Data Delivery Pattern Enhancement in Wireless Ad-Hoc Networks Using Co-ordinate Schemes

ONIFADE F.W. OLUFADE & LONGE, O.BABATOPE*
Department of Computer Science, University of Ibadan, Nigeria

AKANDE OYINDAMOLA. O,
Department of Computer Science & Information Technology, Bowen University, Nigeria.

Current multicast protocols in mobile ad hoc networks as dynamic movement of group members can cause the frequent tree reconfiguration with excessive channel overhead and loss of datagrams [Johnson and Maltz, 1996; Joa-Ng and Lu, 1999; Navid et al, 1999; Zhou and Singh, 2000; Haas and Pearlman, 1998; Ramanathan and Steenstrup, 1998; Jinyna, et al, 2000]. Building on an earlier proposal for angular schemes [Onifade et al, 2007], we present a protocol for improving data delivery patterns in wireless ad-hoc networks using co-ordinate schemes. The proposed location-based multicast algorithm limit the forwarding space for a multicast packet to the so-called forwarding zone. Simulation results showed that our efforts will result into lower message delivery overhead with the potential for achieving accuracy of multicast delivery comparable with multicast flooding.

Categories and Subject Description: C2[Computer-Communication Networks]C.2.1. *Wireless communication* C.2.2. *Routing protocols*
General Terms: *Angular Schemes, Co-ordinate Schemes, Forwarding Zones and Flooding.*
Additional Keywords and Phrases: *Multicast Packets, Flooding, Request Zone, MANET, LAR and Multicast Region.*

IJCIR Reference Format:

Olufade F.W. Onifade, Longe O. Babatope & Akande Oyindamola. O. Data Delivery Pattern Enhancement in Wireless Ad-Hoc Networks Using Co-ordinate Schemes. International Journal of Computing and ICT Research. Vol. 2, No. 2, pp. 75-83. http://www.ijcir.org/volume2-number2/article 7.pdf.

1. INTRODUCTION

Angular scheme has been proposed as a reliable geocast transmission method for mobile ad-hoc networks [Onifade et al, 2007]. This improvements to Location-Aided Routing (LAR) scheme consisted of reducing the number of unnecessary duplicate route formation packets, but doing so in a manner that produces more efficient routes. Limiting the forwarding space results into fewer geocast messages, while

* Author's Address: Onifade*, F.W. Olufade, Department of Computer Science, University of Ibadan, Ibadan, Nigeria; Longe, O.Babatope, Department of Computer Science, University of Ibadan, Ibadan, Nigeria; and Akande, Oyindamola, O, Department of Computer Science & Information Technology, Bowen University, Iwo, Osun State, Nigeria.

International Journal of Computing and ICT Research, ISSN 1818-1139 (Print), ISSN 1996-1065 (Online), Vol.2, No.2 pp. 75-83, December 2008.

maintaining "accuracy" of data delivery comparable with multicast flooding [Flikkema, 1995]. In LAR scheme 1, depicted in figure 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, 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

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

is 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 at 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 account for an increase in speed of the destination by increasing the size of the forwarding zone. With this error factor, the formula for R becomes

$R = (V_{avg} \times (t_1 - t_0)) + \partial$ ………………….(2)

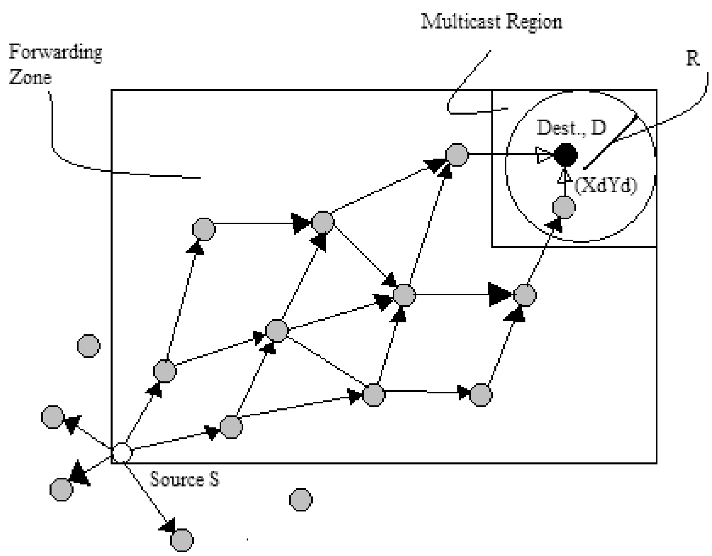

Figure 1: LAR scheme 1

LAR schemes 1 depicted in figure 1 above proceeds in a two stage route discovery method. In the first stage, the route request packet is forwarded according to LAR scheme 1. 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 Mobile Ad-hoc Network (MANET). If a route reply packet is (again) not received within the route request timeout period, then D is considered unreachable.

2. RELATED WORK

Since the development of the LAR schemes, a number of improvements have being proposed [Ko and Vaidya, 1998; Colagrosso et al, 2004]. Efforts most related to our own was that carried out in [R. Ramanathan, and M. Steenstrup, 1998]. 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, V.N.Sastry and P.Supraja (2005) 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 [Ko Young-Bae, and N.H.Vaidya, 2000] 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 [Chai-Keong Toh, 1996]. 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.

K. Wang et. al. (2008) 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.

3. COORDINATE SCHEME

The modification presented in our research utilizes the concept of assessment delay (AD) such that nodes that are closer to a geographically constructed diagonal and in the direction of the multicast region broadcast sooner. This method is aimed at reducing cost computing of mobile nodes such that nodes rebroadcast packets almost instantaneously once it examines its coordinates with that of the forwarding zone specified in the received packet. The forwarding zone adaptation utilized in our work however, further reduces the number of nodes which rebroadcasts the geocast packets.

Consequent upon the above, we propose a scheme called the coordinate scheme which tends to modify the criteria under which nodes rebroadcasts geocast packets. In the LAR scheme 1, nodes that are inside the forwarding zone when they receive geocast packets rebroadcasts the packets. Our scheme involves the source node implicitly constructing a diagonal line which is constructed from the source through to the geometrical centre (or geocentre) of the multicast region as shown in Figure 2, such that nodes which are located on the diagonal line or close to it will have a lower AD and rebroadcast the packet immediately reducing end-to-end delays as well as reducing the number of nodes that rebroadcasts the packet. When the packet is received by any node within the multicast region, all it does is to broadcast the message to all nodes within the multicast region since all nodes in this location are expected to receive the packet.

The coordinate scheme is implemented as follows: Assume that a source node S wishes to send a packet that will be received by nodes within a multicast region whose geometrical centre is specified by coordinates (X_D, Y_D) as shown in Figure 2. We assume that every node within the network is able to determine their own location using Geographic Positioning System (GPS). When a source S wants to send a multicast packet, the forwarding zone coordinates is still maintained as described and the main purpose is to take into consideration, the mobility of nodes as well as the fact that not all nodes will be on the diagonal or close to it, and also, the transmission range limitations. The forwarding zone coordinates are sent along with each broadcast packets as well as the diagonal coordinates so that nodes can determine if they are within the forwarding zone and if they are, their closeness to the diagonal.

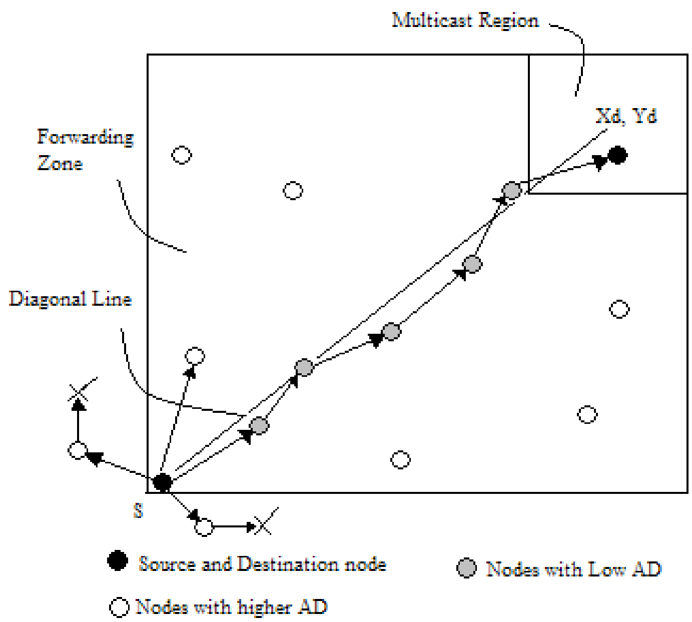

Figure 2: Coordinate scheme

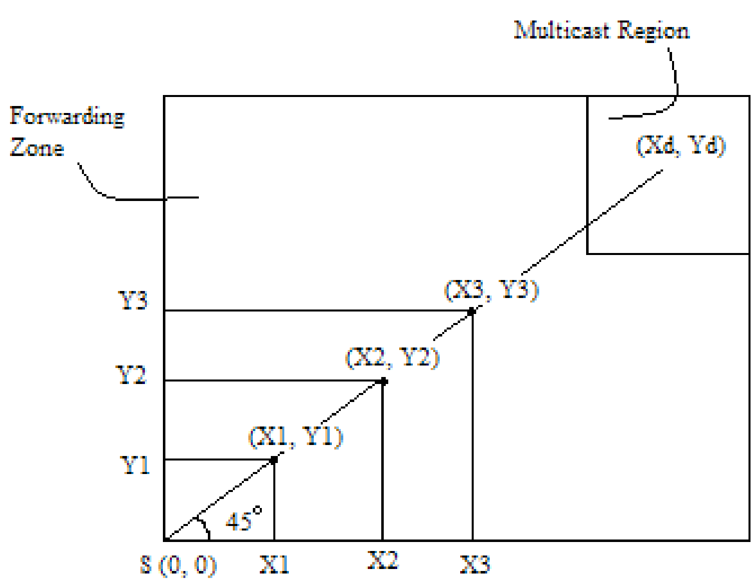

Figure 3(a): Diagonal construction

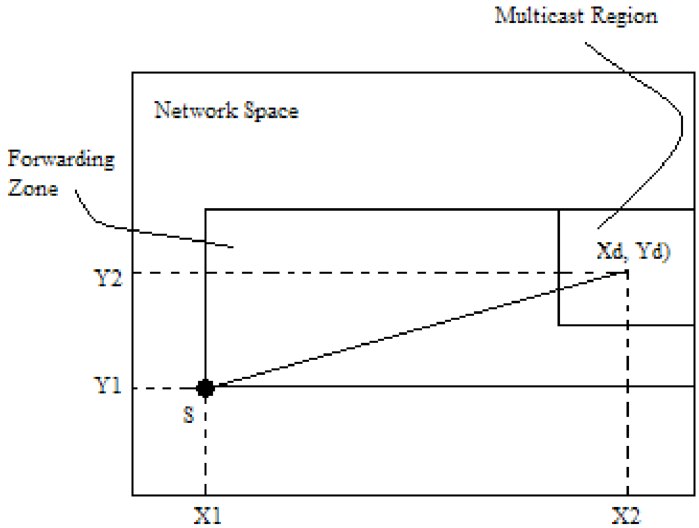

Figure 3(b): Alternative diagonal construction

The diagonal is constructed thus: since the line is meant to traverse the path from source S having coordinates (XsYs) and destination D having coordinates (X_D, Y_D). Suppose the multicast region is exactly 45˚ from the current location of S with coordinates at (0, 0), the coordinates of the diagonal will have coordinates X = Y at every point on the diagonal as shown in the Figure 3(a). However, as this is not possible for all scenarios, we further extend the construction of the diagonal line as follows (i.e. when the multicast region is not at 45˚or coordinates is not at (0, 0)). Since the coordinates of the X and Y axis will be different, the diagonal line is constructed from the source S for simplicity, having coordinates (X_1, Y_1). The geocenter of the multicast region is denoted by coordinates (X_2, Y_2) as shown in Figure 3.3(b). The horizontal and vertical distance between source S and destination D is calculated thus:

Horizontal = $X_2 - X_1$ …………………….(3)

Vertical = $Y_2 - Y_1$…………………….......(4)

Based on the above, suppose the horizontal and vertical distance produces X and Y as distances respectively, the coordinates of the diagonal is then constructed from source S to destination D based on ratio of X to Y and subsequent increases based on ratio of X:Y. For example, if distance X is 50 and that of Y is 10, the ratio would be 5X : Y (i.e. every single unit on the Y axis produces 5 corresponding units on the X axis) and coordinates of the diagonal will increase based on this specification.
We also introduce an error factor ∂ that takes into consideration the mobility of mobile nodes as it is not possible for nodes to always be on the diagonal. However, closeness to this diagonal is desired. When ∂ is positive, the width of the diagonal is extended in positive and negative X and Y directions by ∂ (thus each side increases by 2∂ thereby increasing the size of the diagonal).

4. 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 coordinate scheme. The simulation results are then compared 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 [Ko and Vaidya, 1998] and found that the co-ordinate scheme further decreased overhead and end-to-end delay, while increasing the effectiveness of the network by increasing the data delivery ratio, as analyzed in subsequent graphs.

4.1 Simulation Model

Number of nodes in the network was chosen to be 50. The nodes in the mobile ad hoc network are 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 continuously, without pausing at any location. Each node moves with an average speed v. The actual speed is uniformly distributed in the range $v \pm \mu$ units/second, where, we use $\mu = 2.5$. 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 $v \pm \mu$. 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 means that 1000 multicasts have been done in each simulation run.

4.2 End to End Delays

Figure 4(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 coordinate scheme. The 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. The delay is however further reduced in the coordinate scheme as shown in Fig 4(a) as nodes which are on the diagonal rebroadcast the packet immediately. We also discovered that with increased node density, delay experienced in our scheme is further reduced as more nodes tend to "move" around the diagonal and rebroadcast packets on time.

4.3 Control Packet Overhead

We also compared control packets transmitted when simulating our model with that of flooding and LAR Box the result of which is shown in figure 4(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 coordinate scheme. The control packet overhead is further reduced in our scheme compared to that of LAR Box since lesser nodes exchange control packet information.

4.4 Accuracy of Delivery

The accuracy of delivery of any protocol is one of the most important aspects of any routing protocol. However, no one protocol can boast of 100 percent accuracy. Due to varying network properties, the accuracy of delivery is affected. In our model, we achieved a relatively high level of accuracy when compared with flooding and LAR Box even with reduced number of nodes receiving and rebroadcasting the geocast packet which is a significant improvement. The accuracy is comparable with that of the LAR

Box with high transmission range as nodes on the diagonal send packets over longer distances in turn reducing end to end delays.

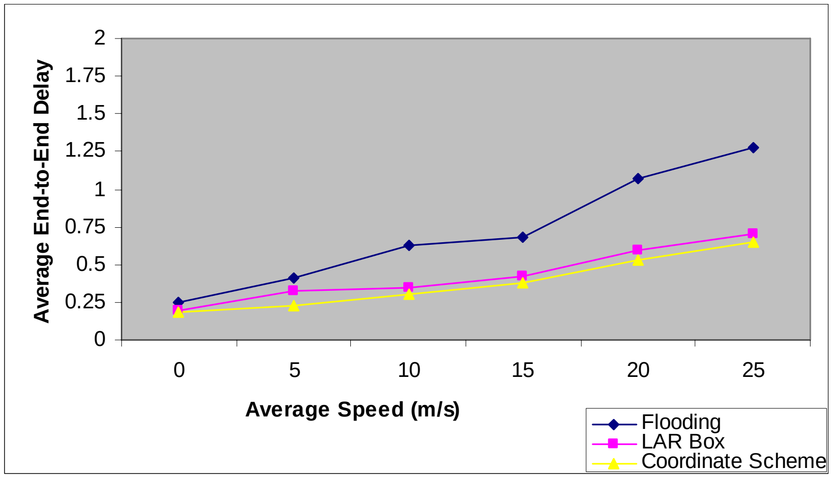

Figure 4(a:) End-to-End Delays

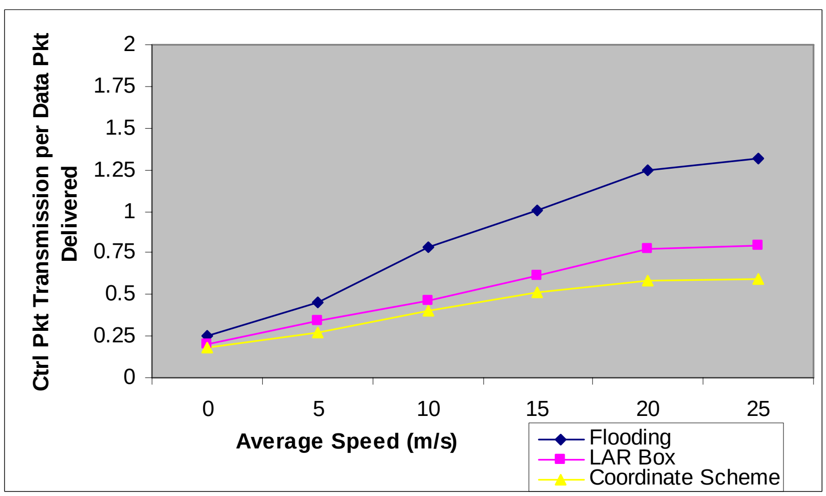

Figure 4 (b) Control Packet Overhead

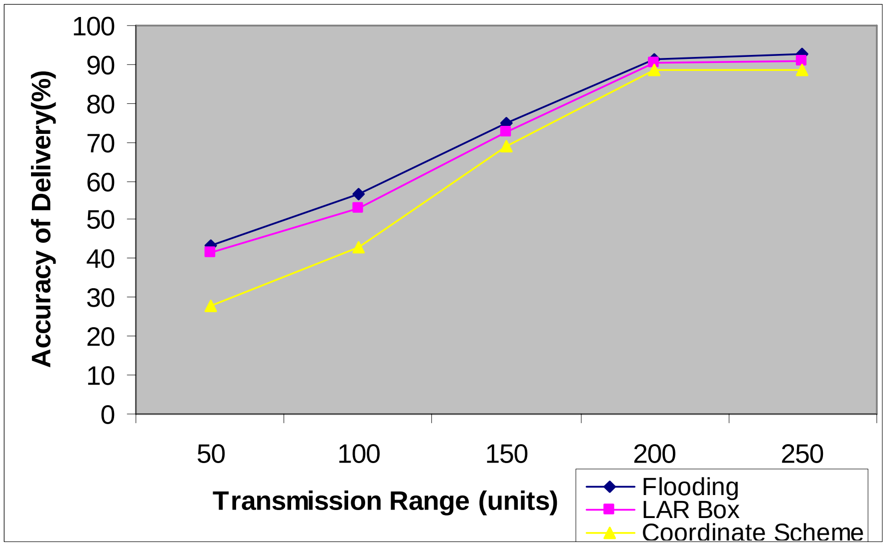

Figure 4 (c) Accuracy of Delivery

5.0 CONCLUSION AND FUTURE WORK DIRECTION

We proposed two location-based multicast algorithms. 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 comparable with multicast flooding.

Interoperability remains an onus in the development of networks for the new millennium. The overall throughput of geocast routing schemes when extensively researched will aid in improving overall efficiency. Our future work direction will involve concerted efforts to increase packets delivery accuracy and further reduces the control packets overhead aimed at improving the efficiency and reliability of the protocol.

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