ANGULAR DISPLACEMENT SCHEME (ADS): Providing Reliable Geocast Transmission for Mobile Ad-Hoc Networks (MANETs)

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Abstract
In wireless ad hoc environments, two approaches can be used for multicasting: multicast flooding or multicast tree-based approach. Existing multicast protocols mainly based on the latter approach, may not work properly in mobile ad hoc networks as dynamic movement of group members can cause the frequent tree reconfiguration with excessive channel overhead and resulting into loss of datagram. Since the task of keeping the tree structure up-to-date in the multicast tree-based approach is nontrivial, sometimes, multicast flooding is considered as an alternative approach for multicasting in MANET. The scheme presented in this research attempts to reduce the forwarding space for multicast packets beyond earlier presented scheme and also examine the effect of our improvements upon control packet overhead, data packet delivery ratio, and end-to-end delay by further reduction in the number of nodes that rebroadcasts multicast packets while still maintaining a high degree of accuracy of delivered packets.
The simulated result was carried out with OMNeT++ to present the comparative analysis on the performance of angular scheme with flooding and LAR box scheme. Our result showed a better improvement compared to flooding and LAR box schemes.
Keywords:
Angular Schemes, Forwarding Zones, Multicast Packets, Flooding, Request Zone and Multicast Region.

1.0 INTRODUCTION

LAR is a reactive source routing protocol which exploits position information and is proposed to improve the efficiency of the route discovery procedure by limiting the scope of route request flooding. In LAR, a source node estimates the current location range of the destination based on information of the last reported location and mobility pattern of the destination. Considering operations in LAR, a multicast region (expected zone) is defined as a region that is expected to hold the current location of the destination node. During route discovery procedure, the route request flooding is limited to a request zone, which contains the expected zone and location of the sender node.

Our improvements to LAR scheme consist of reducing the number of unnecessary duplicate route formation packets, however, this is done in a manner that produces more efficient routes. Limiting the forwarding space resulting in fewer geocast messages, while maintaining "accuracy" of data delivery comparable with multicast flooding [10]. In LAR scheme 1, a neighbour of S determines if it is within the forwarding zone by using the location of S and the expected zone for D. As shown in Figure 1.0, the expected zone for D is a circular area determined by the most recent location information on D, (X_D, Y_D), the time of this location information, (t_0), the average velocity of D, (V_{avg}), and the current time, (t_1). This information creates a circle with radius R such that:

$$R = V_{avg} \times (t_1 - t_0) \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

centered at (X_D, Y_D) (note however that this is for individual nodes within the multicast region which is denoted by a rectangle and all nodes within this region is expected to receive the multicast message). The forwarding zone is a rectangle with S in one corner, having coordinates (X_S, Y_S), and the circle containing D in the other corner. In addition, an error factor ∂ can be added to this radius to

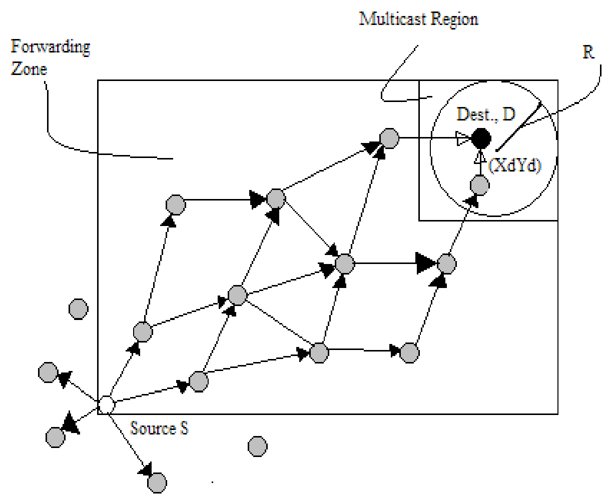

Figure 1: LAR scheme

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The extended LAR scheme involves a two stage route discovery method. In the first stage, the route request packet is forwarded according to the proposed LAR scheme, If a route reply packet is not received within the route request timeout period, then a second route request packet is flooded through the entire MANET. If a route reply packet is (again) not received within the route request timeout period, then D is considered unreachable. The above process is considered too rigid for a dynamically changing environment which characterizes MANETs. It therefore behoves that while location information assists in reducing the route discovery message, it should made adaptive not to unnecessarily flood the network.

The rest of the paper is organized as follows: in section 2, we presented the related work and the principal work which we enhanced. We introduced our contribution in section 3 with the mathematical models. Section 4 presents the performance evaluation and the result discussion. We conclude in section with future work directions.

2.0 RELATED WORK

Several research attempts have been made to drive home the importance and main characteristics of location aided routing (LAR). LAR protocols employ location information (which may be out of date before it is used) to reduce the possible search space in locating a desired route. The essence of reduction in the search space is to limit the route discovery messages to be broadcasted.

Since the development of the LAR schemes, a number of improvements have been proposed [7, 11]. Efforts most related to our own was that carried out in [5, 7]. In this case, their improvements were based on the idea of count restrictions of rebroadcasts. Whenever a node receives a route request, the node first waits for an Assessment Delay (AD) to determine how many other nodes rebroadcast the same packet. If the number of duplicate rebroadcasts heard is below some threshold: the Count Threshold (CT)), then the node will rebroadcast the route request. Otherwise, the node in question just drops the packet. The purpose behind this count restriction is to reduce the number of control packets by reducing the number of unnecessary rebroadcasts. The authors devised a model termed the projection method. The main concept behind the projection method involves nodes that are closest to the destination D, to rebroadcast sooner, and nodes that are further will have a higher assessment delay, causing them to wait longer before rebroadcasting. It involves calculating the AD such that it is higher if the receiving node is far from the sending node (which is bounded by the transmission range) but lower if the receiving node is in the same direction as the destination node.

In Location-Based Associativity for MANET, [16] combined the ideas of two earlier papers and propose an algorithm, which is useful to derive bandwidth-efficient and long-lived routes, resulting in the improvement of performance of mobile ad hoc networks. Their work was supported with complexity analysis. The two papers are: The Location-Aided Routing Algorithm of [14] which made use of physical location information of destination node to reduce the search space for route discovery only, and not for data delivery. It does not cover route maintenance in case of broken links. The second is the Associativity-Based Routing Algorithm of [15]. It selects the route, based on node's associativity states. Therein, the search space used to determine the route to the destination node is equal to the entire network space and due to broadcast, the amount of routing related traffic increases, thereby consuming large portion of bandwidth.

[17] proposed a Distance-Based Location-Aided Routing (DBLAR) for MANETs. In their research, tracing the location information (LI) of destination nodes and the change of distance between nodes can be used to adjust route discovery dynamically, the proposed routing algorithm is made to avoid flooding in the whole networks. Besides, Distance Update Threshold (DUT) is set up to reach the balance between real-time ability and update overhead of location information (LI) of nodes.

In the scheme introduced in [7] however, the forwarding zone is specified explicitly by the source S, and is modified by any intermediate node. By adapting the forwarding zone at any intermediate node I, the performance of the scheme can be improved. As an illustration in figure 2, when node I receives the multicast data packet from the source S and forwards the packet to its neighbours, because I is within the forwarding zone Z (defined by S), it can replace Z by an adapted forwarding zone Z as shown in figure 2 before forwarding the packets.

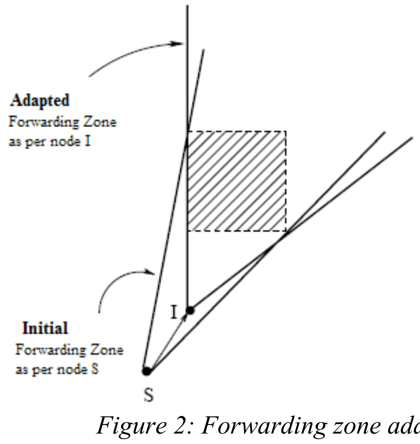


Figure 2: Forwarding zone adaptation

Considering the above and applying the same reasoning, suppose node J receives the data packet from node I, the forwarding zone will again be adapted. However, this method tends to increase the computing path cost as each node has to recalculate the forwarding zone specification from its location with respect to the multicast region.

Another notable drawback is that the authors assumed (explicitly) that only one neighbour of the sender forwards multicast packets. They do not take into consideration the source's neighbours which may also define their own forwarding zone thereby increasing the complexity as nodes do not know whether they are still within the forwarding zone or not. In this scenario, each node defines its own forwarding zone with respect to the multicast region. The above described resulted into high end-to-end delay, unstable data delivery ratio which is not favourable for the operations in MANETs.

3.0 ANGULAR DISPLACEMENT SCHEME (ADS)

Our proposed scheme is based on modification of the forwarding zone as specified in [7] which we called the angular displacement scheme (ADS). ADS attempts to reduce the delay experienced in the scheme in [7] by defining the forwarding zone from the source S and intermediate nodes do not have to adapt the forwarding zone based on their own location but rebroadcasts the packet once it is within the forwarding zone as defined by source S.

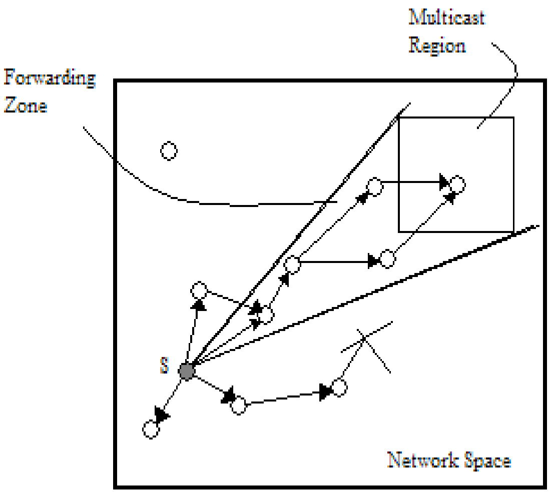


Figure 3: Forwarding zone modification

However, in this scheme, every neighbour (nodes within S's transmission range) of S rebroadcast the packet (this is determined by sequence numbers in the geocast packet which is 1 for every neighbour of S). This is to take care of the limited coverage area for the forwarding zone specification from source S.

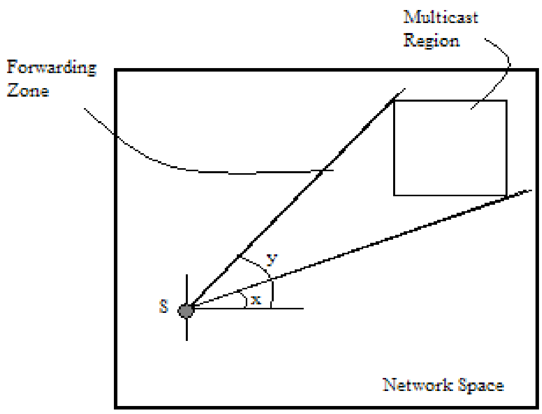


Figure 4: Defining the forwarding zone

Operationally, the forwarding zone is defined thus: S compares its location with that of the multicast region to derive two angles x and y as shown in Figure 4. The angular displacement □ of the multicast region from the source is then given by

$$\square = y - x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

To provide additional control on the size of the forwarding zone, we define a parameter ∂, which can be used to extend the forwarding zone. When ∂ is positive, the displacement angle is extended in positive and negative X and Y directions by ∂. Thus, the angular displacement equation becomes

$$\square = (y - x) + \partial \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Equation is therefore employed to dynamically adjust the forwarding zone based on the calculation of the angular displacement of every participating node within the network. We present the simulated environment and the results in the next section.

4.1 PERFORMANCE EVALUATION

To evaluate our schemes, we performed simulations using OMNet simulator which is a discrete event simulator built to provide a flexible platform for the evaluation and comparison of network routing algorithms. Two protocols were simulated – multicast flooding and angular scheme- and we compared our results with that of LAR Box scheme. We studied several cases by varying the number of nodes, the network size, the size of forwarding zone and transmission range of each node as well as the size of the geocast zone. We also compared our results with a similar implementation of schemes proposed in [7] and the result showed that ADS scheme improved on the inherent overhead and end-to- end delay.

There is also corresponding increase in the effectiveness of the network by increasing the data delivery ratio, as analyzed in subsequent simulation results graphs. The data delivery ratio is defined as the number of data packets received at the destination nodes divided by the number of data packets transmitted from the source nodes.

4.2 Simulation Model

Number of nodes in the network was chosen to be 50. The nodes in the mobile ad hoc network were confined to a 500 unit x 500 unit square region. Initial locations (X and Y coordinates) of the nodes are obtained using a uniform distribution. We assume that a node knows its current location accurately. Also, we assume that each node moves randomly, without pausing at any location. Each node moves with an average speed v. The actual speed is uniformly distributed in the range v ± μ units/second, where, we use μ = 2.5. In our preliminary evaluation, we only consider average speed (v) of 2.5 units/sec.

The mobility model utilized was the random waypoint mobility model. Each node makes several "moves" during the simulation. A node does not pause between moves. During a given move, a node travels distance *d*, where *d* is exponentially distributed with mean 10. The direction of movement for a given move is chosen randomly. For each such move, for a given average speed *v*, the actual speed of movement is chosen uniformly distributed between *v* ± μ. If during a move (over chosen distance *d*), a node "hits" a wall of the network region, the node bounces and continues to move after reflection, for the remaining portion of distance *d*.

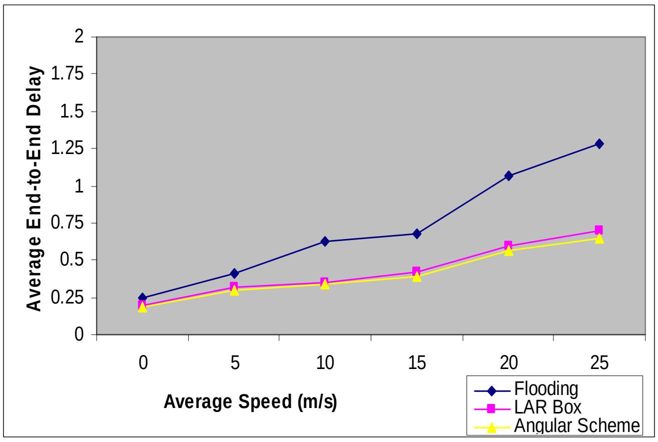
Two mobile hosts are considered disconnected if they are outside each other's transmission range. All nodes have the same transmission range. For the simulations, transmission range values of 50, 100, 150 200 and 250 units were used. All wireless links have the same bandwidth, 2 Megabytes per second. Each simulation run simulated 1000 seconds of execution. For the simulation, a sender is chosen randomly and a multicast region is predefined. We assume that the multicast region is a 150 unit x 150 unit square region with both X and Y coordinates in the range between 250.00 and 400.00. The source performs one multicast per second, which implies that 1000 multicasts was achieved in each simulation run.

4.3 RESULTS DISCUSSION

In our simulations, we do not model the delays that may be introduced when multiple nodes attempt to transmit simultaneously. Transmission errors and congestion are also not considered.

4.3.1 End to End Delays

Figure 5(a) shows the graph of end to end delays experienced by three protocols compared in our simulation against average speed of nodes. Since traditional flooding scheme involves every node receiving the geocast packet, the average delay is higher than that of the LAR Box and the angular displacement scheme.

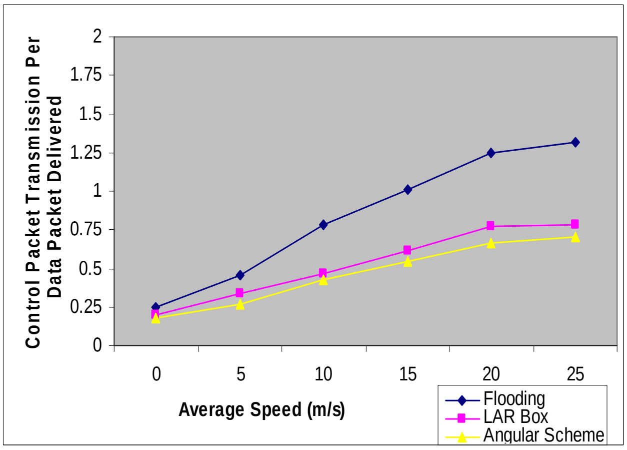


5(a): End-to-End Delays

This delay is reduced in the LAR Box method since fewer nodes receive the geocast packets and lesser nodes requires processing of geocast packets for re-routing. However, the angular displacement scheme further reduces this delay when compared with the result of LAR Box. This result was made possible by the introduced displacement angle, which was employed in determining the transmission range of the nodes in the network.

4.3.2 Control Packet Overhead

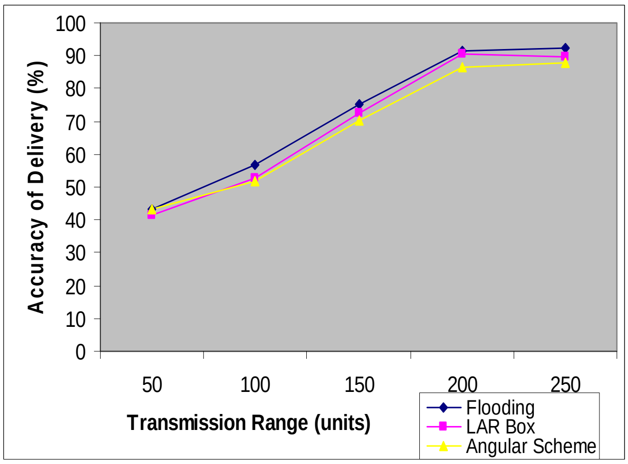
We also compared control packets transmitted when simulating our model alongside with flooding and LAR Box the result of which is shown in figure 5(b). The control packets are those exchanged between nodes to ensure that a sent packet is delivered to the correct recipient, in this case any node in the geocast region. In multicast flooding, since every node receives the packet (in some cases more than once), the control packet overhead is far higher than that of the LAR Box or the angular scheme. Simulated results depicts that control packet overhead is further reduced in our scheme compared to that of LAR Box since lesser nodes now require the exchange control packet information. The above result on control packet overhead is further improved in the angular scheme when there is increases speed of nodes.



5(b): Control Packet Overhead

4.3.3 Accuracy of Delivery

The accuracy of delivery of any protocol is one of the most important aspects of any routing protocol. However, there is no known protocol that can boast of 100 percent accuracy. Due to varying network properties, the accuracy of delivery is affected.



5(c): Accuracy of Delivery

In our model, we achieved a relatively high level of accuracy contrary to expectation when compared with flooding and LAR Box. This is sequel to the reduced number of nodes receiving and rebroadcasting the geocast packet which is a significant improvement. As seen in Fig 5(c), flooding amongst the three simulated protocol had the highest accuracy of delivery, the reason is not far fetched judging from its operation, however, this singular factor is marred with incurred end to end delay, and soaring control overhead as every packets need be equipped with appropriate information. It therefore worthwhile to note that the accuracy of delivery of our scheme, present not very significant difference when compared with that of multicast flooding and LAR Box method.

5.0 CONCLUSION

We proposed a new location-based multicast algorithm. The proposed algorithms limit the forwarding space for a multicast packet to the so-called forwarding zone. Simulation results indicate that proposed algorithms result in lower message delivery overhead, as compared to multicast flooding. As simulation results show, while reducing the message overhead significantly, it is possible to achieve accuracy of multicast delivery that compares favourably with multicast flooding.
As networks of the new millennium increasingly tend towards interoperability, the overall throughput of geocast routing schemes should be extensively researched so as to improve the efficiency. Already developed protocols can be improved to increase robustness and reduce traffic overhead caused by control packets.

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