ON-DEMAND MULTICAST ROUTING PROTOCOLS PERFORMANCE ISSUES IN AD HOC NETWORKS

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ABSTRACT: - This paper presents a novel multicast routing protocol for mobile ad hoc wireless networks. The protocol, termed ODMRP (On-Demand Multicast Routing Protocol), is a mesh-based, rather than a conventional tree based, Multicast scheme and uses a forwarding group concept (only a subset of nodes forwards the multicast packets via scoped flooding). It applies on-demand procedures to dynamically build routes and maintain multicast group membership. ODMRP is well suited for ad hoc wireless networks with mobile hosts where bandwidth is limited, topology changes frequently, and power is constrained. We evaluate ODMRP's scalability and performance via simulation.

1. INTRODUCTION

A Mobile ad hoc network (MANET) is a collection of wireless nodes which dynamically configure themselves to form a network without the need for fixed infrastructure. For relaying the packets towards the destination, each node needs to implement routing functionality. As a result, the connection between any two nodes forms a multi-hop path supported by other nodes. However, for the network to operate, each node must be willing to forward packets on behalf of other nodes.

Multicasting is the transmission of datagram's to a group of hosts identified by a single destination address and hence is intended for group-oriented computing. Multicasting can efficiently support a variety of applications that are characterized by collaborative efforts and data transmission. Multicasting techniques can be considered as an efficient way to deliver packets from the source to any number of client nodes.

Multicast routing algorithms have become increasingly important in the field of wireless ad-hoc networks, because they enable the distribution of data to a potential large set of nodes. Nodes form a multicast delivery structure which in normal cases performs better than using multiple unicast routing paths. This is crucial in ad-hoc environments, where bandwidth and power resources are at a premium.

2. ON DEMAND MULTICAST ROUTING PROTOCOL – OVERVIEW

In ODMRP, group membership and multicast routes are established and updated by the source *on demand*. Similar to on-demand unicast routing protocols, a request phase and a reply phase comprise the protocol. While a multicast source has packets to send, it periodically broadcasts to the entire network a member advertising packet, called a JOIN REQUEST.

This periodic transmission refreshes the membership information and updates the route as follows. When a node receives a non-duplicate JOIN REQUEST, it stores the upstream node ID (i.e., backward learning) and rebroadcasts the packet. When the JOIN REQUEST packet reaches a multicast receiver, the receiver creates or updates the source entry in its Member Table. While valid entries exist in the Member Table, JOIN TABLES are broadcasted periodically to the neighbors. When a node receives a JOIN TABLE, it checks if the next node ID of one of the entries matches its own ID. If it does, the node realizes that it is on the path to the source and thus is part of the forwarding group. It then sets the FG Flag and broadcasts its own JOIN TABLE built upon matched entries. The JOIN TABLE is thus propagated by each forwarding group member until it reaches the multicast source via the shortest path. This process constructs (or updates) the routes from sources to receivers and builds a mesh of nodes, the *forwarding group*.

One of the basic internet tasks is routing between various nodes. It is nothing other than establishing a path between the source and the destination. However in large and complex networks routing is a difficult process because of the possible intermediate hosts it has to cross in reaching its final destination. In order to reduce the complexity, the network is considered as a collection of sub domains and each domain is considered as a separate entity. This helps routing easy. However basically there are three routing protocols in ad hoc networks namely proactive, reactive and hybrid routing protocols. Of these reactive routing protocols establish and maintain routes based on demand.

The reactive routing protocols (e.g. AODV) usually use distance-vector routing algorithms that keep only information about next hops to adjacent neighbors and costs for paths to all known destinations. The reactive routing protocols (e.g. AODV) usually use distance-vector routing algorithms that keep only information about next hops to adjacent neighbors and costs for paths to all known destinations.

The nodes then collectively ensured that all mobile nodes belonging to the multicast group get the message. If a node moves from one cell to another while a multicast is in progress, delivery of the message to the node was guaranteed.

Tree-based multicast routing provides fast and most efficient way of routing establishment for the communications of mobile nodes in MANET. The authors described a way to improve the throughput of the system and reduce the control overhead. When network load increased, MAODV ensures network performance and improves protocol robustness. Its PDR was found to be effective with reduced latency and network control overhead.

On Demand Multicast Routing Protocol is a multicast routing protocol (ODMRP) designed for ad hoc networks with mobile hosts. Multicast is nothing but communication between a single sender and multiple receivers on a network and it transmits a single message to a select group of recipients. Multicast is commonly used in streaming video, in which many megabytes of data are sent over the network. The major advantage of multicast is that it saves bandwidth and resources.

Moreover multicast data can still be delivered to the destination on alternative paths even when the route breaks. It is an extension to Internet architecture supporting multiple clients at network layers. The fundamental motivation behind IP multicasting is to save network and bandwidth resource via transmitting a single copy of data to reach multiple receivers. Single packets are copied by the network and sent to a specific subset of network addresses. These addresses point to the destination. Protocols allowing point to multipoint efficient distribution of packets are frequently used in access grid applications. It greatly reduces the transmission cost when sending the same packet to multiple destinations.

3. ODMRP FEATURES

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 REQUEST 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 removes the corresponding entries from its Member Table and does not transmit the JOIN TABLE for that group.

Nodes in the forwarding group are demoted to non-forwarding nodes if not refreshed (no JOIN TABLES received) before they timeout.

i) Data Structures

Network hosts running ODMRP are required to maintain the following data structures.

- Member Table: Each multicast receiver stores the source information in the Member Table. For each multicast group the node is participating in, the source ID and the time when the last JOIN REQUEST is received from the source is recorded. If no JOIN REQUEST is received from a source within the refresh period, that entry is removed from the Member Table.
- Routing Table: A Routing Table is created on demand and is maintained by each node. An entry is inserted or updated when a non-duplicate JOIN REQUEST is received. The node stores the destination (i.e., the source of the JOIN REQUEST) and the next hop to the destination (i.e., the last node that propagated the JOIN REQUEST). The Routing Table provides the next hop information when transmitting Join Tables.
- Forwarding Group Table: When a node is a forwarding group node of the multicast group, it maintains the group information in the Forwarding Group Table. The multicast group ID and the time when the node was last refreshed are recorded.
- Message Cache: The Message Cache is maintained by each node to detect duplicates. When a node receives a new JOIN REQUEST or data, it stores the source ID and the sequence number of the packet. Note that entries in the Message Cache need not be maintained permanently.

Schemes such as LRU (Least Recently Used) or FIFO (First In First Out) can be employed to expire and remove old entries and prevent the size of the Message Cache to be extensive.

ii) *Unicast Capability*

One of the major strengths of ODMRP is its unicast routing capability. Not only ODMRP can work with any unicast routing protocol, it can function as both multicast and unicast. Thus, ODMRP can run without any underlying unicast protocol. Other ad hoc multicast routing protocols such as AMRoute, CAMP, RBM, and LAM must be run on top of a unicast routing protocol. CAMP, RBM, and LAM in particular, only work on top of certain underlying unicast protocols.

4. PERFORMANCE EVALUATION

The simulator is implemented within the Global Mobile Simulation (GloMoSim) library. The GloMoSim library is a scalable simulation environment for wireless network systems using the parallel discrete-event simulation capability provided by PARSEC. Our simulation models a network of 50 mobile hosts placed randomly within a 1000 area. Radio propagation range for each node is 250 meters an_ d channel capacity is 2 Mbits/sec. Each simulation executes for 300 seconds of simulation time. Multiple runs with different seed numbers are conducted for each scenario and collected data is averaged over those runs.

A free space propagation model with a threshold cutoff is used in our experiments.

In the radio model, we assume the ability of a radio to lock on to a sufficiently strong signal in the presence of interfering signals, i.e., radio capture. If the capture ratio (the minimum ratio of an arriving packet's signal strength relative to those of other colliding packets) is greater than the predefined threshold value, the arriving packet is received while other interfering packets are dropped. The IEEE 802.11 Distributed Coordination Function (DCF) is used as the medium access control protocol. The scheme used is Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) with acknowledgments.

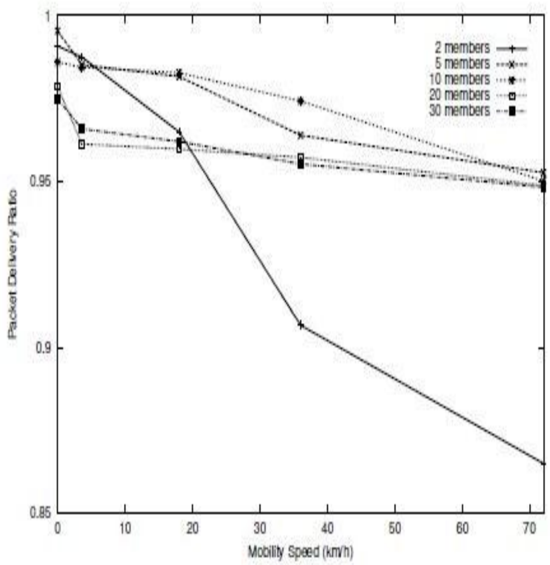
The metrics used in ODMRP evaluation are:

- **Packet Delivery Ratio**: The number of data packet delivered to multicast receivers over the number of data packets supposed to be delivered to multicast receivers.
- **Number of Control Bytes Transmitted per Data Byte Delivered**: Instead of using a pure control overhead, we choose to use a ratio of control bytes transmitted to data byte delivered to investigate how efficiently control packets are utilized in delivering data. In addition to bytes of control packets (e.g., JOIN REQUESTS, JOIN TABLES), bytes of data packet headers are included in calculating control bytes transmitted. Accordingly, only bytes of the data payload contribute to the data bytes delivered.
- **Number of Data and Control Packets Transmitted per Data Packet Delivered**: This measure shows the efficiency in terms of channel access and is very important in ad hoc networks since link layer protocols are typically contention-based.

5. SIMULATION RESULTS

The size of multicast group is varied to examine the scalability of the protocol. Having only two multicast members corresponds to a unicast situation. The result indicates that ODMRP delivers high portion of data packets in most of our scenarios. In highly mobile situations, the performance is the least effective in the two members' case.

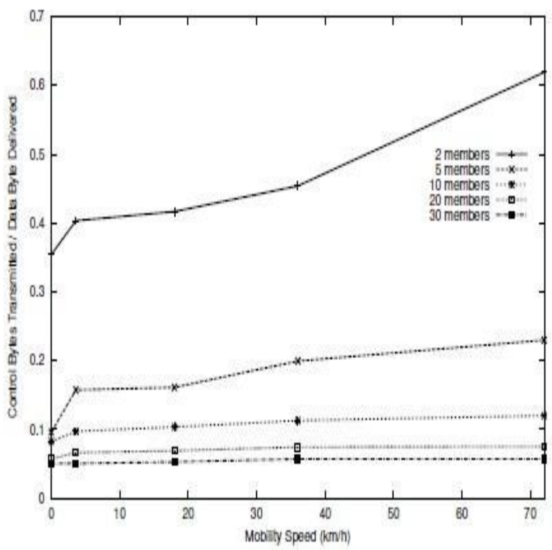
When ODMRP functions as a unicast protocol, a mesh is not formed and there is no redundancy in packet forwarding. Since there are no multiple routes, the probability of packet drop increases with mobility speed. This performance degradation with speed increase also occurs in other unicast routing algorithms. As the number of members increases, the forwarding group mesh creates richer connectivity among members. The mesh makes the protocol scalable and robust to speed. In a tree configuration, a link break prevents packets from being delivered until the tree is reconfigured. But in the mesh, the data can still reach receivers via other redundant routes formed by the forwarding group nodes. We can see from the result that ODMRP delivers over 95% of multicast packets even in the face of high mobility.

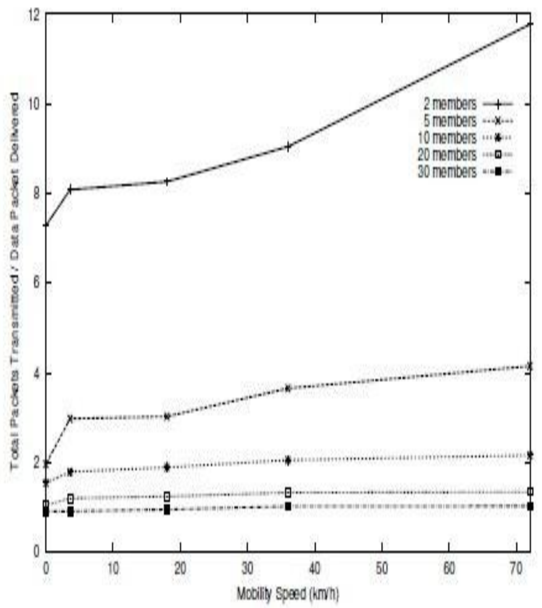


The average number of control bytes transmitted per data byte delivered is shown in Fig. 6. We can see that ODMRP efficiently utilizes control packets in delivering data. JOIN REQUESTS are transmitted by the source only when it has data to send. JOIN TABLES are sent by receivers when valid sources exist in their Member Table.

Thus, control packets are generated only if needed and all the control messages are utilized in establishing or refreshing routes and group membership. Furthermore, the transmission of control packets is periodic and the pure control overhead remains relatively constant regardless of mobility speed.

As expected, the efficiency improves as the number of multicast members grows larger. Although more JOIN TABLES are propagated when more nodes participate in a multicast group, the number of data delivered increases since more members receive the data.





6. CONCLUSIONS

We have proposed ODMRP (On-Demand Multicast Routing Protocol) for a mobile ad hoc wireless network. ODMRP is based on mesh (instead of tree) forwarding. It applies on demand (as opposed to periodic) multicast route construction and membership maintenance. Simulation results show that ODMRP is effective and efficient in dynamic environments and scales well to a large number of multicast members. The advantages of ODMRP are:

- Low channel and storage overhead
- Usage of up-to-date and shortest Routes.
- Robustness to host mobility.
- Maintenance and exploitation of multiple redundant paths.
- Scalability to a large number of Nodes.

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