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Efficient Local Broadcasting in Wireless Ad Hoc Networks Using Dynamic Approach

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ABSTRACT

Broadcasting is one of the funmental operations in wireless ad hoc networks, where a node disseminates a message to all other nodes in the network. It is a common operation for route establishment and for sending control and emergency messages. The primary goal of broadcasting is to successfully reduce the number of transmissions that are required to achieve full delivery with energy consumption using local broadcast algorithm. The two main approaches used for local broadcasting are static and dynamic approaches. In static approach, using the local topology information, the local algorithm determines the status of each node and also the priority function. Using this approach it is not possible to achieve the good approximation factor to the optimum solution. The hybrid local broadcast algorithm based on dynamic approach is proposed for guarantee with full delivery and successful approximation to the optimum solution without considering the node position. In dynamic approach the position of the node is determined "on-the-fly" based on local topology information. So, it is possible to get the good approximation factor to the optimum solution. The position information is the solution for getting good approximation factor. But in some applications it may not be possible to get position information because of the sheer nature of ad hoc networks that allow mobility cause dynamic, unpredicted and frequent topology changes. In those situations also the proposed local broadcast algorithm can achieve both full delivery and a constant approximation to the optimum solution in which the status of each node is decided "on-the-fly.

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1. INTRODUCTION

An ad hoc wireless network is a collection of wireless mobile hosts forming a temporary network without the aid of any centralized administration or standard support services. In order to meet day to day applications, the improvement of the networking concepts is important. So the ad hoc protocol method is introduced in wireless networks. It has different protocols that are Destination Sequence Distance Vector (DSDV), Dynamic Source Routing (DSR), Ad hoc On-demand Distance Vector (AODV), and Temporally Ordered Routing Algorithm (TORA). These protocols are coming under either proactive or reactive protocols. Proactive protocol method is also called as "up-to-date", because it stores all the information about routing continuously. The reactive protocol is also called as "on-the-fly", because it keeps the address on demand. DSDV method is worked under the category of proactive protocol. In DSDV, each node maintains a routing table, in which the sequence number is used. The counting of hops is used to find out the shortest path for destination from source node. A destination sequence number is created by destination itself. This sequence number is used to avoid the formation of loops, and also old broken routes. The reactive protocol contains DSR, AODV, and TORA method. In which the routing information for destination is stored, when it is needed. In this paper, AODV method is used. The proposed protocol overcomes the drawbacks of DSR. This protocol is the combination of DSR and AODV protocols. The DSR includes the source route in packet headers. So it degrades its performance but the AODV protocol maintains the routing table at nodes. In that protocol the intermediate nodes also send a route reply, this knows the more recent paths [1].

Sender sends the message to a particular node that is commonly called as destination. To find the position of that destination node, the route discovery method has to be initiated. But in this method some problem such as Broadcast Storm Problem is occurred [2]. This problem caused by sending the request more than one time to a same node. This high broadcast redundancy can result in high power and bandwidth consumption in the network. Moreover, it increases packet collisions, which can lead to additional transmissions. This can cause severe network congestion or significant performance degradation. This type of the waste transition of route request, the node position will be found. In this case, the node position is analyzed by the dynamic approach in local broadcast algorithm. Commonly a set of nodes form a Dominating Set (DS) [3] if every node in the network is either in the set or has a neighbor in the set. A group of DS is called a Connected Dominating Set (CDS) [4], [5]. Clearly, the forwarding nodes, connected with the source node, form a CDS. On the other hand, any CDS can be used for broadcasting a message. Therefore, the problems of finding the minimum number of required transmissions and finding a Minimum Connected Dominating Set (MCDS) can be reduced to each other. Unfortunately, finding a MCDS was proven to be Non Probabilistic (NP) hard even when the whole network topology is known [6], [4]. Using the dynamic approach, the status of each node is determined “on-the-fly” (i.e. reactive protocol) as the broadcasting message propagates in the network.

In dynamic approach, there is no facility to find the position of node practically. The proposed method in local broadcast algorithms is introduced to achieve a constant approximation factor without using position information. That is each node has a list of its 2-hop neighbors [7]. This can be achieved in two rounds of information exchange. In the first round, each node broadcasts its id to its 1-hop neighbors. Thus, at the end of the first round, each node has a list of its neighbors. In the second round, each node transmits its id together with the list of its neighbors. In this proposed broadcast algorithm, every broadcasting node selects at most one of its neighbors. A node has to broadcast the message in the selected path. So the number of transmissions in broadcast is reduced.

2. BROADCASTING USING DYNAMIC APPROACH

The main objective of efficient broadcasting algorithms is to reduce the number of broadcasts while keeping the bandwidth and computational overhead as low as possible. One approach to classify broadcasting algorithms is based on the neighbor information they use. Many of the existing neighbor-information-based broadcast algorithms in this category can be further classified as neighbor-designating and self-pruning algorithms [8]. In neighbor designating algorithms, each forwarding node selects some of its local neighbors to forward the message. Only the selected nodes are then required to forward the message in the next step [8]. In self-pruning algorithms, on the other hand, each node decides by itself whether or not to forward a message. The decision is made based on a self-pruning condition [8], [9]. The proposed algorithm is both neighbor-designating and self-pruning, i.e. the status of each node is determined by itself and/or other nodes. In particular, using our proposed algorithm, each broadcasting node selects at most one of its neighbors to forward the message. If a node is not selected to forward, it has to decide, on its own, whether or not to forward the message.

2.1. Collection of two hop information

In wireless ad hoc networks, the fundamental operation of network is broadcasting. The broadcasted node will be selected with respect to the flooding. Before using this method, the blind broadcasting method is used for selecting the nodes [2]. In which the source node will send the request to the neighboring node. After receiving that request, the received node has the sender node information in its header or its nodes memory. Every node has some range power, that node covers the other nodes which are all comes under that range. So the broadcasted request is wasted on its discovery time period. Because every node has to be send its request to the neighbor nodes, which nodes in its range (neighboring nodes). To avoid this rebroadcast, hybrid algorithm (both neighbor-designating and self-pruning algorithms) with dynamic approach is used. In self-pruning, every node has its neighbor node information due to two hop information or the one hop information. The one hop information is the self-pruning technique. But this is the two hop information with dynamic approach. So here the two hop information is used. The 2 hop information is get with two rounds.

The first round, the request should send with its id number. After the first round, every node has its neighbor node id number. In the second round, the neighbor node information is send with its id number to its id requesters. So in a global static network, every node has its neighbor node list. It is shown in Fig. 1. Due to this, the selection of minimum number of nodes to forward the message is easy.

2.2. Neighbor set coverage and creation of covered area

The proposed broadcast algorithm is a hybrid algorithm, because every node that broadcasts the message may select some of its neighbors to forward the message [3]. In this proposed broadcast algorithm, every broadcasting node selects at most one of its neighbors. A node has to broadcast the message if it is selected to forward [5]. Other nodes that are not selected have to decide whether or not to broadcast on their own. This decision is made based on a self-pruning condition called the coverage condition [4], [10]. After selecting the minimum number of nods to forward the message, the covered area will be created. To evaluate the coverage condition, every node maintains a list of neighboring nodes. Every node has its neighbor node information with its id number. The id number is used to find the place of destination node. After receiving the message, a node has to be creating the coverage area with its id number of neighboring nodes. For example, a node one sends the id number for requisition to the neighboring node number two. If the message is received from its neighboring node number two, second node does not select the node one and node three to send the message. Note that the third node may not be a neighbor of first node. However, since the third node is a neighbor of second node, it is at most 2 hops away from first node. Having id's of second and third node are stored in the covered area details. Since the third node will eventually broadcast the message, by updating the list, the first node removes those neighbors that have received the message or will receive it, eventually. Every time the first node receives a copy of message and it will be up dated in the list of that node. If the first node is selected by the second node to send the message, the neighbors of second node is deleted in the list of first node. Because the first node has to be update the present level to avoid the waste transition.

2.3. Scheduling and removing function

In the neighbor-designating method the forwarding status of the each node is determined by its neighbor. The source node selects a subset of its 1-hop neighbors as forward nodes to cover 2-hop neighbor. A node determines whether its neighbors should forward broadcast packets. When a first node receives a message, it creates a list if it is not created yet and updates the list. Then, based on whether the first node was selected to forward or whether the coverage condition is satisfied, the first node may schedule a broadcast by placing a copy of message in its Medium Control Access (MAC) layer queue. There are at least two sources of delay in the MAC layer. First, a message may not be at the head of the queue so it has to wait for other packets to be transmitted. Second, in contention based channel access mechanisms such as Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA), to avoid collision, a packet at the head of the queue has to wait for a random amount of time before getting transmitted [11]. In this paper, it is assumed that a packet can be removed from the MAC layer queue if it is no longer required to be transmitted. Therefore, the broadcast algorithm has access to two functions to manipulate the MAC layer queue. The first function is the scheduling function, which is used to place a message in the MAC layer queue. That the scheduling function handles duplicate packets, i.e., it does not place the packet in the queue if a copy of it is already in the queue. The second function is called to remove a packet form the queue. Note that to remove a packet from the queue because the algorithm needs to have access to the MAC layer queue [11]. This requires a cross-layer design. In the absence of any cross-layer design, the broadcast algorithm can use a timer at the network layer.

2.4. Reducing redundancy and removal of duplicate packets

The first node discards a received message if it has broadcast message before. If the first node is selected to forward the message, it schedules a broadcast and ever removes the messages from the queue in future. The first node may change or remove the selected node's id from the scheduled message every time it receives a new copy of the message and updates the list. Suppose the first node has not been selected to forward the message by a particular time and the list becomes empty. Then at the particular time, the message from the MAC layer queue is removed [11]. The first node can select the node with the minimum number of forward nodes. In the low power, it does not select the forward nodes to send the message. This is the only case where a broadcasting node does not select any of its neighbors to forward the message. Every node broadcasts a message at most once. Therefore, the broadcast process eventually terminates. By contradiction, assume that node destination has not received. Since the network is connected, there is a path from the source node to the destination node. Clearly, the first and second nodes on this path such that the first and second nodes are neighbors, the first node have received the messages; the second node does not receive the message. The first node has not broadcast the message since the second node has not received it. Therefore the first node not been selected to broadcast the request. Thus the coverage condition must have been selected for the first node. The second node must have a neighbor of third node, which has broadcast the message or was selected to broadcast. All the selected nodes will eventually broadcast the message. Deletion of unwanted node formation and removal of duplicate packets reduce the redundancy and the number of transmissions. The hybrid broadcast algorithm can achieve full delivery and reduce the number of transmissions only using connectivity information.

3. PERFORMANCE EVALUATION AND SIMULATION RESULTS

Simulation of the local broadcast algorithm with that two special algorithm is conducted using Network Simulator NS2. By using this hybrid algorithm, such as self pruning and dynamic approach the rate of transmission of broadcast is reduced. The rate of transmission of request, total number of generated packets and received packets, Packet delivery Ratio, end to end delay, and normalized routing load are calculated. The total number of transmission rate is reduced successfully. The simulation parameters are shown in Table 1.

Table 1. Simulation Parameters

Parameter	Value	Parameter	Value
Simulator	Ns-2(Version2.33)	Antenna Model	Omni-directional
Bandwidth	2 Mb/sec	Area	1000m x 1000m
MAC Layer	IEEE802.11	Average Forwarding Delay	1 ms
Propagation Model	Two-Ray Ground	Transmission Range	50-300m
Packet Size	256 bytes	Number of Nodes	25-1000

Table 2. Trail Values

Evaluation Metric	Value
Generated data Packets	3412
Received data Packets	3391
Packet Delivery Ratio	99.3554%
Total Dropped Packets	22
Total Overhead	9487

The NAM (Network Animators) instances of collection of two-hop information and final position of the proposed broadcasting algorithm are shown in the Figures 1, 2. In this simulation node 0 is considered as sender and node 24 is considered as destination. In mobility environment how source reaches destination through intermediate routers is depicted in Figure 2.

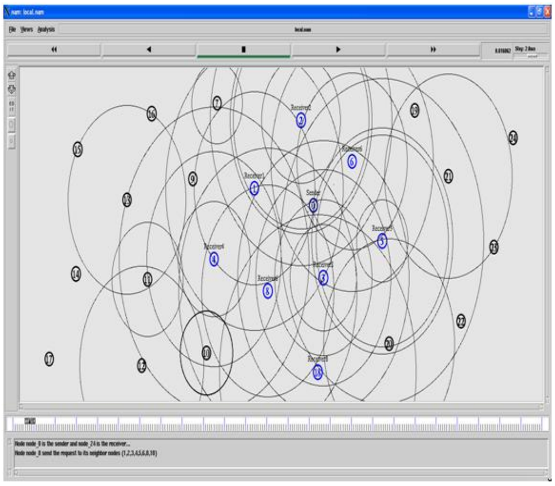

Figure 1. Every node sends its information to every other neighbor nodes

Figure 2. Final position – source reaches destination through two routers

Evaluation metrics: The metrics used in this evaluation are defined as follows:
Packet delivery ratio: It is the ratio between the number of packets that are successfully received and the total number of packets sent.

Packet loss ratio: It is the number of data packets lost divided by number of lost packet and number of packets received successfully.
Packet drop: It is the number of data packets dropped by the intermediate nodes due to congestion or collision.
Routing Overhead: The number of control packets for the routing protocol over the number of data packets sent.
Average End-to-End Delay: Time taken for the packets to reach the destination.
Normalized routing load: It is the ratio between the number of routing packets sent by all the nodes for route and discovery and the number of data packets delivered to the destination nodes.

Table 2 shows sample values for taken evaluation metrics regarding total number of generated packets, total number of received packets, packet delivery ratio, total number of dropped packets, and total overhead.

Figure 3. Packet delivery ratio vs. Time

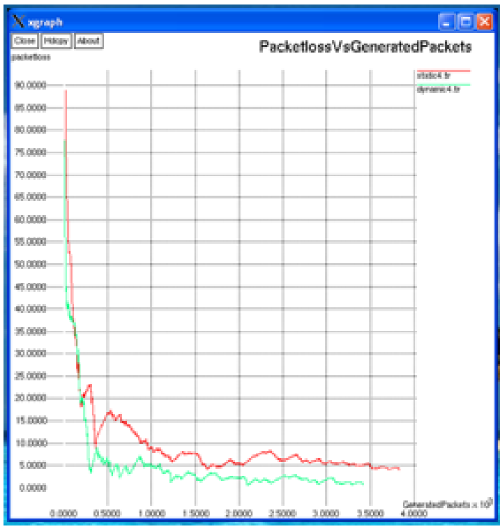

Figure 4. Packet loss ratio vs. Generated packets

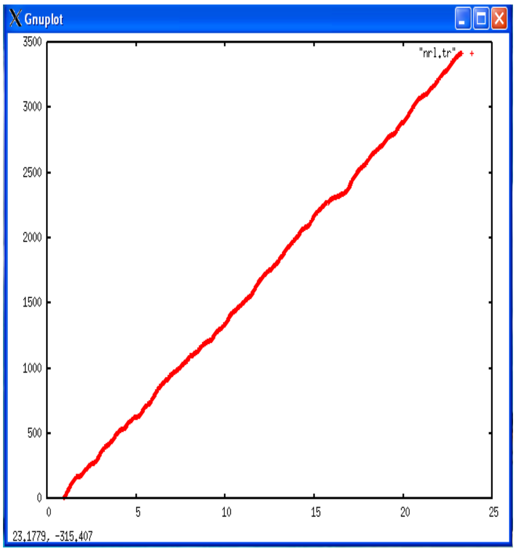

Figure 5. Normalized routing loads

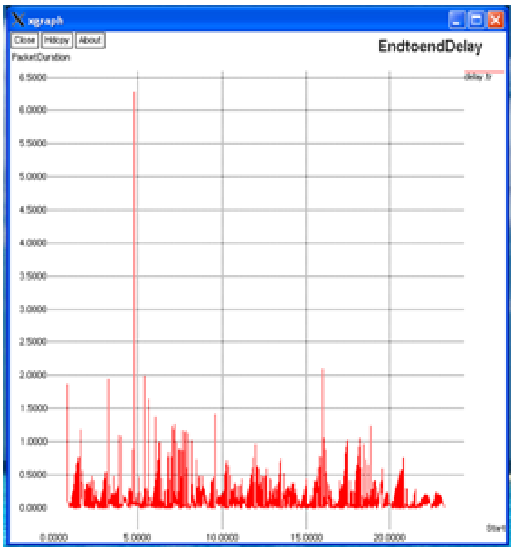

Figure 6. End to end delay (Start vs. Packet duration)

Xgraphs are generated to compare broadcasting algorithms based on the performance metrics. The comparison of packet delivery ratio between static and dynamic approaches in local broadcasting is shown in the Figure 3. Packet delivery ratio is the number of data packets received by the destination nodes divided by the source nodes. Even though node mobility in dynamic approach, it provides good results in packet delivery ratio. Compared to static approach, the dropped packet rate in dynamic approach is also reduced.

Figure 4 depicts the packet loss ratio for static and dynamic approaches. The packet loss ratio is decreased when total number of generated packet increases. Although topology changes problem, packet loss ratio based on dynamic approach provides better results than static approach. In some places it provides somewhat too less packet loss ratio than static approach. Normalized routing load for the proposed hybrid local broadcasting algorithm is shown in the Figure 5. Normalized routing load will increase with increase in time. When compared with other broadcasting algorithms it minimizes the routing overhead. End to end delay for dynamic approach is depicted in Figure 6. In end to end delay calculation starting time and packet duration are taken as main values. The proposed algorithm provides very low delay values for maximum packets. The algorithm reduces routing overhead by minimizing end to end delay.

4. CONCLUSION

In local broadcast algorithm, the number of transmission rates is high for broadcast. An efficient broadcast method should generate a small forwarding node set without excessive overhead. Local broadcast algorithms based on static approach cannot guarantee a small sized CDS if the position information is not available. The position information is the solution for getting good approximation factor. But in some applications it may not be possible to get position information. In dynamic approach the position of the node is determined “on- the- fly” based on local topology information. Using this approach, the constructed CDS may vary from one broadcast instance to another even when the whole network topology and the source node remain unchanged. The sheer nature of ad hoc networks that allow mobility cause dynamic, unpredicted and frequent topology changes which require effective method to find two hop neighbor information. Even though mobility problems the proposed hybrid algorithm which is the combination of self-pruning algorithm and neighbor-designating algorithm reduces bandwidth utilization and eliminates overhead. By using 2-hop neighborhood information it is possible to achieve a good balance between efficiency and overhead. The proposed algorithm provides good approximation factor for optimum solution. So the number of transmission rate is reduced that are required to achieve the full delivery in packet ratio with energy consumption using local broadcast algorithm based on dynamic approach.

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