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Efficient Multicast Ad-hoc On-Demand Distance Vector Routing Protocol

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Abstract –Mobile Ad-hoc Network (MANET) is an autonomous, multi-hop and dynamic network composed of number of wireless mobile nodes. Routing protocols are challenges in designing Mobile Ad-hoc networks with low energy consuming and low control overhead. Ad-hoc on demand distance vector routing protocol (AODV) is specially designed for mobile ad-hoc networks with Expanding Ring Search (ERS) technique for route discovery process. This paper modifies the expanding ring search (ERS) algorithm used by AODV Protocol optimize the energy consuming and control overhead caused by broadcasting redundancy messages for Multicast operation. Our approach saves energy and overhead of the nodes by avoiding the redundant rebroadcasting of the route request packets and by reduction in the total number of mobile nodes participating in multicast routing. Simulation results show that the performance of proposed protocol Efficient MAODV (EMAODV) is improved compared to MAODV protocol.

Index Terms – Control Overhead, Mobile Ad hoc Network, broadcasting

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1. INTRODUCTION

An ad hoc network is a collection of autonomous mobile nodes formed by means of multi-hop wireless communication without the use of any type of existing network infrastructure. Ad hoc networks have become increasingly relevant in recent years due to their potential applications in rescue operations, battlefield, emergency disaster relief and node can serve as a router. Mobile nodes self-organize to form a network over radio many more. In an ad hoc network, each mobile links [20].Group communication is most important in MANET. Many ad hoc Network applications which require close association of the member nodes depends on group communication. Disaster relief, conferences, action directions given to the soldiers in a battlefield and communications required during a rescue operation are some examples of these applications. In addition, many routing protocols for MANET need a broadcast or multicast as a communication primitive to update their states and maintain the routes between various member nodes [1],[15]. Based on topology, Multicast protocols can be categorized in tree based and mesh based protocols. In wired as well as in wireless networks, maintaining group membership information and building an optimal multicast distribution structure, typically in the form of a routing tree, is challenging task. A detailed survey of the work done in that area and a discussion of various design tradeoffs can be found in [2]. Route discovery and Group management is one of the challenging task for MANET. Nodes are free to move arbitrarily. Bandwidth scarcity, limited power resource and above all dynamicity of topology in a mobile ad hoc network make the multicast protocol design predominantly challenging than that for wired network [15].

The primary goal of an ad hoc routing protocol is to establish a correct and efficient route between any pair of member nodes with minimum overhead. Routing overhead is a very important metric to evaluate the performance of the any routing protocol. If the control overhead of a proposed method is very high, then that method cannot work well in MANET. In recent years, various multicast routing protocols have been proposed to reduce various overheads during routing. It would be a difficult and challenging task to offer optimal, reliable, energy efficient and with low control overhead multicast routing in MANETs. These protocols have unique attributes and utilize different recovery mechanisms on overhead reduction. Multicast Ad-hoc on Demand Distance Vector Protocol (MAODV) is one of the best examples of on-demand multicast routing protocol. MAODV is the multicast extension version of Ad-hoc on Demand Distance Vector

Protocol (AODV). In MAODV, node discover the route only if it needs to send the data to the destination nodes and maintain only active routes. So that overhead can be reduced .Because of this reason MAODV is widely used in MANET. But, there are two limitations of this protocol: (1) many control massages are transmitted by flooding (2) Tree will not be repaired until link breakage will happens during communication. So that in this paper, based on the expanding ring search method, protocol is modified in which initial route establishment related procedure is improved which will reduce the total number of control messages during the whole communication process.

The remainder of this paper is organized as follows. In section-2, we explain the working of MAODV. Section-3 explains the new idea based on which expanding ring search approach is modified to surmount the limitations of original MAODV. Section-4 shows the comparative results for modified and original MAODV. At last section-5 concludes the results.

2. RELATED WORK

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A number of multicast protocols have been proposed to provide multicasting in MANET like challenging environments [1-13]. During multicasting, a multicast group is formed by various senders and receivers. For connecting senders and receivers, each protocol constructs either a tree or a mesh as the routing structure. There are some nodes called forwarding nodes in the routing structure that are not interested in multicast packets but act as routers to forward them to receivers. Group members (senders and receivers) and forwarding nodes are also called tree or mesh nodes depending on the routing structure. In the routing structure, a node is an upstream/downstream node of another node if it is closer to / farther away the root of the tree. If the two nodes belong to the same link, the upstream/downstream node is also called the parent/child of the other node. Generally, a sender initially floods a join message to all nodes in the network. Interested nodes reply to the sender via the reverse path. After all reply messages arrive at the sender, a multicast tree rooted at the sender is formed. This kind of tree construction is called a sender-tree-based one. A multicast group usually has several senders and thus it costs high for each sender to build its own tree. Instead of that, some protocols select a single sender to build a multicast tree that is shared with other senders. This kind of tree construction is called a shared-tree-based one and the selected sender is called the group leader / core node. Other senders first transmit data packets to the group leader and the group leader then relays the packets downward the shared tree to all receivers. The kind of initialization of tree construction by one or more senders is called a sender-initiated scheme. The receiver-initiated scheme requires receivers to initiate the tree construction, and it is often used for the shared-tree structure. Sender-tree-based protocols incur higher control overhead than shared-tree-based ones because each sender builds its own tree. Shared-tree-based protocols have two main drawbacks: single point of failure of the group leader and sub-optimal multicast paths. Moreover, the group leader may locate in a bad position which further decreases multicast efficiency and increases packet latency. The mesh structure is robust against topology changes, but multicast efficiency is reduced [23]. Because of all these reasons, routing and route discovery in MANETs are among the most actively researched issues in the area of wireless communication.

2.1 Tree Based Multicast Routing Protocol

Tree based multicast routing protocol maintains either a shared tree or multiple source based multicast routing tree in which one for each group source, to deliver data packets from source/s to receivers of a group. Tree based protocols are generally more efficient in terms of data transmissions but they are not robust against topology changes as there are no alternative paths/links between the source/s and destinations. There are number of tree based multicast routing protocols are designed like MAODV, AMRIS, AMROUTE, MOLSR, ADMR.

2.2 Multicast Ad-hoc on Demand Distance Vector Protocol (MAODV)

Multicast Ad-hoc on Demand Distance Vector Protocol is the multicast extension version of unicast routing protocol Ad-hoc on Demand Distance Vector Protocol (AODV). MAODV is enough capable to handle unicasting, multicasting and broadcasting the message/s. MAODV is the best example of on-demand multicast routing protocol i.e. node discover the route only if it needs send data to the destination nodes and maintain only active routes. It establishes routes on demand using the route discovery mechanism with smaller delay [21]. Route discovery process includes broadcast route request and unicast route reply discovery cycle. MAODV uses the multicast distribution mechanism of bi-directional shared tree approach, consisting of members of the multicast group and several routers, which are not group member but exist in the tree to connect the group members. In MAODV each multicast group has a unique address, which is known as multicast group address, and one group leader, which is known as core node. The group member who initiates the tree construction is known as group leader. Each broadcast packet has one a broadcast ID which is known as sequence number of that packet. The network address and sequence number collectively identify the packet uniquely. Because of this, multiple times broadcasting of packets can be prevented. Core node/ group leader is responsible to maintain the group sequence number which is periodically broadcasted within the network in the form of Group Hello (GRPH) messages [22].

MAODV describe route discovery to multicast tree and maintenance of the multicast tree. If any node wants to join a multicast group, or wants to send any data to multicast group which does not know about the route to the multicast tree, it will broadcast Route Request (RREQ) message. This message includes RREQ_J and RREQ_NOFLAG, which are used to represent route request to join the group and transmit data to a multicast group respectively. With the RREQ's broadcasting along the whole network, all intermediate nodes prepare the reverse route to the sender nodes and continue to broadcast the messages to their neighbours. When RREQ_J will be received by a member node of the tree or RREQ_NOFLAG will be received by any node which has new route to the multicast group, the node will respond the message and unicast Route Reply back along the reverse route details towards the source node of the tree. The source node chooses one RREP which has greatest sequence number and minimum number of hops the nearest member of the multicast tree. Then it will reply with unicast Multicast Activation (MACT) message along route of this selected route reply message.

During communication, Multicast group links may break due to node's movement or expired route timers. When a link breakage is detected during communication, the downstream node of break (i.e., the node that is further from core node) is responsible to repair the broken link. The downstream node initiates the repair by broadcasting a route request message with Dest_Addr set to the IP address of the core node and with the J_flag set. The Multicast Group Hop Count (Mgroup_Hop) extension is set to the distance of the node from core node. The only nodes which may reply to a RREQ with the Mgroup_Hop extension are nodes that are at least as close to the core node, or the core node itself.

According to the principle of MAODV, it is analyzed that there are some drawbacks in the protocol as below:

(1) Many control massages in MAODV are transmitted by flooding. The method of blind flooding create the RREQ and GRPH be forwarded to whole network, which will utilize the valuable network resources, and may create network congestion, then increases packet's collision probability and packet's loss.

(2) Tree will not be repaired until link breakage will happens during communication. And when a node detects link breakage, it sends RRER to the source node and then handle. With the increase of network size and node's movement/speed, this problem will be infinitely zoomed, and will result in degradation of network performance.

3. THE PROPOSED MULTICAST ROUTING PROTOCOL - EMAODV

Route discovery in MANET often relies on some form of network flooding where each node in the network forwards a route request message to all of its neighbours. This process is inefficient because it results in control messages visiting the network nodes even if the path to destination is located in a different portion of the network. To improve network utilization of the flooding-based route discovery protocols, MAODV uses expanding ring search (ERS) technique for controlling dissemination of Route Request Messages. In ERS, the source node will be the center of the search ring. ERS successively searches a larger area till the node having needed information being searched is not found. Using the conventional method of flooding algorithm and expanding ring search method following equation is derived for calculating the total number of transmissions for a farthest destination assuming nodes in the radio range of each mobile node n [21].

$(n-2)^{d+1} - d(n-2) + (d-3)$, **where** d is the network diameter.

As per the expanding ring search algorithm, a node initiates a route request with initial value of Time to Live (TTL) equal to 1. If the originating node will not receive a RREP message within a certain period of time limit then it rebroadcasts the RREQ message with TTL value incrementing by 1. The node continues to broadcast messages with increasing TTL value up to predefined network diameter value until it receives a route reply. One important parameter of ERS is the initial value of TTL. It is a parameter that must be selected carefully to get the best possible result. A good initial TTL value can reduce the number of re-transmitted request messages in the whole route discovery process, which means it can reduce the network overhead. So that instead of choosing the TTL value randomly, in proposed technique, initial value of TTL will be set to 1. After starting the route discovery process with TTL=1, based on the odd and even numbered generated ring for searching the nodes, broadcasting and unicasting is applied respectively. To support that, expanding ring search implementation is modified. Instead of each and every time broadcasting the RREQ to neighbours, if RREQ propagation

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method will be changed then it will effectively reduce overhead transmissions. If overhead transmissions will be effectively reduced, then utilization of energy of intermediate node for receiving and forwarding the request will be minimized and so that lifetime of network can be prolonged.

4. SIMULATIONS

The purpose behind the simulation is to measure the routing overhead for original MAODV and modified MAODV i.e. First is based on original expanding ring search and second is - with the modified expanding ring search for MAODV. It will help us understand how effectively the suggested approach reduces the routing overhead in MAODV. The goal behind the simulation is to determine the effect of changing the value of TTL_INCREMENT and TTL_THRESHOLD with original ERS and modified ERS based MAODV protocol. To evaluate results Throughput, Packet Delivery Fraction (PDF) and Average End-to-End Delay metrics are used. A Simulation model based on NS-2.26 is used for evaluation. Throughput gives the ratio of the total size of received data packets to the duration of time when it receives. Packet Delivery Fraction specifies the ratio of the number of data packets expected to be received to the number of data packets delivered to the destinations and End-to-End Delay indicates the average time a packet takes for delivery to its destination after it was transmitted. It tells how a protocol adapts or arranges for an immediate delivery of packets to its desired destination. Average delay is all possible delays like route discovery latency, queuing at the interface queue, retransmission delays at the MAC etc [9]. As a simulation parameters- Network Size is 500*500, Number of Nodes are 7, IEEE 802.11 for MAC Layer protocol and 200ms as simulation duration are considered. Considering the TTL_START =1, TTL_THRESHOLD and TTL_Increment values are modified to evaluate the performance of original and modified approach.

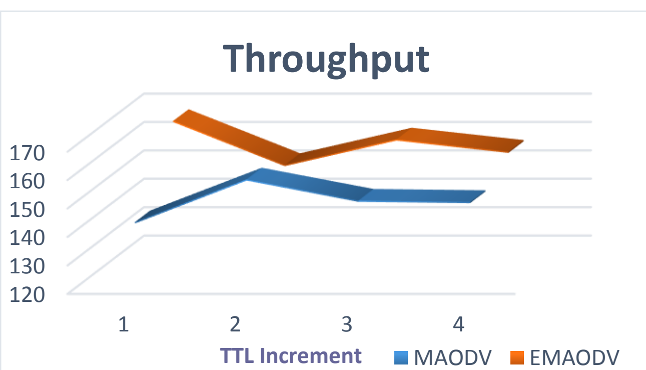

Figure 1 Results for Throughput

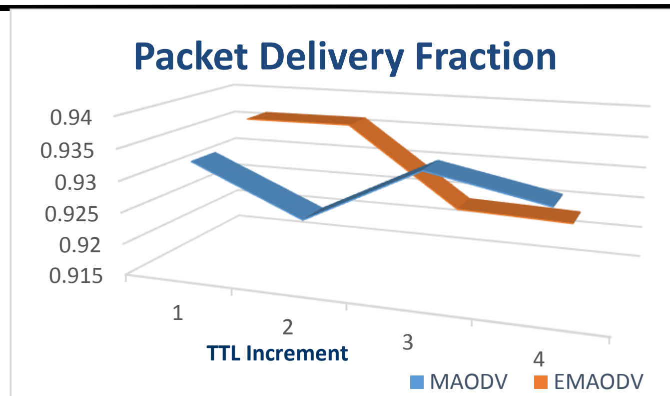

Figure 2 Results for PDF

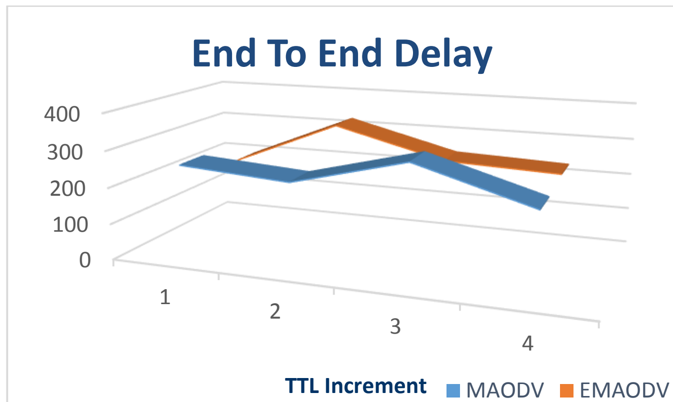

Figure 3 Results for E2E Delay

Above figures show the comparison between MAODV based on original ERS concept and EMAODV based on proposed ERS concept. From figure 1 we can observe that overall throughput is increased with proposed modified ERS. Performance improvement done by modified MAODV is also supported by figure 2 and figure 3. Every time, instead of broadcasting the control packets to each node during route discovery process, based on the generated ring, if unicasting or broadcasting will be done then it will directly affect the required total number of retransmissions. Throughput and Packet Delivery Fractions support this fact also. As number of retransmissions will be reduced, transmission overhead will be reduced and if overall overhead will be reduce , it will directly affect the lifetime of individual node as well as whole network also.

5. CONCLUSIONS

In this paper, expanding ring search approach which is used by MAODV during the route discovery process is analyzed and based on that new concept is suggested. Using various performance metrics, MAODV and EMAODV protocols are compared and from results of same it is concluded that suggested idea increase the throughput and also reduces the end to end delay. From the various results it is also observed that at some point for specific TTL_Increment value, EMAODV does not give the better performance. Several other parameters such as mobility of nodes, radio range of nodes, traffic patterns may affect the routing performance. So this work can be further explored to find out the solution for same.

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