Study of Multicast Routing Protocol in Wireless Mobile Adhoc Network

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Abstract: In Adhoc networks, each host must act as a router since routes are mostly multi hop. Nodes in such a networks move arbitrarily, thus network topology changes With the advance of wireless communication technology, portable computers with radios are being increasingly deployed in common activities. Applications such as conferences, meetings, lectures, crowed control, search and rescue, disaster recovery, and automated battlefields typically do not have central administration. A Mobile Ad Hoc Network (MANET) is formed by a cluster of mobile hosts without any predefined base station infrastructure. 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 sub- set 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. The major strengths of ODMRP are its simplicity and scalability. The Effective Multicasting routing Protocol in Wireless Mobile Ad hoc Network is used to enhance the effectiveness and efficiency of ODMRP. Primary Goals of Enhanced ODMRP: Improve adaptively to node movement patterns. Transmit control packets only when necessary, Reconstruct routes in anticipation of topology changes, Improve hop -by-hop transmission reliability, and Eliminate route acquisition latency.

1. Introduction:

We have a protocol termed ODMRP (On Demand Multicast Routing Protocol), is a mesh based multicast protocol that provides richer connectivity among multicast members. By building a mesh and supplying multiple routes, multicast packets can be delivered to destinations on the face of node movements and topology changes. To establish a mesh for each multicast group, ODMRP uses the concept of forwarding group. 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 FGFlagand broadcasts its own JOIN TABL E 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, called as forwarding group.

The forwarding group is a set of nodes responsible for forwarding multicast data on shortest paths between any member pairs. ODMRP also applies on-demand routing techniques to avoid the channel overhead and improve scalability. A soft-state approach is taken to maintain multicast group members. The major strengths of ODMRP are its simplicity. It introduces new techniques to enhance the effectiveness and the efficiency of ODMRP.

1.1 Data forwarding:

After the group establishment and route construction process, a multicast source can transmit packets to receivers via selected routes and forwarding groups. Periodic control packets are sent only when outgoing data packets are still present. When receiving a multicast data packet, a node forwards it only if it is not a duplicate and the setting of the FG_Flag for the multicast group has not expired. This procedure minimizes traffic overhead and prevents sending packets through stale routes.

1.2 Soft State:

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

2. Adapting the refresh interval via Mobility Prediction

ODMRP requires periodic flooding of JOIN QUERIES to build and refresh routes. Excessive flooding is, however, is not desirable in Adhoc networks because of bandwidth constraints. Furthermore, flooding often causes congestion, contention, and collision.

In the prediction method, we assume a free space propagation model, The free space propagation model assumes a transmit antenna and a receive antenna to be located in an otherwise empty environment. Neither absorbing obstacles nor reflecting surfaces are considered. In particular, the influence of the earth surface is assumed to be entirely absent. where the received signal strength solely depends on its distance to the transmitter. We also assume that all nodes in the network have their clock synchronized. Therefore, if the motion parameters of two neighbors are known, we can determine the duration of time these two nodes will remain connected. Assume two nodes i and j are within the transmission range r of each other. Let (x_i, y_i) be the coordinate of mobile host i and (x_j, y_j)

$$D_t=\frac{-(ab+cd)+\sqrt{(a^2+b^2)r^2-(ad-bc)^2}}{a^2+b^2}$$

Where $a=V_i\cos T_i - V_j\cos T_j$

$b=X_i - Y_i$

$c=V_i\sin T_i - V_j\sin T_j$

$d=Y_i - Y_j$

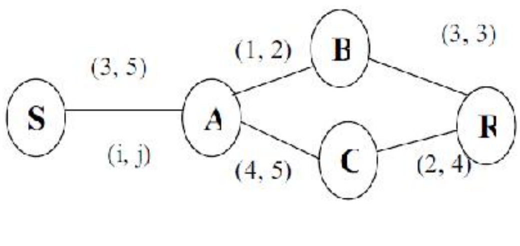
be that of mobile host j. Also let v_i and v_j be the speeds, and Ti and Tj(0<= Ti, Tj<2 Σ) be the moving direction of nodes i and j respectively, Then, the amount of time that they will stay connected, D_t is predicted by:

When a source sends JOIN QUERIES it appends its location, speed and direction. The next hop neighbor, upon receiving a JOIN QUERY, predicts the link expiration time (LET) between itself and the previous hop. The rationale is that as soon as single link on a path is disconnected, the entire path is invalidated. When a multicast member receives the JOIN QUERY, it calculates the predicted LET of the last link of the path. The minimum between the LET and the MIN_LET (Minimum Link Expiration Time) value specified in the JOIN QUERY is the RET (Route Expiration Time). The RET value is enclosed in the JOIN QUERY and broadcasted. If a forwarding group node receives multiple JOIN QUERIES with different RET values it selects minimum RET among them and sends its own JOIN REPLY with the chosen RET value attached. When the source receives JOIN REPLIES, it selects the minimum RET among all the JOIN REPLIES received. Then the source can build new routes by flooding a JOIN QUERY before the minimum RET approaches. In addition to the estimated RET value, other factors need to be considered when choosing the flood interval of JOIN QUERIES are:

1. If the node mobility rate is high and the topology changes frequently, routes will expire quickly and often.
2. The source may propagate JOIN QUERIES excessively and this excessive flooding can cause collisions and congestion, and clogs the network with control packets. Thus, the MIN-RFERESH-INTERVAL should be enforced to avoid control message overflow.
3. If the nodes are stationary or move slowly and link connectivity remains unchanged for a long duration of time, routes will hardly expire and the source will rarely send JOIN QUERIES.

3. Route Selection Criteria:

In the basic ODMRP, a multicast receiver selects routes based on the minimum delay. The Associatively-Based Algorithm (ABR) protocol chooses associatively stable routes. In an ad-hoc mobile network where mobile hosts (MHs) are acting as routers and where routes are made inconsistent by MHs' movement, we employ an associatively based routing scheme where a route is selected based on nodes having associatively states that imply periods of stability. In this manner, the routes selected are likely to be long-lived and hence there is no need to restart frequently, resulting in higher attainable throughput. Route requests are broadcast on a per need basis. The association property also allows the integration of ad-hoc routing into a BS-oriented Wireless LAN (WLAN) environment, providing the fault tolerance in times of base stations (BSs) failures. To discover shorter routes and to shorten the route recovery time when the association property is violated, the localized-query and quick-abort mechanisms are respectively incorporated into the protocol. To further increase cell capacity and lower transmission power requirements, a dynamic cell size adjustment scheme is introduced. The protocol is free from loops, deadlock and packet duplicates and has scalable memory requirements. Simulation results obtained reveal that shorter and better routes can be discovered during route re-constructions. In this new algorithm, instead of using the minimum delay path, we can choose a route that is the most stable (i.e. the one with the largest RET).To select a route, a multicast receiver must wait for an appropriate amount of time after receiving the first JOIN QUERY. So, that all possible routes and their RETs will be known. The receiver then chooses the most stable route and broadcasts a JOIN REPLY. Consider an example:



Link with delay i and link expiration time j

Figure: 1

	Route1	Route2
Path	S-A-B-R	S-A-C-R
Delay	7	9
RET	2	4

Rout Table

Two routes are available from the source S to the receiver R.Route1 has a path of <S-A-B-R> and Route2 has a path of <S-A-C-R>. If the minimum delay is used as the rote selection metric, the receiver node R selects Route1. Route1 has a delay of 7 (3+1+3=7) while the Route2 has a delay of 9 (3+4+2=9). Since the JOIN QUERY that takes Route1 reaches the receiver first, node R chooses Route1. If the stable route is selected instead, Route2 is chosen by the receiver. The expiration time of Route1 is 2 (min(5,2,3)=2) while that of Route2 is 4 (min(5,5,4)=4). The receiver selects the route with the maximum RETs, and hence Route2 is selected.

4. Reliability:

The reliable transmission of JOIN REPLIES plays an important role in establishing and refreshing multicast routes and forwarding groups. If JOIN REPLIESs are not properly delivered, effective multicast routing cannot be achieved by ODMRP. The IEEE 802.11 MAC (Medium Access Control) protocol which is emerging standard in wireless networks, performs reliable transmission by retransmitting the packet if no acknowledge is received. However, if the packet is broadcasted, no acknowledgments and retransmissions are sent. In ODMRP, the transmissions of JOIN REPLIES are often broadcasted to more than one upstream neighbor since we are handling multiple sources. In such cases, the hop-by- hop verification ofJOIN REPLY delivery and the retransmission cannot be handled by the MAC layer. Because of the limitations such as if many stations attempt to communicate at the same time, many collisions will occur which will lower the available bandwidth and possibly lead to congestive collapse and there is no notion of high or low priority traffic. Hence it must be done indirectly by ODMRP. Another option for reliable delivery is to subdivide the JOIN REPLY into separate sub- tables, one for each distinct next node. These JOIN REPLIES are separately unicasted using a reliable MAC protocol such as IEEE 802.11 or MACAW. Multiple Accesses with Collision Avoidance for Wireless (MACAW) is a slotted Medium Access Control (MAC) protocol widely used in Ad-hoc networks. The IEEE 802.11 RTS/CTS mechanism is adopted from this protocol. It uses RTS-CTS-DS-DATA-ACK frame sequence for transferring data, sometimes preceded by an RTS-RRTS frame sequence, in view to provide solution to the hidden terminal problem. MACAW is a non-persistent slotted protocol, meaning that after the medium has been busy, for example after a CTS message, the station waits a random time after the start of a time slot before sending an RTS. This results in fair access to the medium.

The below figure illustrates the mechanism:

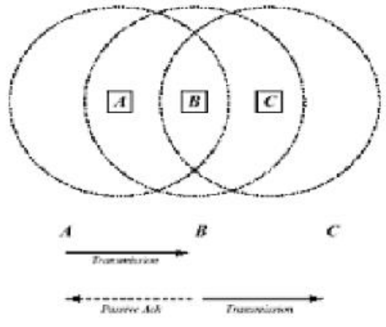


Figure: 2

When node B transmits a packet to node C after receiving a packet from node A, node A can hear the transmission of node B if it is within B's radio propagation range. Hence, the packet transmission by node B to node C is used as a passive acknowledge to node. We can utilize this passive acknowledge to verify the delivery of JOIN TABLE. Note that the source itself must send an active acknowledgement to the previous hop since it does not have any next hop to send a JOIN REPLY to unless it is a forwarding group node for other sources.

5. Elimination of Route Acquisition Latency :

The major drawback of on-demand routing protocols is the delay required to obtain a route. Route acquisition latency refers to the delay in discovering the route to a destination. This route acquisition latency makes on-demand protocols less attractive in networks where real-time traffic is exchanged. In the basic ODMRP, when no multicast route information is known by the source, data transmission is delayed for a period of time. In unicast, the source can send data as soon as a ROUTE REPLY is received. IN ODMRP, however, the data transmission cannot be made immediately after receiving the first JOIN REPLY since routes to receivers that are farther away may not yet have been established. To eliminate these problems, when a source has data to send but no multicast route is known, it floods the data instead of JOIN QUERY. The periodic transmission of JOIN QUERY is also replaced by data. Basically, JOIN DATA becomes a JOIN QUERY with data payload attached. Thus, the flooding of JOIN DATA achieves data delivery in addition to constructing and refreshing the routes. Although the size of the flooded packet is larger compared to JOIN QUERIES, route acquisition is eliminated.

6. Simulation Model and Methodology

6.1 Methodology:

To invest the impact of our enhancements, we simulated the following three schemes:

1. Scheme A: the basic ODMRP
2. Scheme B: the enhanced ODMRP that uses the minimum delay as the route selection metric.
3. Scheme C: the enhanced ODMRP that uses the route expiration time as the route selection metric.

Both enhanced schemes included reliable

transmission and route acquisition latency elimination features. The protocols were evaluated as a function of a) Speed and
b) Multicast group size.

In the first set of experiments, the size of multicast group was set constant to 10 and speed varied from 0 km/hr to 72 km/hr. In the second set of simulations, node mobility speed was constant at 18 km/hr and the multicast group size varied from 2(unicast) to 20.

The metrics of interest are:

- Packet delivery ratio: The number of data packets actually received by multicast members over the number of data packets supposed to be received by multicast members.
- End-to-end delay: The time elapsed between the instant when the source has data packet to send and the instant when the destination receives the data. Note that if no route is available, the time spent in building a route is included in the end-to-end delay.
- Control overhead: The total control bytes transmitted.
- Bytes of data packet and JOIN DATA headers in addition to bytes of control packets are calculated as a control overhead.
- Number of total packets transmitted per data packet delivered: The number of all packets transmitted divided by data packet delivered to destinations. 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.

6.2 Simulation results:
6.2.1 Packet delivery ratio:
The packet delivary ratio as a function of mobility speed and the multicast group size are shown in the below figures:

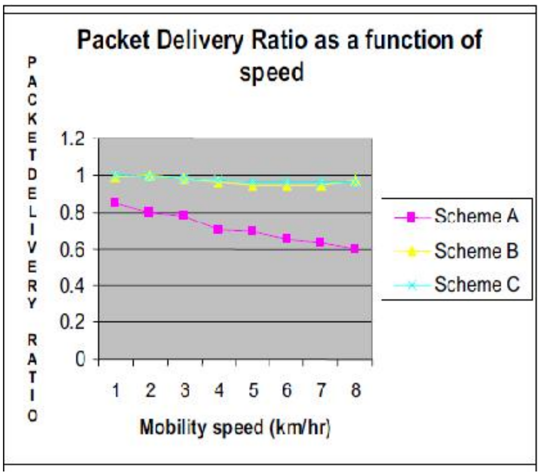


Fig:3

In the figure 3 as the speed increases, the routing effectiveness of Scheme A degrades rapidly compared to Schemes B and C. Both Schemes B and C have very high delivery ratios of over 96% regardless of speed. In Scheme A, JOIN QUERIES and JOIN REPLIES are transmitted periodically without adapting to mobility speed and direction. In Scheme A, nodes do not verify the reception of JOIN REPLIES transmitted. Most JOIN REPLIES failed to reach the source and establish the forwarding group. Thus, when data is sent by the source, the multicast route is not properly built and packets can not be delivered. Both Scheme B & C enforce reliable transmissions of JOIN REPLY.

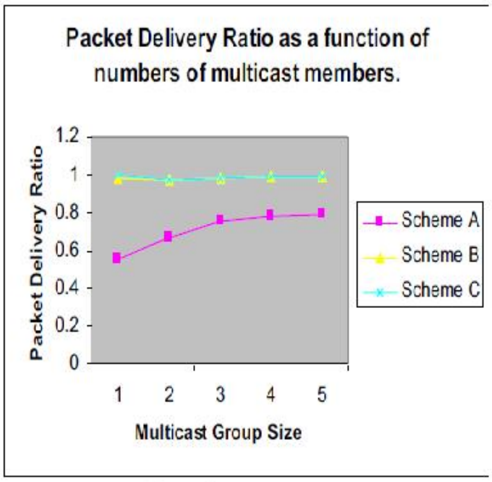


Figure: 4

In Figure: 4, Scheme B & C outperform Scheme A again. The result shows that our enhanced protocols are robust to multicast group size in addition to mobility speed. Scheme A's performance improves as the size becomes larger. As the number of receivers increases, the number of forwarding group nodes increases accordingly. Hence, the connectivity of multicast group members becomes richer and the redundancy of the paths helps delivering data to destinations.

6.2.2 End-to-end delay:

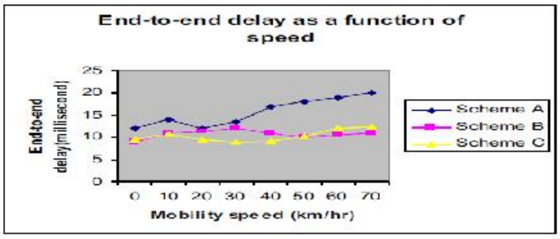


Figure: 5

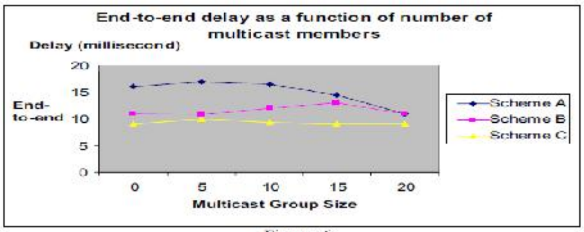


Figure: 6

Figure: 5 and Figure: 6 show the end-to-end delay of each

Scheme A. In Scheme A, sources flood JOIN QUERIES and must wait for a certain amount of time to send data until routes are established among multicast members. In Schemes B & C, on the contrary, sources flood JOIN DATA immediately even before routes and forwarding group are constructed. The route acquisition latency is eliminated and packets are delivered to receivers in shorter delays. The delay of Scheme B which uses the minimum delay route is larger than that of Scheme C which uses the stable route. When compared to stable routes, the minimum Delay routes break more frequently and data may need to traverse through longer redundant routes formed by forwarding group nodes.

6.2.3 Control overhead:

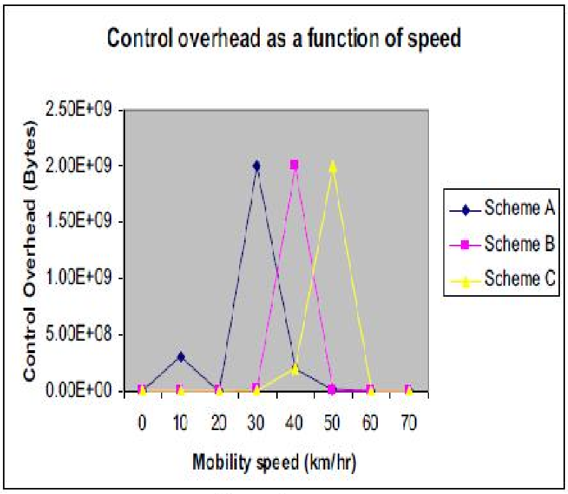


Figure: 7

Figure: 7 shows the control byte overhead as a function of mobility speed for each control. Transmission of control packets in Scheme A is time triggered only without adapting to mobility speed. Hence, the amount of control overhead does not increase as the mobility speed increases. Actually, control overhead decreases as nodes move faster. The overhead of Schemes B & C goes up as mobility speed increases. It is important to observe that the overhead of Scheme B & C are both significantly less than that of Scheme A in low mobility cases because control packets are transmitted only when necessary in Schemes B & C. The control overhead of all schemes increases when the number of multicast group increases. As there are more multicast receivers, more JOIN REPLIES are built and propagated.

6.2.4 Number of Total Packets Transmitted per Data Packet Delivered:

The number of total packets transmitted per data packet delivered is shown in figure:8 and figure:9

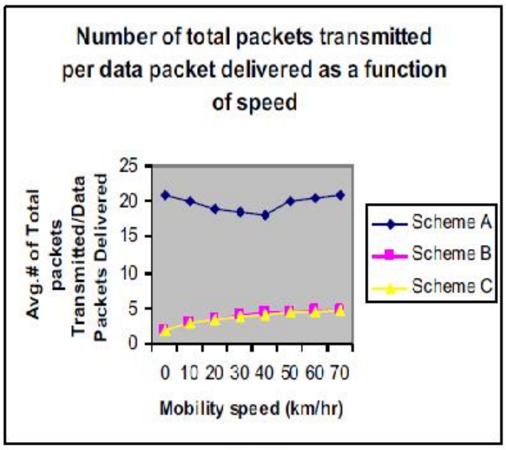


Figure: 8

In the above figure the number for scheme A remains relatively constant to mobility speed.the number for scheme A thus remains almost unchanging. The measure for scheme B and scheme C gradually increase with mobility speed. The control packets must be sent in order to adapt node mobility speed, and thus the total number of packets transmitted increases with speed.

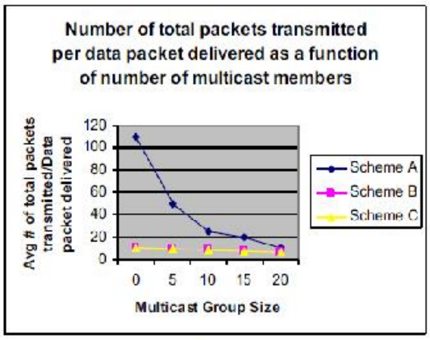


Figure: 9

In the above figure the number of all packets transmitted per data packet delivered decreases as the group size becomes larger for all schemes. This result is expected as the number of multicast members' increases, the number of data packets received by members' increases accordingly. Again scheme B and scheme C has greatly improved the efficiency of scheme A.

7. Conclusion:

This paper presented new techniques to improve the performance of ODMRP. By using the mobility and link connectivity prediction, routes and forwarding groups are reconstructed in anticipation of topology changes. This adaptive selection of the refresh intervals avoids the transmission of unnecessary control packets and the resulting bandwidth wastage. We have applies a new route selection algorithm to choose routes that will stay valid for the longest duration of time. The usage of stable routes further reduces the control overhead.Passive acknowledgements and retransmissions have been to improve the reliable delivery of JOIN REPLIES. The improved reliability plays a factor in protocol enhancement since the delivery of JOIN REPLIES in critical establishing the routes and forwarding group nodes. This also introduced a method to eliminate route acquisition latency. Simulation results showed that these new methods improved the basic scheme significantly. More data packets were delivered to destinations, less control packets more efficiently in high mobility, and end-to-end delay was shorter. The enhanced ODMRP was scalable, robust to host mobility, and efficient in channel access.

References:

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