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Survey of Routing Algorithms for MANETs

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Abstract

Mobile Ad Hoc Networks (MANETS) are communication networks built up of a collection of mobile devices which can communicate through wireless communications. In recent years, on-demand routing protocols have attained more attention in MANETs due to their abilities and efficiency as they are able to organize themselves dynamically. Quality of Service has always been the hot topic in academic. In this paper, the performance analysis of three on demand multicast routing protocols are focused, namely, Multicast Ad-hoc On-demand Distance Vector (MAODV), Multisource Multicast Ad-hoc On-demand Distance Vector (MMAODV) and On-Demand Multicast Routing Protocol (ODMRP) by extensively using various performance metrics like packet delivery ratio, control overhead, forwarding efficiency, average delivery delay, average recovery time. Preliminary simulation results are also reported.

Keywords: MANETS, Ad Hoc

Introduction

Ad-hoc network is an autonomous system of mobile nodes. It does not use any pre existing infrastructure and there is no centralized administration. Multicasting is a transmission of packets from a source or group of sources to a one or more host. Multicast supports advanced applications such as military operations (formations of soldiers, tanks, planes), civil applications (audio and video conferencing, sport events, telemetric applications (traffic)), disaster situations (e.g. emergency and rescue operations, national crises, earthquakes, fires, floods), and integration with cellular systems.

Multicasting in a MANET is more challenging in that all the group members keep moving, making reliable and efficient packet delivery to all members more difficult.

This paper summarizes the analysis of some of the multicast protocols like MAODV, ODMRP [11] [12], MMAODV [8] in MANET environment.

This paper is organized as follows. Chapter 2 introduces related works. The operation of three protocols, namely, MAODV, ODMRP and MMAODV is summarized in Chapter 3. The simulation based Comparison is performed in chapter 4 and conclusion is described in chapter 5.

Related Work

Ad-hoc mobile multicast routing protocol is a complex task that has to take into account new challenges [1]. Considering the limited buffering, the computational capacity and the dynamic nature of the topology, the problem associated with ad-hoc network routing is to adapt routing methods to the increasing number of nodes.

Ad-hoc routing protocols can be classified into two main categories: proactive (or table driven) protocols and reactive (or source initiated on-demand driven) protocols. Proactive protocols maintain consistent and up-to-date routing information (routes) from each node to every other node in the network. Topology updates are propagated throughout the network. Keeping routes for all destinations has the advantage that communication experiences minimal initial delay. These protocols have the disadvantage of generating additional control traffic due to the update of route entries [7].

In reactive protocols when a source node requires a route to a destination, it initiates a route discovery procedure to establish the route. Some form of route maintenance procedure is used to maintain it. These protocols tend to use less bandwidth for maintaining the route tables at every node.

However, the latency drastically increases, leading to long delays before a communication can start. This is because a route to the destination has to be acquired first. Moreover, these protocols have large control overhead when the number of source to destination connections is large.

Multicasting is a data communication in which the same data is sent to multiple recipients, multicasting can reduce the consumptions of network bandwidth and host power. We can classify multicast routing algorithms as Tree-based and mesh based. In tree based approaches there is only one path between the source-receiver pair. In a mesh-based multicast routing algorithm, there may be more than one path between a source-receiver pair, thus making it more robust. Due to the lower overhead, tree based are more efficient than mesh based approaches. In a harsh environment, where the network topology changes frequently, mesh-based protocols seem to Outperform tree-based protocols, due to the availability of alternative paths even if links fail.

Multicast Protocols for Mobile Ad-hoc Networks

Multicast ad-hoc On Demand Distance vector:

MAODV is a multicast routing protocol based on AODV [11], which can perform unicasting, broadcasting and multicasting. It discovers multicast routes on demand using a broadcast route discovery mechanism employing the Route Request (RREQ) and Route Reply (RREP) messages. A mobile node originates a Route Request (RREQ) message when it wishes to join a multicast group, or when it has data to send to a multicast group but it does not have a route to that group. Only a member of the desired multicast group may respond to join-RREQ. The RREQ broadcast throughout the network and send back with the RREP message. The nodes forwarding RREQ and RREP record the path backwards to the source of packet, as they will do in unicast routing. If a member node wishes to terminate its group membership, that node has to ask for the termination to the group. Then its membership will be terminated. Every MAODV multicast group also has a sequence number to indicate the freshness of the routing information. The group member that first constructs the tree is the group leader for that tree, which is responsible for maintaining the group tree by periodically broadcasting Group Hello (GRPH) message [4]. Each node has three tables namely Unicast Route Table, Multicast Route Table and Group Leader Table. Unicast Route Table has an address of the next hop to which the message is to be forwarded. Multicast Route Table has the address of the next hops for the tree structure of the each multicast group. The Group Leader Table records the current multicast group addresses with its group leader address and the next hop address towards that group leader receives a periodic GRPH message. If a member terminates its membership with the group, the multicast tree requires pruning. Links in the tree are monitored to detect link breakages. When a link breakage is detected, the node that is further from the multicast group leader (downstream of the break) is responsible for repairing the broken link. If the tree cannot be reconnected, a new leader for the disconnected downstream node is chosen.

On-Demand Multicast Routing Protocol:

ODMRP is a soft state reactive mesh based multicast routing protocol. In this approach, the source establishes and maintains group membership and multicast mesh on demand if it needs to send data packets to the multicast group, which is somewhat similar to MAODV. But, it builds a mesh instead of tree for packet transmission. In ODMRP, group membership and multicast routes are established and updated by the source on demand [11]. It does not maintain route information permanently. Member nodes are refreshed as needed and do not send explicit leave messages. Similar to on-demand unicast routing protocols, a request phase and a reply phase comprise the protocol. When multicast sources have data to send, but do not have routing or membership information, it broadcasts a Join-Query control packet to the entire network. This Join-Query-packet is periodically broadcast to refresh the membership information and update routes. When an intermediate node receives the Join-Query packet, it stores the source ID and the sequence number in its message cache to detect any potential duplicates [12]. The routing table is updated with the appropriate node ID (i.e. backward learning) from the message was received for the reverse path back to the source node. If the node receives a Join-Reply it checks whether the next hop node ID of one of the entries matches its own ID. If it matches, the same node is on the path to the source and it is in the part of the forwarding group. It then broadcasts its own Join Table built upon matched entries [12]. The next hop node ID field is filled by extracting information from its routing table. The same process is repeated until it reaches the multicast source via the selected path. This process constructs the routes from sources to receivers and builds a mesh of nodes, the forwarding group [12].This procedure minimizes the traffic overhead and prevents sending packets through stale routes. In ODMRP, no explicit control packets need to be sent to join or leave the group. If a multicast source wants to leave the group, it simply stops sending Join-Query packets since it does not have any multicast data to send to the group. If a receiver no longer wants to receive from a particular multicast group, it does not send the Join- Reply for that group. Another unique property of ODMRP is its unicast capability. Not only can ODMRP coexist with any unicast routing protocol, it can also operate very efficiently as unicast routing protocol. Thus, a network equipped with ODMRP does not require a separate unicast protocol [11].

Multisource Multicast Ad-hoc on-demand Distance Vector:

MMAODV is similar to MAODV. It uses REQ/RREP/MACT messages and route discovery cycle to discover the routing path and establish the multicast tree [8]. Node will initiate join procedure by broadcasting a RREQ message with the IP address of that group as destination address. The members of that group may respond to the RREQ by unicast a RREP back to the requesting group member. The temporary path(s) between requesting group member and the multicast routing tree is established. Since it may receive more than one reply, a Multicast Activation (MACT) message is used to ensure that the multicast tree does not have multiple paths to any tree node. The MACT is initiated by the requesting member to discover the route that has the best performance between requesting member and the multicast group. To achieve multi source multicast routing on the tree constructed in the route discovery cycle, multicast Reverse Path Forwarding (RPF) technique is used. If the router finds a matching routing entry packet is forwarded to all interfaces that are participating in multicast group, then the node will relay this multicast packet to all the next hops and parent node of this multicast group except the incoming node. Parent address can be obtained by group hello message.

If no RREP is received, the multicast routing tree will be split into partitions. If there exists multiple partitions, then leads to long recovery time. To reduce the long recovery time, a virtual mesh topology between the 1-hop neighbors of the leader is maintained. [8].

Performance Evolution

Comparisons of MAODV and ODMRP:

We evaluate the performance of the routing protocols namely ODMRP & MAODV using the simulations of ODMRP, MAODV in network simulator ns2 [4]. This simulation models a network of 200 mobile hosts placed randomly within a 1000m X 1000m area. Radio propagation range is 500 meters in scenarios without unidirectional links. The multicast data streams are Constant Bit Rate (CBR) streams with jitters. The size of data packet is 512 bytes. The multicast sources are selected from all 200 nodes randomly and most of them act as receivers at the same time. The [4] [11][12]
references are mainly used for this implementation.
We have used the following metrics in comparing protocol performance

- Packet Delivery Ratio: Packet Delivery

Ratio is defined as the number of data packets delivered to multicast receivers over the number of data packets supposed to be delivered to multicast receivers. This ratio represents the multicasting effectiveness of the protocol. Higher value implies better performance.

- Multicast Efficiency: It is defined as the number of data packets delivered to multicast receivers over the number of total data packets forwarded. Higher value implies better performance.

Multicast Efficiency = total received packets / total forwarded packets

- Control Overhead: It is defined as the summation of the control messages generated the protocol over the network.

Simulation Results

On varying the number of senders to evaluate the protocol scalability based on the number of multicast source nodes and the traffic load. We inferred from the Figure-1 that ODMRP is more effective than MAODV in data delivery ratio as the number of senders increases.

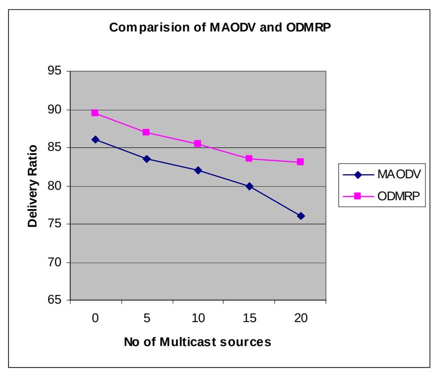

Figure - 1.

Similarly the control overhead of MAODV increases on increasing the number of senders and receivers, whereas the control overhead of ODMRP shows little variation (Figure -2).

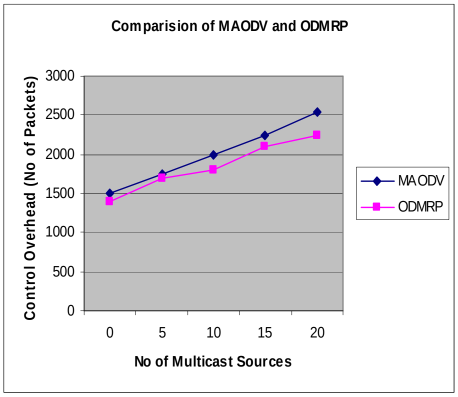

Figure - 2.

From Figure- 3, it is inferred that the forwarding Efficiency of ODMRP is greater than MAODV on increasing the number of senders and receivers.

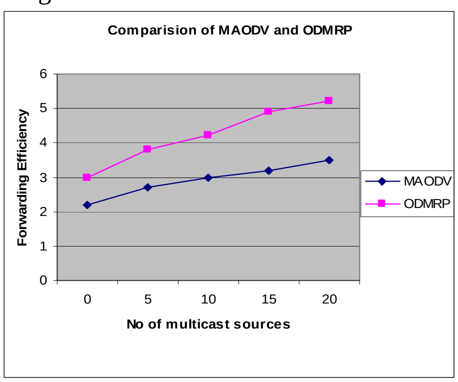

Figure - 3.

Comparisons of MAODV and MMAODV

Simulation Results

The performance of MMAODV scheme is evaluated and compared to the performance of MAODV [17][8].The simulation scenario consists of 25 multicast nodes randomly distributed in a 600m × 400m area. The random waypoint model [18] is used to model the mobility of mobile nodes. The moving speed of the mobile nodes is uniformly distributed in 1m to 10 m per second. For multi source simulation, 35% of group members are selected as the multicast source.

The following three performance metrics are used:

- **Average delivery delay:** The average time taken for data packets to be transmitted across a network from source to destination is Average delivery delay,
- **Control overhead:** This is the total number of control packets and total number of bytes of control information.
- **Average recovery time:** This is average time taken to recover tree from root failure.

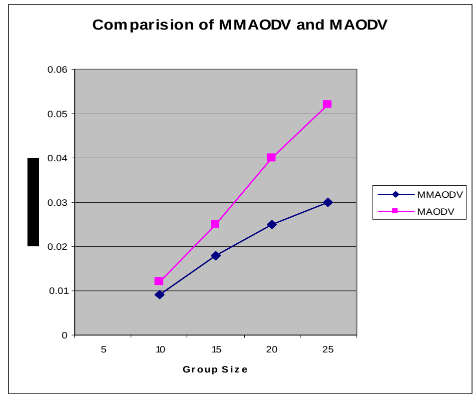

Figure- 4

Figure - 4 shows that the average delivery delay of MMAODV is lower than MAODV. On increasing the group sizes the delay of MAODV increases faster than MMAODV. This is due to the bottle neck of data delivery when the number of group members becomes larger

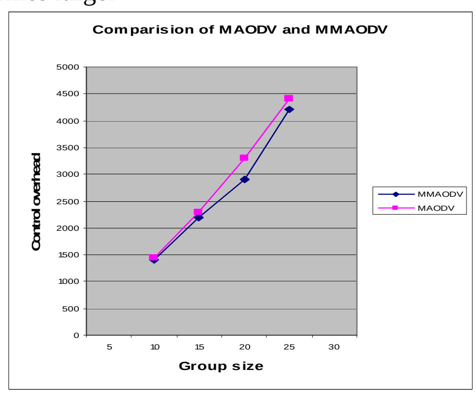

Figure - 5

Figure - 5 depicts that the average recovery time of MMAODV is smaller than MAODV. In MAODV protocol, the recovery procedure takes a long time to repair the partition. When the number of partition becomes large, the overhead of granting time will be increased. In MMAODV, the recovery procedure is initiated by the group leader of partitioned tree without any permission granting is required. Hence, the recovery time can be reduced.

Figure - 6 indicates that the control overhead MMAODV is lower than MAODV. Since MAODV saves RREQ / RREP overhead by maintaining a virtual mesh topology.

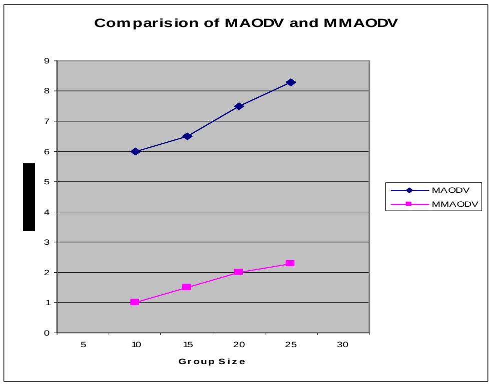

Figure - 6.

Conclusion

A general conclusion is that, in a mobile scenario, a mesh-based protocol out performed tree-based protocols. ODMRP was very effective and efficient in most of our simulation scenarios. It showed a rapid increasing of overhead as the number of senders increases. MAODV is the bi-directional shared tree which results the poor delivery ratio.

MMAODV provides multisource and also avoids bottleneck problem. By maintaining the candidate leader, the partition can be recovered by the group leader of each partitioned tree without requiring any permission granting is required. Hence, the recovery time and control overhead can be reduced

We experimented with scenarios which are the most representation of ad hoc wireless network applications. The results of this paper can provide guidelines, but the final selection of a multicast protocol should take into account other considerations which cannot be valuated via simulation alone.

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