

A New Reliable Broadcasting in Mobile Ad Hoc Networks

S.V.M.G.Bavithiraja M.E.,¹

Dr R. Radhakrishnan M.E., P.hD.,²

¹ Lecturer, Department of CSE, VLB Janakiammal College of Engineering and Technology, Coimbatore-42, India.

² Professor, Department of ECE, Sri Ramakrishna Engineering College, Coimbatore-22, India.

Summary

A New Reliable Broadcasting Algorithm for mobile ad hoc networks will guarantee to deliver the messages from different sources to all the nodes of the network. The nodes are mobile and can move from one place to another. The solution does not require the nodes to know the network size, its diameter and number of nodes in the network. The only information a node has its identity (IP Address) and its position. On average, only a subset of nodes transmits and they transmit only once to achieve reliable broadcasting. The algorithm will calculate the relative position of the nodes with respect to the broadcasting source node. The nodes that are farthest from the source node will rebroadcast and this will minimize the number of rebroadcasts made by the intermediate nodes and will reduce the delay latency. The proposed algorithm will adapt itself dynamically to the number of concurrent broadcasts and will give the least finish time for any particular broadcast. It will be contention free, energy efficient and collision free.

Key words

Broadcasting Algorithm, IP Address, Mobile Ad Hoc Networks, Collision, Delay latency.

1. Introduction

In wireless communication systems, there will be a need for the rapid deployment of independent mobile users. Significant examples include establishing survivable, efficient, dynamic communication for emergency/rescue operations, disaster relief efforts, and military networks. Such network scenarios can not rely on centralized and organized connectivity, and can be conceived as applications of Mobile Ad Hoc Networks (MANET).

A Mobile Ad Hoc Network (MANET) is a set of nodes communicating with each other via multi-hop wireless links. Each node can directly communicate with only those nodes that are in its communication range. Intermediate nodes forward messages to the nodes that are more than one hop distance from the source. Since the nodes are mobile, the topology of the network is constantly changing. The set of applications for MANETs is diverse, ranging from small, static networks that are constrained by power sources, to large-scale, mobile,

highly dynamic networks. Broadcasting is the process in which one node sends a packet to all other nodes in the network. Broadcasting is often necessary in MANET routing protocols. For example, many routing protocols such as Dynamic Source Routing (DSR), Ad Hoc on Demand Distance Vector (AODV) and Location Aided Routing (LAR) use broadcasting to establish routes. The broadcast is spontaneous. Any mobile host can issue a broadcast operation at any time.

Existing broadcasting methods in mobile ad hoc networks are single source broadcasting algorithms in which only one source node can send the broadcast message to all the nodes in the network. Existing broadcasting algorithms are classified into following types.

Simple flooding - It starts with a source node broadcasting a packet to all its neighbours. Now each of the neighbours that receive this packet will rebroadcast the packet exactly once and this continues until all the nodes in the network have received the packet. The duplicate packets are not broadcasted again. The technique is expensive and results in collision.

Probability Based Method - Source node broadcasts the packet to all its neighbours. Some neighbour nodes rebroadcast the packet. The selection is based on predetermined probability. When the probability is 100%, this scheme is same as simple flooding. This method is well suited for dense networks. For sparse networks, all the nodes might not receive the packets.

Area Based Method - In the area based method, the packet is re-broadcasted only if the node covers a significant amount of area than the sender who sent the packet. Suppose a node receives a packet from a sender that is located very close to it. If the receiving node rebroadcasts, the additional area covered by the retransmission is low. If the receiving node is located at the boundary of the sender node's transmission distance, then a rebroadcast would reach significant additional area.

Distance-Based Method - A node using the Distance-Based Scheme compares the distance between itself and each neighbor node that has previously rebroadcast a given packet. Upon reception of a previously unseen packet, a RAD (Random Assessment Delay) is initiated and redundant packets are cached. When the RAD expires, source node location is examined to see if any node is closer than a threshold distance value. If true, the node doesn't rebroadcast [1].

Neighbor knowledge method - In this method each node will have knowledge of its neighbors and maintains neighbors list. A node that receives a broadcast packet compares its neighbor list to the sender's neighbor list. If the receiving node would not reach any additional nodes then it will not re-broadcast. Otherwise the node rebroadcasts the packet. This is called as self-pruning.

The proposed multi source broadcasting algorithm allows multiple sources broadcast the messages to all the nodes in the network. It combines area based technique and neighbor based technique. Each node will have knowledge of its neighbours and maintains neighbours list. The algorithm calculates the relative position of the nodes with respect to the broadcasting source node. The nodes that are farthest from the source node rebroadcasts next. The algorithm tries to minimize the number of rebroadcasts made by the intermediate nodes and thus reduces latency.

The rest of the paper is organized as follows. The proposed system is described in Section 2. Concluding remarks and future works are described in Section 3.

2. Proposed System

The proposed system is multi source reliable broadcasting which can broadcast the messages reliably from different sources to all the nodes in the network. The solution does not require the nodes to know the network size, its diameter and number of nodes in the network. The only information a node has its identity and its position. On average, only a subset of nodes transmits and they transmit only once to achieve reliable broadcasting.

The algorithm calculates the relative position of the nodes with respect to the broadcasting source node. It propagates the message as far as possible to minimize the delay. The nodes that are farthest from the source node are scheduled to transmit first. The algorithm minimizes the number of transmissions made by the participating nodes. If a node that is scheduled to transmit a message in a round realizes that its transmission cannot propagate the message to any new node, it cancels its scheduled transmission. This minimizes the number of

rebroadcasts made by the intermediate nodes and reduces the delay latency.

MANET is represented as a grid based graph where a vertex of the graph represents a node and there is a directed edge from node i to node j if node j is in the range of node i . Nodes are located at grid points and they know their own position [2],[3]. A node that has received the broadcast message is called a covered node and a node that has not yet received the broadcast message is called an uncovered node. Each node is equipped with a GPS receiver to know its own location.

Global Positioning System (GPS) is a constellation of 27 Earth-orbiting satellites. The GPS receiver JP3 is shown in the Figure 1. It continuously tracks all the satellites in view, and provides accurate satellite position data. It locates four or more of these satellites, calculates the distance to each, and uses this information to detect its own location. Initially, only the source node is covered. Messages can be directly transmitted by a node to other nodes that are no more than R grid distance away, where $R > 1$ is the maximum communication range of each node.



Figure 1: GPS Receiver JP3

Time is divided into synchronous rounds. It takes one round for a node to move from one grid point to a neighboring grid point. Each round consists of multiple time-slots, of which the first time-slot is referred to as the control slot. During the control slot nodes only exchange control information with other nodes within a certain distance. The remaining slots of a round are referred to as application slots. During the application slots, nodes can transmit the broadcast message. Nodes very close to each other are considered to be collocated at a point. Maximum of k nodes can be collocated at a grid point.

2.1 Broadcasting Protocol

In order to reliably broadcast a message to all the nodes of the network, the scheduling algorithm considers

the relative position of the nodes with respect to the broadcast source. In every round, the covered node that is farthest from the source transmits. Algorithm also minimizes the number of transmissions by the participating nodes. If a node that is scheduled to transmit a message in a round realizes that its transmission cannot propagate the message to any new node, it will cancel its scheduled transmission.

Control Slot

A single round with control and application slots is shown in the Fig 1. The only information required by the scheduling algorithm is for each node to be aware of all the other nodes that are within one grid distance from itself and their intended mobility for a round. In the first half of the control slot, all the nodes collocated at a grid point communicate with each other to learn their respective direction of movement for this round.

This can be done reliably and deterministically by the CSMA/DCR (Carrier Sense Multiple Access with Deterministic Collision Resolution) protocol. This communication requires nodes to transmit using a very small range to avoid collisions with messages transmitted in neighboring grid points. After this communication, a node is aware of all the nodes collocated with itself and can determine if it has the smallest ID among the collocated nodes[12].

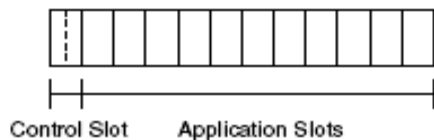


Figure2. A round with control and application slots

The second half of the control slot is divided into three transmission phases: the node with the smallest ID at grid point i transmits in phase $i \bmod 3$ to convey the mobility information for all the nodes collocated at grid point i to the nodes at neighboring grid points. Hence, at the end of a control slot, a node has enough knowledge to determine the positions of other nodes that are one grid distance from it for the remaining slots of that round.

Application Slot

The source node starts the broadcast by transmitting in the first application slot of a round. The broadcast message carries the initial position of the source node as well as the grid segment of the transmitting node.

Upon receiving the broadcast message, a node uses this information to determine its grid segment and calculates its transmission schedule for the next round.

2.2 Algorithm Description

In order to reliably broadcast a message to all the nodes of the network, the scheduling algorithm considers the relative position of the nodes with respect to the broadcast source. In every round, the covered node that is farthest from the source transmits. The algorithm minimizes the number of rebroadcasts made by the participating nodes. If a node that is scheduled to transmit a message in a round realizes that its transmission cannot propagate the message to any new node, it will cancel its scheduled transmission[11].

The grid segments relative to the source node are shown in the Fig 2. An unshaded circle represents an uncovered node and a shaded circle represents a covered node. A node with the thick circle is the one that transmits in that slot.

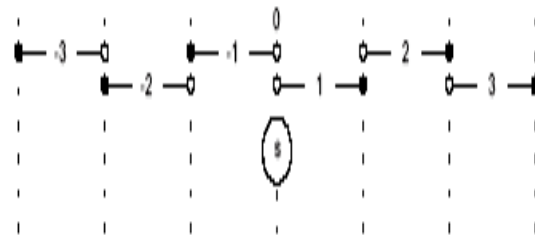


Figure3. The grid segments relative to the source node

Let grid point p be the position of the source node at the beginning of the broadcast. Let $1, 2, 3, \dots$ be the grid segments $(p, p+1), (p+1, p+2), (p+2, p+3), \dots$, respectively, and let $-1, -2, -3, \dots$ be the grid segments $(p-1, p), (p-2, p-1), (p-3, p-2), \dots$, respectively. The source node and all the nodes collocated with the source node are in grid segment 0, which is a special grid segment consisting of a single point [4],[5].

The source node starts the broadcast by transmitting in the first application slot of a round. The broadcast message carries the initial position of the source node as well as the grid segment of the transmitting node. Upon receiving the broadcast message, a node uses this information to determine its grid segment and calculates its transmission schedule for the next round. A node is not allowed to transmit in the same round it received a broadcast message. It can only transmit in the next round. Whenever a node gets a new broadcast message it sets its counter equal to $R - |p_1 - p| + 2$, where p_1 is the grid

segment of the receiving node and p is the grid segment of the transmitting node.

When a node in segment p transmits, it covers all the nodes in segments $p, p \pm 1, p \pm 2, \dots, p \pm R$, where $R > 1$ is the maximum communication range of each node. If a transmitting node is in grid segment p , then in the next round a receiving node from grid segment $p \pm (R + 1), p \pm R, p \pm (R - 1), \dots, p \pm 1, p$ could transmit in slots 1, 2, 3, $\dots$, $R+1, R+2$, respectively. Whenever a node gets a new broadcast message it sets its counter equal to $R - |p - p_1| + 2$, where p is the grid segment of the receiving node and p_1 is the grid segment of the transmitting node.

In the beginning of every application slot of the next round, each node decrements its counter by 1. If on decrementing, the counter reaches 0, the node is eligible to transmit in that slot. Let A be a node that is scheduled to transmit in a slot. Let node A be located in grid segment i and let there be another node B be located in grid segment j . On the right hand side of message propagation, if $i < j \leq i + R$ then node B has already transmitted in an earlier slot. In this case the transmission of node A is redundant and does not help to propagate the message any further. Hence, node A cancels its counter and does not transmit. Similarly, on the left hand side of message propagation, if $i > j \geq i - R$ then node B has already transmitted in an earlier slot and the transmission of node A is redundant. Hence, if a node whose counter is not yet 0 again receive the same broadcast message, it cancels the counter and does not transmit.

2.3. Execution of the Algorithm for Static Nodes

Execution of the reliable broadcasting algorithm when the nodes are static is shown in the Figure 4. An unshaded circle represents an uncovered node and a shaded circle represents a covered node. A node with the thick circle is the one that transmits in that slot. If there are multiple nodes collocated at the same point and more than one of them are scheduled to transmit in the same slot, then only one of them transmits. All the collocated nodes would be aware of each other following communication in the control slot. By using node IDs, nodes are totally ordered and node with the smallest ID will transmit first.

If there are multiple nodes in a grid segment and more than one of them are scheduled to transmit in the same slot, then only one of them transmits. If the segment number is positive then the right most nodes in that grid segment transmits. If the segment number is negative then the left most nodes in that grid segment transmits. So, to the right of the point of origin of the broadcast, the right most nodes transmit and in the other

direction the left most nodes transmits. After its initial transmission a source node just acts like an ordinary node and is allowed to move freely.

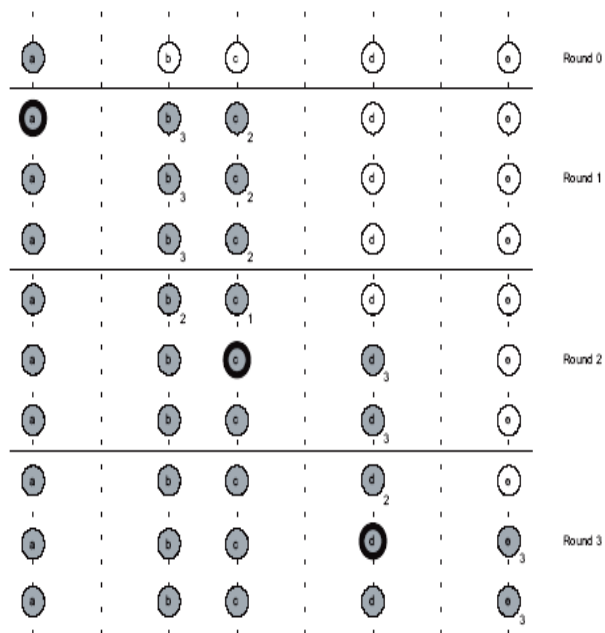


Figure4. Execution of the algorithm when the nodes are static, $R=3$

2.4. Execution of the Algorithm for Mobile Nodes

Execution of the reliable broadcasting algorithm when the nodes are mobile is shown in the Figure 5. Let A be a node got covered in the previous round. Let that node move from grid segment p_1 to a neighboring grid segment p . If $|p| > |p_1|$ then node A decrements its counter by 1, and if $|p| < |p_1|$ then node A increments its counter by 1. This ensures that the rightmost and leftmost covered nodes have the smallest counter value [5]. When a node transmits, all the nodes collocated with the transmitting node and the transmitting node itself set their counter to $R - |p - p_1| + 2$, where p is the grid segment of the receiving node and p_1 is the grid segment of the transmitting node, only if they have not already transmitted twice.

If a node is mobile then adjust the counter of that node depending on whether the node moves towards or away from the initial position of the source. When a node moves to a new grid segment then the counter is updated. Let A be a node that got covered in the previous round. Let node A move from grid segment p_1 to a neighboring grid segment p . If $|p| > |p_1|$ then node A decrements its

counter by 1, and if $|p| < |p_1|$ then node A increments its counter by 1. This ensures that the rightmost and leftmost covered nodes have the smallest counter value.

In every round the covered node that is farthest from the source node transmits. Whenever a node transmits a broadcast message, all the receiving nodes set a counter when they receive this message. The value of this counter depends on the position of the receiving node at the time it received the broadcast message. The counter value is inversely proportional to the absolute value of the grid segment number. Even if the nodes move, the counters are adjusted such that this property is preserved. Since these counters are decremented in every slot and the node whose counter is equal to 0 transmits, the nodes in the grid segment farthest from the source always get a chance to transmit first and their transmission never gets suppressed by the transmission of any other node [6],[7].

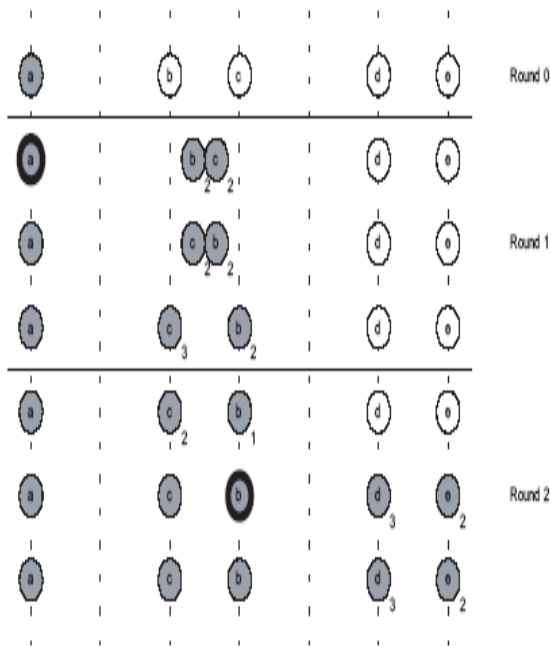


Figure5. Execution of the algorithm when the nodes are mobile, R=3

2.5. CSMA/DCR Protocol

Execution of CSMA/DCR protocol on a binary tree is shown in the Fig 3. Let n be the total number of nodes in the network and let k be the maximum number of competing collocated nodes. All the n nodes construct an identical static binary tree with exactly n leaves representing the nodes identifiers. When a collision is detected, the nodes initiate a deterministic balanced tree

search by recursively searching a sub tree with only one active leaf.

Initially, all nodes may transmit a message. Suppose that a collision happens in the first slot. Then, in the second slot, only the nodes whose identifiers belong to the left sub tree are allowed to transmit. If the transmission succeeds, then nodes whose identifiers belong to the right sub tree are allowed to transmit [8].

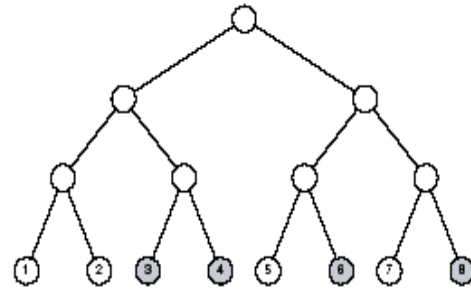


Figure6. CSMA/DCR execution on a binary tree

State of a channel during the execution of the protocol CSMA/DCR [9] is shown in the Table 1. The active nodes that have a message to transmit are represented as dark circles. In the first slot, nodes 3, 4, 6 and 8 transmit and cause a collision (denoted by C). In the second slot, only nodes belonging to the left sub tree transmit, namely nodes 3 and 4, which results again in a collided channel. In the next slot, the protocol allows only nodes 1 and 2 to transmit. Since none of them have a message to send, the slot is empty (denoted by E). Then, nodes in the right sub tree may transmit and node 3 successfully sends its message in slot 5 and so on. Overall, the protocol requires 9 slots.

TABLE I.
THE STATE OF THE CHANNEL DURING CSMA/DCR
EXECUTION
C - Collision, E - Empty channel, T - Transmission.

slots								
1	2	3	4	5	6	7	8	9
C	C	E	C	T	T	C	T	T
3	3		3	3	4	6	6	8
4	4		4			8		
6								
8								

The CSMA/DCR protocol is used in the first half of the control slot. Nodes transmit with a very small range during this time. Hence, if one node at grid point i detects a collision due to the broadcast of nodes collocated

at grid point i , all the nodes at the same grid point also detect that collision. This means that the hidden terminal problem does not occur with this schema.

In multi source reliable broadcasting algorithm, multiple sources can initiate the broadcasts at a time. The algorithm takes into consideration node mobility and multiple nodes co-located at the same point. This algorithm delivers the messages within a bounded time. It minimizes the number of re-broadcasts made by the intermediate nodes. The algorithm reduces routing overhead by minimizing end to end delay.

2.6. Simulation

The performances of flooding, probability based broadcasting and reliable broadcasting for single and multi sources are analyzed. The simulations are performed using ns2. The list of Simulation Parameters is given in table II.

TABLE II.
SIMULATION PARAMETERS

Simulation Parameters	Values
Bandwidth	1Mb
Routing Protocol	DSDV
MESSAGE_PORT	42
BROADCAST_ADDR	-1
Nam Animation Speed	250 Micro Seconds
Node Velocity	20,40,60,80,100,120 meters per sec
Transmission Probability	50
Broadcast Probability	50
Broadcast Delay	0.01 Micro Seconds
Hello Reply Delay	0.01 Micro Seconds
Nam Animation Speed	250 Micro Seconds
Message Size	100 bytes (Max 1500 bytes)
Interface queue type	Queue/DropTail/PriQueue
Antenna model	Antenna/OmniAntenna

The NAM (Network Animators) instances of initial and final phases of Single and Multi source reliable broadcasting algorithms are shown in the Figures 7,8,9,10. The Gold nodes are the source nodes which initiate the broadcasting. Red nodes receive the broadcast message and forward it to the neighboring nodes. Blue nodes receive the message but will not forward it.

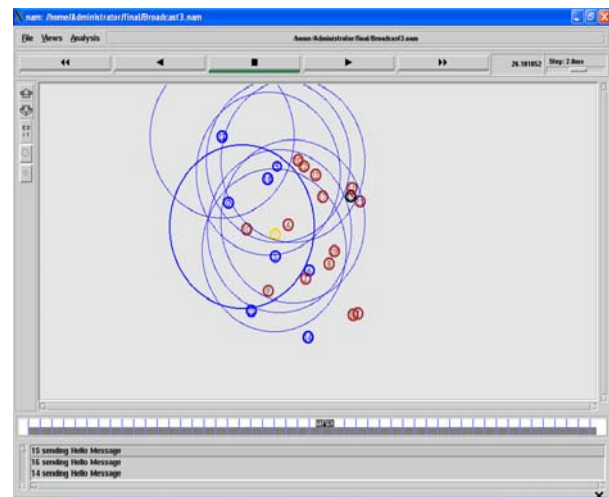


Figure7: Initial Phase of Single Source Reliable Broadcasting Algorithm

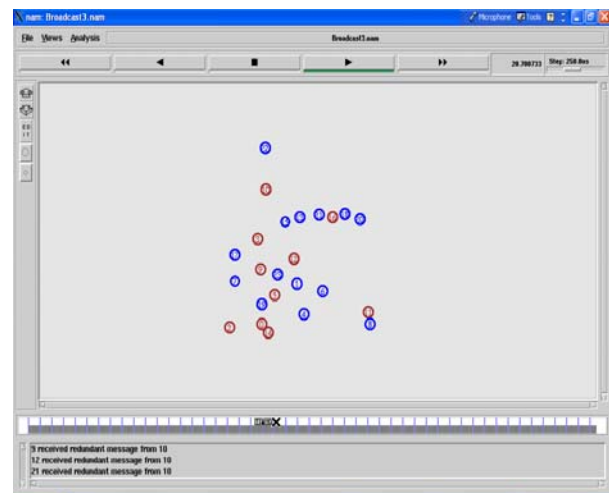


Figure8: Final Phase of Single Source Reliable Broadcasting Algorithm

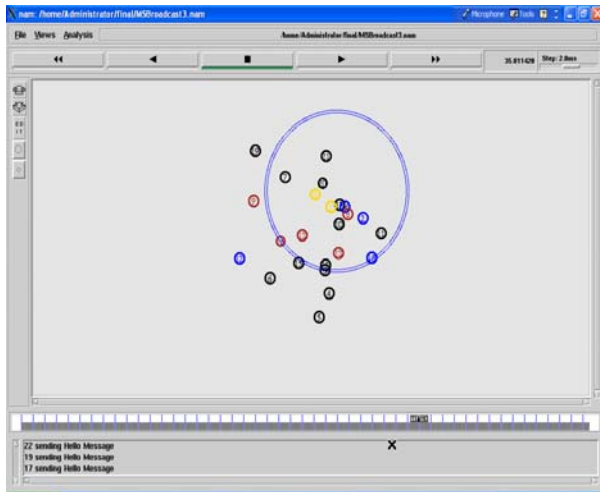


Figure9: Initial Phase of Multi Source Reliable Broadcasting Algorithm

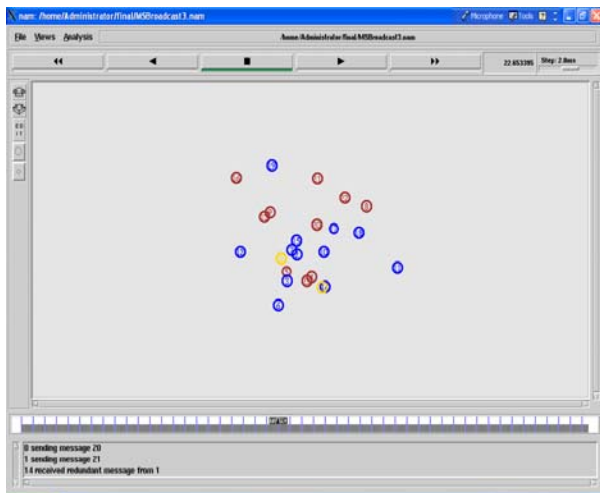


Figure10: Final Phase of Multi Source Reliable Broadcasting Algorithm

The performance metrics to be observed are:

Packet delivery ratio is the number of data packets received by the destination nodes divided by the number of data packets transmitted by the source nodes.

Normalized routing load is the ratio between the number of routing packets sent by all the nodes for route maintenance and discovery and the number of data packets delivered to the destination nodes. Figure 4: Initial Phase of Multi Source Reliable Broadcasting Algorithm

Xgraphs are generated to compare various broadcasting algorithms based on the above two metrics.

Each point in the plot is an average of over ten simulation runs. Simulation results based on different threshold values are presented to verify and compare the effectiveness of these algorithms.

The comparisons of packet delivery ratio for various single and multi source broadcasting algorithms are shown in the Figures 11 and 12. In general, data packet delivery ratio will decrease with increase in node speed because it is very difficult to find a stable route to the destination. When compared with other broadcasting algorithms reliable broadcasting algorithm maximizes the packet delivery ratio because number of re-broadcasts made by the intermediate nodes is very less.

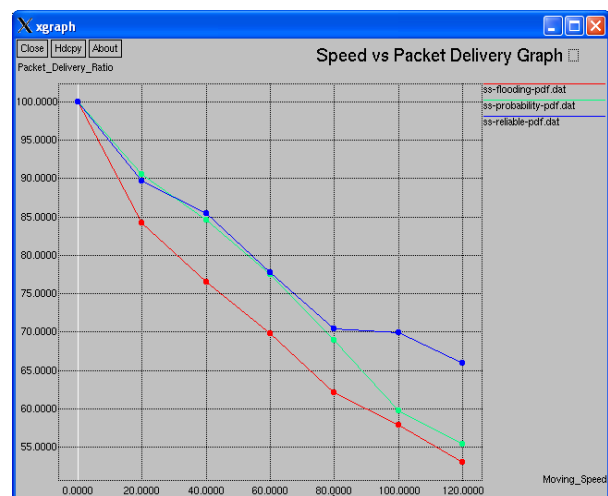


Figure 11: Speed vs. Packet Delivery Ratio for various Single Source Broadcasting Algorithms

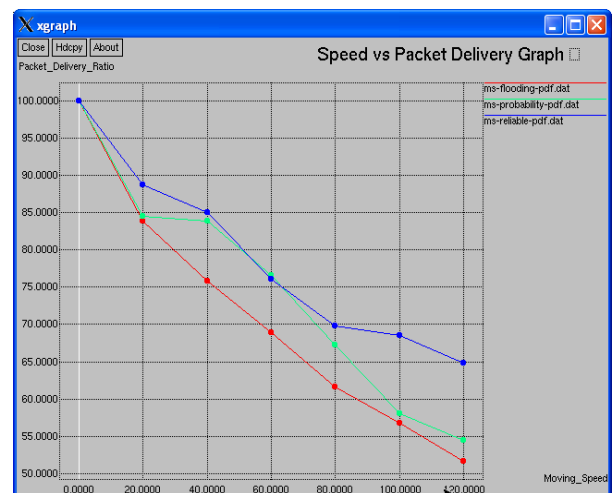


Figure 12: Speed vs. Packet Delivery Ratio for various Multi Source Broadcasting Algorithms

The comparisons of normalized routing load for various single and multi source broadcasting algorithms are shown in the Figures 13 and 14. Normalized routing load will increase with increase in node speed because of heavy traffic. When compared with other broadcasting algorithms reliable broadcasting algorithm minimizes the routing overhead.



Figure 13: Speed vs. Normalized Routing Load for various Single Source Broadcasting Algorithms

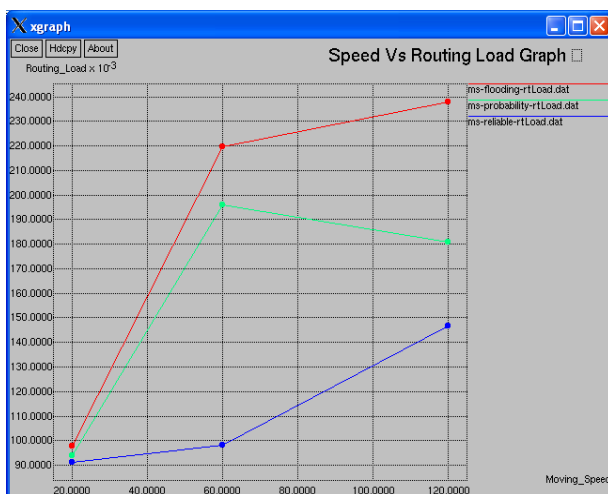


Figure 14: Speed vs. Normalized Routing Load for various Multi Source Broadcasting Algorithms

3. Conclusion and Future Work

Broadcasting plays a vital role in mobile ad hoc networks. So this work provides reliable broadcasting by reducing the unnecessary retransmissions. The algorithm takes into consideration node mobility and multiple nodes located at the same point. The algorithm is

energy efficient, has low latency, has minimum number of retransmission and is collision free. CSMA/DCR protocol was used to resolve conflict between collocated nodes. This algorithm delivers the messages within a bounded time. Flooding, Probability based broadcasting and Reliable Broadcasting algorithms for multiple sources are compared. The metrics Packet Delivery Ratio and Normalized Routing Load are used to evaluate these algorithms. Simulation results based on different threshold values are presented to verify and compare the effectiveness of these algorithms. As compared to the basic flooding approach and probability based broadcasting approach, reliable broadcasting algorithm eliminates many redundant rebroadcasts and reduces delay latencies.

For future work, the algorithm can be extended to work under error-prone conditions, i.e., location errors, imperfect time synchronization, and message losses.

References

- [1] L. Briesemeister, L. Sch"afers, and G. Hommel, "Disseminating messages among highly mobile hosts based on inter-vehicle communication," in *IEEE Intelligent Vehicle Symposium*, Oct. 2000, pp. 522–527.
- [2] W.-H. Liao, J.-P. Sheu, and Y.-C. Tseng, "GRID: A fully location aware routing protocol for mobile ad hoc networks," *Telecommunication Systems*, vol. 18, no. 1–3, pp. 37–60, 2001.
- [3] F. L. V. Scoy and J. A. Brooks, "Broadcasting multiple messages in a grid," *Discrete Applied Mathematics*, vol. 53, no. 1–3, pp. 321–336, 1994.
- [4] G. Korkmaz, E. Ekici, F. " Ozg"uner, and U. " Ozg"uner, "Urban multihop broadcast protocol for inter-vehicle communication systems," in *VANET '04: Proceedings of the first ACM workshop on Vehicular Ad Hoc Networks*, Oct. 2004, pp. 76–85.
- [5] X. Yang, J. Liu, F. Zhao, and N. H. Vaidya, "A vehicle-to-vehicle communication protocol for cooperative collision warning," in *Proceedings of the First Annual International Conference on Mobile and Ubiquitous Systems: Networking and Services (MobiQuitous'04)*, Aug. 2004, pp. 114–423.
- [6] H. Wu, R. Fujimoto, R. Guensler, and M. Hunter, "MDDV: A mobility centric data dissemination algorithm for vehicular networks," in *VANET '04: Proceedings of the first ACM workshop on Vehicular Ad Hoc Networks*, 47–56, Oct. 2004.
- [7] E. Kranakis, D. Krizanc, and A. Pelc, "Fault-tolerant broadcasting in radio networks," *Journal of Algorithms*, vol. 39, pp. 47–67, 2001.
- [8] F. L. V. Scoy and J. A. Brooks, "Broadcasting multiple messages in a grid," *Discrete Applied Mathematics*, vol. 53, no. 1–3, pp. 321–336, 1994.
- [9] A. Sen and M. L. Huson, "A new model for scheduling packet radio networks," in *Proceedings of the 15th Annual Joint Conference of the IEEE Computer and Communication Societies (IEEE INFOCOM'96)*, vol. 3, Mar. 1996, pp. 1116–1124.

- [10] I. Wojciechowska, "Broadcasting in grid graphs," Ph.D. dissertation, West Virginia University, 1999.
- [11] H. Lim and C. Kim. Multicast tree construction and flooding in wireless ad hoc networks. In *Proceedings of the ACM International Workshop on Modeling, Analysis and Simulation of Wireless and Mobile Systems (MSWIM)*, 2000.
- [12] J. Boleng. Normalizing mobility characteristics and enabling adaptive protocols for ad hoc networks. In *Proceedings of the IEEE Local and Metropolitan Area Networks Workshop (LANMAN)*, pages 9–12, 2001.



Mrs S.V.M.G. Bavithiraja was born in Madurai, Tamilnadu, India on May 31, 1980. She obtained her B.E. (CSE) from Madurai Kamraj University, Madurai, , India in 2002 and received her Master of Computer Science and Engineering from Anna University, Chennai, India in 2008. She is currently a lecturer in VLB. Janakiammal College of

Engineering and Technology, Coimbatore, India. Her current research interests are WiMAX (World Wide Interoperability for Microwave Access) and Wireless Sensor networks.