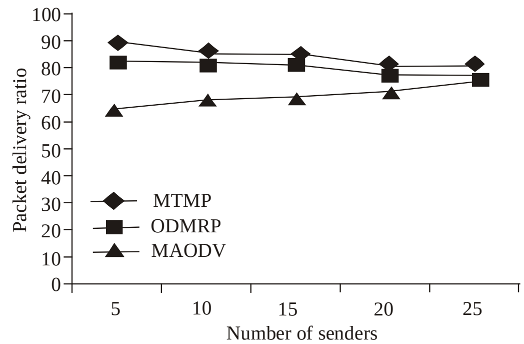

Fig. 8: Packet delivery ratio as a function of number of traffic sources (30 receivers, 50 Kbps)

Routing overhead is the ratio between the number of control bytes transmitted to the number of data bytes received.

The simulation results of our proposed MTMP protocol are compared to other leading protocols ODMRP and MAODV. In these simulations, we use synthetic MANET scenarios, in which we subject the protocols to a wide range of mobility, traffic load and multicast group characteristics (i.e., group size and number of sources).

Figure 7 shows the packet delivery ratio as a function of traffic load. It is observed that all protocols are affected by the increase in network traffic. For the traffic loads considered, MTMP still outperforms ODMRP and MAODV in terms of delivery ratios. The performance of MTMP is much more better to ODMRP and MAODV as traffic load increases on account of the great number of redundant transmissions.

Figure 5 depicts the control overhead per data byte delivered as a function of traffic load. It can be seen that MTMP control overhead remains almost constant with increasing load. The high routing overhead seems to suggest that MTMP can be quite expensive at higher traffic loads and, hence, not scalable with increased traffic loads.

Figure 8 shows the packet delivery ratio as a function of the number of senders. Note that both the MTMP and ODMRP packet delivery ratios remain fairly constant with the number of senders;

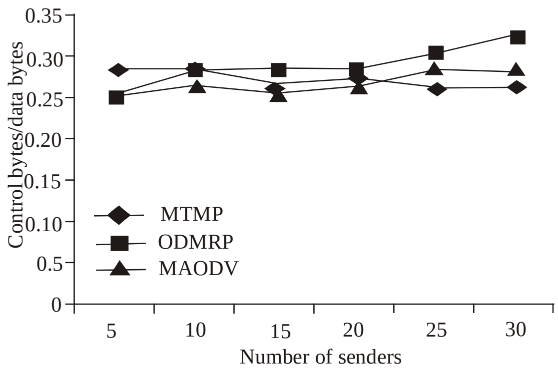

Fig. 9: Routing overhead as a function of traffic sources (30 receivers, 50 Kbps)

thus, they do not suffer from increased contention except at a higher number of sources, where a slight drop off can be observed and is attributed to data packet loss due to collisions. Figure 9 depicts how control overhead varies with the number of traffic sources.

CONCLUSION

In this study, we focus on multicast routing protocol. Routing requirements are reviewed. Some existing protocols are cited. Their advantages and limitations are illustrated. Our aim of this study is to present a new on-demand multicast routing approach MTMP (Mesh and Tree based Multicast Protocol), providing enhancements over other existing strategies. It can detect broken tree branches rapidly, with the support from the passively participating neighboring nodes around the active branches and then repair the broken links. The comparative analysis was that MTMP, which is the simplest routing mechanism, achieves less energy dissipation by eliminating the redundant data receptions, provides higher delivery guarantees than ODMRP and MAODV because all the nodes are continuously relaying all the packets. ODMRP exhibits decent robustness because of its mesh structure. MAODV did not perform as well as the other protocols in terms of packet delivery ratio and group reliability, but has the lowest routing overhead among the protocols considered.

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