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Sender and Receiver Based Efficient Broadcasting Algorithm in Mobile Ad Hoc Networks

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Abstract - **This paper develops novel broadcast algorithms for mobile ad hoc networks to improve the efficiency and provide guarantee for full delivery of broadcasting. An important objective is to reduce broadcast redundancy and to avoid the broadcast storm problem. It proposes two broadcasting algorithms such as, Sender based algorithm and Receiver based algorithm. The proposed Sender based algorithm selects subset of forwarding nodes using 1-hop neighbor information. It can reduce both the computational complexity of selecting the forwarding nodes and the maximum number of selected nodes in the worst case. The proposed receiver based broadcasting algorithm can significantly reduce redundant broadcasts in the network. It decides whether or not to broadcast the message. The probability of two neighbor nodes broadcasting the same message exponentially decreases when the distance between them decreases or when the node density increases. The receiver based algorithm uses the Responsibility based scheme which further reduces the redundancy. The proposed algorithms improve the efficiency and also guarantee full delivery.**

Key Words - **Wireless ad hoc, broadcasting, flooding, B-coverage set, Localized algorithm**

I. 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 cannot 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) [1], Ad Hoc on Demand Distance Vector (AODV) [2], and Zone Routing protocol (ZRP) [3] and Location Aided Routing (LAR) [4] use broadcasting to establish routes. The broadcast is spontaneous. Any mobile host can issue a broadcast operation at any time.

In MANET, broadcasting is used in the route discovery process in several routing protocols, when advising an error message to erase invalid routes from the routing table, or as an efficient mechanism for reliable multicast in a fast moving MANET. In MANETs with the promiscuous receiving node, the traditional blind flooding incurs significant redundancy, collision, and contention, which is known as the broadcast storm problem [5]. Efficient broadcasting in a MANET focuses on selecting a small forward node set while ensuring broadcast coverage. Ad hoc wireless networks are dynamic in nature. Due to this dynamic nature, global information/infrastructure such as minimal spanning tree is no longer suitable to support broadcasting in ad hoc networks.

Broadcasting means one node sends a packet to all other nodes in a network. Efficient broadcasting in a mobile ad hoc network focuses on selecting a small forward node set while ensuring broadcast coverage. The objective is to determine a small set of forward nodes to ensure full coverage. A formal framework is used to model inaccurate local views in MANETs, where full coverage is guaranteed if three sufficient conditions connectivity, link availability, and consistency are met. A MANET consists of a set of mobile hosts that may communicate with one another from time to time. No base stations are supported. Each host is equipped with a CSMA/CA (carrier sense multiple access with collision avoidance) transceiver. In such environment, a host may communicate with another directly or indirectly. In the latter case, a multi hop scenario occurs, where the packets originated from the source host are relayed by several intermediate hosts before reaching the destination. The broadcast problem refers to the sending of a message to other hosts in the network. The problem considered here has the following characteristics. In a broadcast process, each node decides its forwarding status based on given neighborhood information and the corresponding broadcast protocol. Most existing broadcast schemes assume either the underlying network topology is static during the broadcast process such that the neighborhood information can be updated in a timely manner. The results in show that existing static network broadcast schemes perform poorly in terms of delivery ratio when nodes are mobile. There are two sources that cause the failure of message delivery.

- *Collision:* The message intended for a destination collides with another message.
- *Mobility nodes:* A former neighbor moves out of the transmission range of the current node (i.e., it is no longer a neighbor).

Mobile Ad hoc Network (MANET) consist of a collection of mobile hosts without a fixed infrastructure. Due to limited wireless power a host may not communicate with its destination directly. It usually requires other hosts to forward its packets to the destination through several hops. So in MANET every host acts as a router when it is forwarding packets for other hosts. Because of mobility of hosts and time variability of the wireless medium, the topology of MANET varies frequently. Therefore the routing protocol plays an important role in MANET. There has been extensive research on routing protocols, such as DSR, AODV, LAR and ZRP. A common feature of these routing protocols is that their route discovery all relies on network wide broadcasting to find the destination. Recently, a number of research groups have proposed more efficient broadcasting techniques whose goal is to minimize the number of retransmissions while attempting to ensure that a broadcast packet is delivered to each node in the network.

A MANET consists of a set of mobile hosts that may communicate with one another from time to time. No base stations are supported. Each host is equipped with a CSMA/CA (*carrier sense multiple access with collision avoidance*) transceiver. In such environment, a host may communicate with another directly or indirectly. In the latter case, a multihop scenario occurs, where the packets originating from the source host are relayed by several intermediate hosts before reaching the destination. The *broadcast problem* refers to the sending of a message to other hosts in the network. The problem considered here is assumed to have the following characteristics.

- ***The broadcast is spontaneous:*** Any mobile host can issue a broadcast message at any time. For reasons such as host mobility and lack of synchronization, preparing any kind of global topology knowledge is prohibitive (in fact this is at least as hard as the broadcast problem). Little or even no local connectivity information may be collected in advance.
- *The broadcast is unreliable:* No acknowledgement mechanism will be used. However, an attempt should be made to distribute a broadcast message to as many hosts as possible without paying too much effort. The motivations to make such an assumption are

i. A host may miss a broadcast message because it is off-line, it is temporarily isolated from the network, or it experiences repetitive collisions.

ii. Acknowledgements may cause serious medium contention (and thus, another "storm") surrounding the sender, and receiver.

iii. In many applications (e.g., route discovery), a 100% reliable broadcast is unnecessary. In addition, we assume that a host can detect duplicate broadcast messages. This is essential to prevent endless flooding of a message. One way to do so is to associate with each broadcast message a tuple (source ID, sequence number) as that in [1, 2].

II. Related Works

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 [8, 9]: requires each node in a MANET to rebroadcast all packets.

Probability based [10]: assigns probabilities to each node to rebroadcast depending on the topology of the network.

Area based [10]: common transmission distance is assumed and a node will rebroadcast if there is sufficient coverage area.

Neighborhood based [11–15]: State on the neighborhood is maintained by neighborhood method, and the information obtained from the neighboring nodes is used for rebroadcast.

A. Simple Flooding Method

In this method, a source node of a MANET disseminates a message to all its neighbors, each of these neighbors will check if they have seen this message before, if yes the message will be dropped, if not the message will redisseminated at once to all their neighbors. The process goes on until all nodes have the message. Although this method is very reliable for a MANET with low density nodes and high mobility but it is very harmful and unproductive as it causes severe network congestion and quickly exhaust the battery power. Blind flooding ensures the coverage; the broadcast packet is guaranteed to be received by every node in the network, providing there is no packet loss caused by collision in the MAC layer and there is no high-speed movement of nodes during the broadcast process. However, due to the broadcast nature of wireless communication media, redundant transmissions in bound flooding may cause the broadcast storm problem, in which redundant packets cause contention and collision.

B. Probability Based Approach

1. Probabilistic scheme: The Probabilistic scheme from [10] is similar to Flooding, except that nodes only rebroadcast with a predetermined probability. In dense networks multiple nodes share similar transmission coverage. Thus, randomly having some nodes not rebroadcast saves node and network resources without harming delivery effectiveness. In sparse networks, there is much less shared coverage; thus, nodes won't receive all the broadcast packets with the Probabilistic scheme unless the probability parameter is high. When the probability is 100%, this scheme is identical to Flooding.

2. ***Counter-Based scheme:*** Ni et al [10] show an inverse relationship between the number of times a packet is received at a node and the probability of that node being able to reach additional area on a rebroadcast. This result is the basis of their Counter-Based scheme. Upon reception of a previously unseen packet, the node initiates a counter with a value of one and sets a RDT (which is randomly chosen between 0 and Tmax seconds). During the RDT, the counter is incremented by one for each redundant packet received. If the counter is less than a threshold value when the RDT expires, the packet is rebroadcast. Otherwise, it is simply dropped. From [10], threshold values above six relate to little additional coverage area being reached.

C. *Area Based Methods*

Suppose a node receives a packet from a sender that is located only one meter away. If the receiving node rebroadcasts, the additional area covered by the retransmission is quite low. On the other extreme, if a node is located at the boundary of the sender node's transmission distance, then a rebroadcast would reach significant additional area, 61% to be precise [10]. A node using an Area Based Method can evaluate additional coverage area based on all received redundant transmissions. We note that area based methods only consider the coverage area of a transmission; they don't consider whether nodes exist within that area.

1. ***Distance-Based scheme:*** A node using the Distance-Based Scheme compares the distance between itself and each neighbor node that has previously rebroadcast a given packet1. Upon reception of a previously unseen packet, a RDT is initiated and redundant packets are cached. When the RDT expires, all source node locations are examined to see if any node is closer than a threshold distance value. If true, the node doesn't rebroadcast.

2. ***Location-Based scheme:*** The Location-Based scheme [10] uses a more precise estimation of expected additional coverage area in the decision to rebroadcast. In this method, each node must have the means to determine its own location, e.g., a Global Positioning System (GPS). Whenever a node originates or rebroadcasts a packet it adds its own location to the header of the packet. When a node initially receives a packet, it notes the location of the sender and calculates the additional coverage area obtainable were it to rebroadcast. If the additional area is less than a threshold value, the node will not rebroadcast, and all future receptions of the same packet will be ignored. Otherwise, the node assigns a RDT before delivery. If the node receives a redundant packet during the RDT, it recalculates the additional coverage area and compares that value to the threshold. The area calculation and threshold comparison occur with all redundant broadcasts received until the packet reaches either its scheduled send time or is dropped.

D. *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.

III. PROPOSED SYSTEM

This paper proposes two broadcasting algorithms based on 1-hop neighbor information. The two algorithms namely, Sender based algorithm and receiver based algorithm. The first proposed algorithm is a sender-based algorithm.

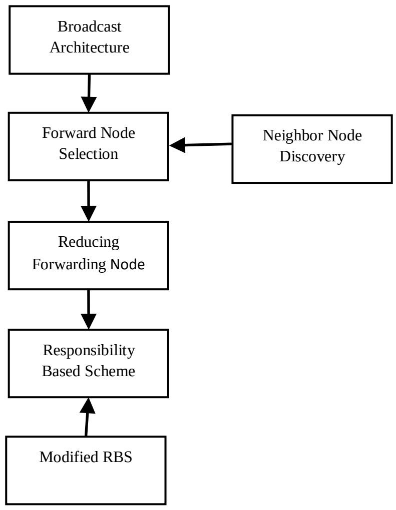

Fig. 1. Broadcasting Process

In sender-based algorithms, the broadcasting nodes select a subset of their neighbors to forward the message and it use 1-hop information. In, Liu et al. propose a broadcasting algorithm that reduces the number of broadcasts and achieves local optimality by selecting the minimum number of forwarding nodes with minimum time complexity O (n log n), where n is the number of neighbors. This optimality only holds for a subclass of sender-based broadcasting algorithms employing 1-hop information and proves that proposed sender-based algorithm can achieve full delivery with time complexity O (n). Moreover, Liu et al.'s algorithm selects n forwarding nodes in the worst case, while this proposed algorithm selects 11 nodes in the worst case. The sender-based algorithm results in fewer broadcasts than does Liu et al.'s algorithm. All these interesting properties are achieved at the cost of a slight increase in end-to-end delay. Thus, the first proposed algorithm is preferred to Liu et al.'s algorithm when the value of n is typically large, and it is important to bind the packet size.

In receiver-based algorithms, the receiver decides whether or not to broadcast the message. The proposed receiver-based algorithm is a novel broadcasting algorithm that can significantly reduce the number of broadcasts in the network. We show that using our proposed receiver based algorithm, two close neighbors are not likely to broadcast the same message. In other words, we prove that the probability of broadcast for a node N_A exponentially decreases when the distance between N_A and its broadcasting neighbor decreases or when the density of nodes increases. The number of broadcasts using our receiver-based algorithm is less than one of the best known approximations for the minimum number of required broadcasts. It uses Responsibility based scheme to further reduce the redundancy also achieves the efficiency.

IV. IMPLEMENTATION

A. Forwarding Node Selection

In the proposed sender-based algorithm each sender selects a subset of nodes to forward the message. The subset of neighbor is called B-Coverage set. A node can have several B-Coverage set. A forwarding node selection algorithm is called slice based algorithm. Slice-based selection algorithm would be one that selects all of the neighbors as the B-coverage set. Sender-based algorithm can achieve full delivery if it uses any slice-based algorithm to select the forwarding nodes. An efficient slice-based algorithm that selects 11 nodes in the worst case and has computational complexity O (n), where n is the number of neighbors.

B. Reducing forwarding nodes

Each broadcasting node attaches a list of its selected forwarding nodes to the message before broadcasting it. This procedure will increase the band width and power required to broadcast the message. The proposed slice-based selection algorithm reduces the number of selected forwarding nodes to 11 in the worst case. It further reduces the number of selected nodes. Then slice-based algorithm selects a subset of neighbors such that there is at least one selected node in any nonempty bulged slice around A. Node N_A extracts the list of the forwarding nodes from each message which it receives.

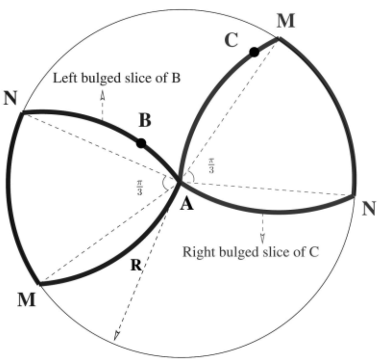

Fig. 2. Bulged Slices

Consider subset of N_A's neighbors that has broadcast the message or been selected by other nodes to forward it. Since all of the selected forwarding nodes are required to broadcast the message, it is sufficient for N_A to find a subset of its neighbors such that any nonempty bulged slice around A contains at least one node from bulged slice. It can be simply extended to achieve this in O (n). Note that the extended algorithm can start with a node N_A and select any node in bulged slice A as soon as it appears in the left bulged slice of the previously selected node. Finally, the extended algorithm removes all of the nodes in bulged slice from the set of selected nodes.

C. Maximizing the minimum node weight of B-Coverage set

Let node N_A assigns a weight to each of its neighbors. The weight can represent the neighbor's battery lifetime, its distance to N_A, the average delay of the node, the level of trust, or a combination of them. In some scenarios, find a B-coverage set such that its minimum node weight is the maximum or its maximum node weight is the minimum among that of all B-coverage sets. For example, assume that the weight of each node represents its battery lifetime in a wireless network. It may be desirable to select the nodes with a higher battery lifetime to forward the message in order to keep the nodes with a lower battery lifetime alive. The slice based algorithm shows how to find a B-coverage set such that its minimum node weight is the maximum among that of all B-coverage sets. The main design challenge is to determine whether or not to broadcast a received message. Although this algorithm is simple to implement, it has limited effect in reducing the number of redundant broadcasts.

D. Responsibility based scheme

The main idea of receiver-based algorithm is that a node avoids broadcasting if it is not responsible for any of its neighbors. A node N_A is not responsible for a neighbor N_B if N_B has received the message or if there is another neighbor N_C such that N_C has received the message and N_B is closer to N_C than it is to N_A. Suppose N_A stores IDs of all its neighbors that have broadcast the message during the defer period. When executed by a node N_A, first uses this information to determine which neighbors have not received the message.

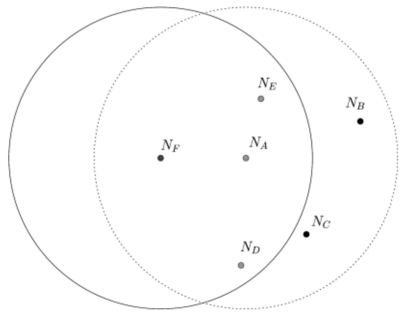

Fig. 3. Example of RBS decision

It then returns false if and only if it finds a neighbor N_B that has not received the message. The output of RBS determines whether or not the broadcast is redundant. So the redundancy is reduced. The modified version of RBS uses the position and transmission range of the broadcasting nodes to determine which neighbors have not received the message.

V. RESULTS

The broadcasting process starts from node 44. The mobility of all nodes is traced. This neighbor information is used to select the optimized forwarding nodes. Slice based algorithm is used to select the forwarding nodes. It reduces the redundancy.

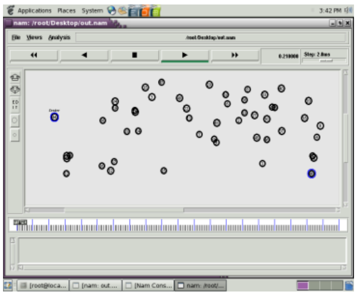

Fig. 4. Initial Node Configuration

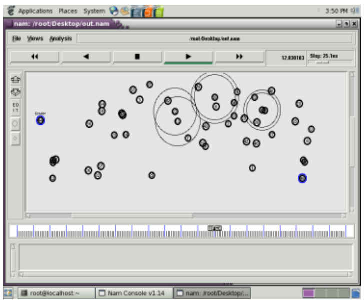

Fig. 5. Broadcasting process

The proposed broadcasting algorithm reduces the redundancy by selecting the minimum number of forwarding nodes and improves the broadcast efficiency.

VI. CONCLUSION

Wireless mobile ad hoc networks present difficult challenges to routing protocol designers. Mobility, constrained bandwidth, and limited power cause frequent topology changes. Broadcasting plays a vital role in mobile ad hoc networks. So this work provides efficient broadcasting by reducing the unnecessary retransmissions. The proposed forwarding-node selection algorithm results in fewer broadcasts in the network. The proposed receiver based algorithm significantly reduces the number of forwarding nodes in the network. So this algorithm is efficient, has minimum number of retransmission and is collision free.

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