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Efficient Local Broadcast Algorithms in Wireless Ad Hoc Networks Using Hybrid Approach

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ABSTRACT: For broadcast algorithms in wireless ad hoc networks two main approaches are basically used which are the static and dynamic approach. The local algorithms determine the status i.e. forwarding or non-forwarding status of each node proactively based on local topology information and a globally known priority function in the static approach. Here it is shown that local broadcast algorithms based on the static approach cannot achieve a good approximation factor to the optimum solution. In the second approach which is the dynamic approach, the status of each node "on-the-fly" is determined by the local algorithms based on broadcast state information and local topology information. Using position information can simplify the problem if the position information is available. Static and dynamic approach has been applied which has its inability to get the full delivery of data and constant approximation factor to the possible solution. A hybrid approach has been proposed based on neighbor-designation information and self-pruning algorithm to achieve full delivery and minimum connected dominating set (MCDS). Therefore, we wish to know whether local broadcast algorithms based on the hybrid approach can achieve a constant approximation factor without using position information.

KEYWORDS: Wireless ad hoc networks; Local Broadcast Algorithms; MCDS; Hybrid approach.

I. INTRODUCTION

A Wireless ad hoc network is a network which can organize itself and consists of wireless mobile nodes that move around arbitrarily and can communicate among themselves using wireless radios, without the help of infrastructure which is any pre-existing. Each participating mobile node can act as sender and a receiver.

One of the fundamental operations in wireless ad hoc networks is broadcasting, where a node broadcast a message to all other nodes in the network. This can be achieved through flooding. Not every node is required to forward/transmit the message in order to deliver it to all nodes in the network. A set of wireless nodes form a dominating Set (DS) in unity disk graph [1]. A dominating set is called a Connected Dominating Set (CDS). Clearly, the forwarding nodes, together with the source node, form a CDS. On the other hand, any CDS can be used for broadcasting a data to all its dominating set in consisting or flooding may occur. Therefore, the problems of finding the minimum number of required transmissions and finding a minimum CDS can be reduced to each other. Unfortunately, finding a minimum CDS was proven to be non probabilistic (NP) hard even when the whole network topology is known [2].

In general, the routing protocols such as table-driven protocols and on-demand routing protocols has been developed in ad hoc network [3]. The table-driven routing protocols maintain its neigh-boring node information continuously, up-to-date routing information for every neigh-boring node. But in on-demand routing protocol generates a route when the path or address is needed [4].The broadcasting means exchanging the data, which defines the predefined routing path. Every node makes decision to forward or non-forward the message, this condition is called self-pruning [5]. The local broadcast algorithm based on static approach can achieve better results and full delivery if the position information is available. In the dynamic approach, is based on topology information. Typically, this approach achieves full delivery. In neigh-boring designation approach, every node selects some of its neighbours to forward the message. Then selected nodes forward the message to other nodes. As compared to self-pruning, neigh-boring designation algorithm can achieve the constant approximation factor and full delivery.

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II. Related work

A. *Broadcasting using the Static Approach:*

In the static approach, using local algorithms any local topology changes can affect only the status of those nodes in the vicinity. Local algorithms can provide scalability as the constructed CDS can be updated efficiently [6]. The existing local algorithms in static approach use a priority function known by all other nodes in order to determine the status of each node. The status of each node does not depend on other nodes. In designing local broadcast algorithms, the status of each node not only guarantees constructing a CDS but also ensure that the constructed CDS has small size. Using only local topology information and a globally known priority function, the local broadcast algorithm based on the static approach can achieve better results such as a constant approximation factor and shortest path preservation if the nodes are provided with position information.

In Wu and Li's algorithm, two pruning rules are used to reduce the size of the resultant CDS. In rule 1, a forwarding node becomes non-forwarding if all of its neighbors are also neighbors of another node that has higher priority value. In rule 2, a forwarding node can be non-forwarding if its neighbor set is covered by two other nodes that are directly connected and have higher priority values.

B. *Broadcasting using the Dynamic Approach:*

Using the dynamic approach, the status (forwarding/non forwarding) of each node is determined "on-the-fly" as the broadcasting message propagates in the network. In neighbour-designating algorithms, each forwarding node selects a subset of its neighbours to forward the message. But in self-pruning algorithms, each node decides its own status after receiving the first or several copies of the message. It was recently proved that self-pruning broadcast algorithms based on the dynamic approach are able to guarantee both full delivery and a constant approximation factor to the optimum solution (i.e. MCDS)[7]. The proposed algorithm uses position information in order to design a strong self-pruning condition. The position information can simplify the problem of reducing the total number of broadcasting nodes. Also in some applications it may not be practical to have the position information. So, it is interesting to know if both full delivery and a constant approximation factor can be achieved when position information is not available. We design a hybrid broadcast algorithm and show that the algorithm can get both full delivery and constant approximation using connectivity information.

III. Proposed algorithm

A. *Design Parameters:*

- ASP.Net with C# Simulator
- IEEE 802.11 MAC Layer
- Uniformly distributed the nodes in square of size 1000 *1000 m^2
- Transmission range varied from 50-300m and shows the transmission Range to 260m
- Fixed the total number of nodes to 1000

B. *Description of the Proposed Algorithm:*

Algorithm is presented below and invoke whenever broadcasting hits the view. Broadcasting takes place when a single node transfers a message to all the other nodes. Suppose each node has a list of its 2-hop neighbours this can be achieved in two rounds of information exchange. The proposed broadcast algorithm is a hybrid algorithm; hence e very node that broadcasts the message may select some of its neighbours to forward the message. In our proposed broadcast algorithm, every broadcasting node selects at most one of its neighbours. A node has to broadcast the message if it is selected to forward. 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.

The proposed hybrid algorithm:

- Extract ids of the broadcasting node and the selected node from the received message m.
- if a node u broadcast the message p before initialize the receiving node x then
- Discard the message.

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- Return
- end if
- if a node u updates its list of neighbors then
- Broadcast packet p to selected destination node v
- end if
- Update the neighbor id
- Remove the information if any node receiving node in previous transmission
- Else
- Node Status = non-forward/unavailable
- Remove the message from the queue if u has not been selected by any node before
- end if
- end if

C. *Analysis of the Proposed Broadcast Algorithm:*

Every node broadcasts a message at most once. Therefore, the broadcast process eventually terminates. Assume that node has not received the message by the broadcast termination. Since the network is connected, there is a path from the source node (the node that initiates the broadcast) to node. Clearly, we can find two nodes u and v on this path such that u and v are neighbours has received the message and v has not received it. The node u has not broadcast the message since v has not received it. Therefore, u has not been selected to broadcast; thus the coverage condition must have been satisfied for u. As the result, v must have a neighbour w, which has broadcast the message or selected to broadcast. Note that all the selected nodes will eventually broadcast the message. This is a contradiction as, based on the assumption, v cannot have a broadcasting neighbour.

D. *The Strong Coverage Condition:*

As proven, the proposed broadcast algorithm guarantees that the total number of transmissions is always within a constant factor of the minimum number of required ones [8]. However, the number of transmissions may be further reduced by slightly modifying the broadcast algorithm [9]. As explained earlier, in the proposed algorithm, a selected node has to broadcast the message even if its coverage condition is satisfied. For example, a selected node u can abort transmission, by removing the message from the queue at time t if by time t and based on its collected information, all its neighbours have received the message.

E. *Extending the Network Model:*

The results presented in the paper can be extended to the case where the nodes are distributed in three-dimensional space. In other words, when the nodes are distributed in three dimensions it can be shown that local broadcast algorithms based on the static approach can provide a constant approximation if nodes have their position information.

IV. Simulation Results

One of the major contributions of this work is the design of a local broadcast algorithm based on the dynamic approach that can achieve both full delivery and a constant approximation factor to the optimum solution without using position information. To confirm the analytical results, we implemented Algorithm, Liu's algorithm (a neighbour designating algorithm) [9], accordingly in the network simulator ASP .net and evaluated the ratio of broadcasting nodes (i.e., number of broadcasting nodes/total number of nodes) and end-to-end delay for each algorithm. Also implemented the Wan-Alzoubi-Frieder algorithm [10] and used it as an approximation of the minimum number of broadcasting nodes required. Note that the Wan-Alzoubi-Frieder algorithm (referred to as ratio-6 approximation algorithm) is not a local algorithm and is only used as a benchmark as it has an approximation factor of at most 6 [11].

To compute the number of broadcasting nodes, the algorithm uniformly distributed the nodes in a square of size $1000\times1000m^2$ and allowed only one network-wide broadcast at each simulation run, selected the next forwarding node randomly, and used the strong coverage condition in Algorithm 1 to further reduce the total number of transmissions.

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Figure 1 shows the ratio of broadcasting nodes for over 500 runs for each given value of the input. The transmission range and the total number of nodes were selected from a large interval so that the simulation covers very sparse and very dense networks as well as the networks with large diameters. To get the results shown in Figure 1, set the transmission range to 260m and varied the total number of nodes from 25 to 1000.

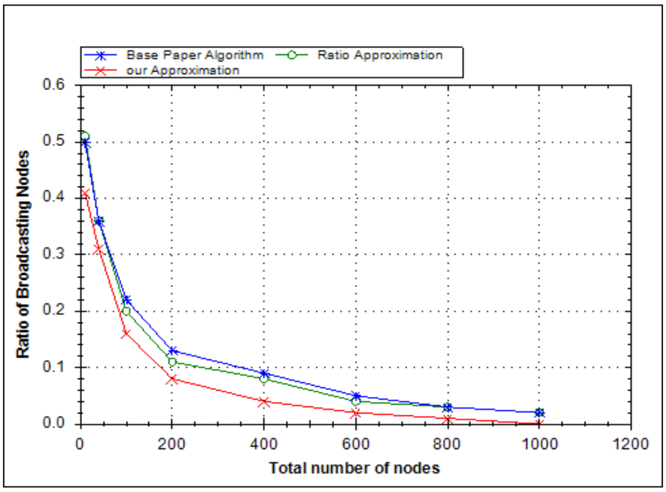

Fig.1. Ratio of broadcasting nodes vs. total number of nodes

The proposed algorithm computed the algorithm delay, which define as the time between the first and the last transmission in a single network wide broadcast. Figure 2 shows the average delay of proposed algorithm and Liu et al.'s algorithm. In previous simulations experiments, nodes do not exchange Hello messages after the broadcast initiation.

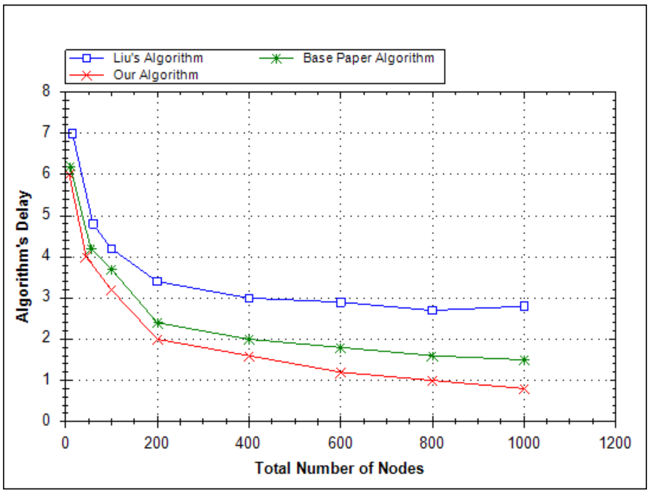

Fig. 2. Average delay vs. total number of nodes

Therefore, they do not take into consideration the overhead of the 2-hop neighbor discovery messages. However, in this, nodes exchange Hello messages during the whole simulation run in order to keep the list of neighbors up-to- date.

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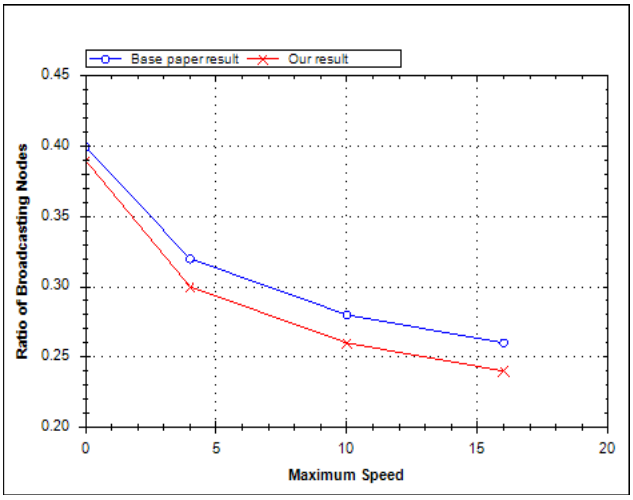

Fig. 3. Ratio of broadcasting nodes vs. maximum speed

Figure 3 shows the effect of mobility on the number of transmissions. As shown in Figure, the number of transmissions slightly decreases as mobility increases.

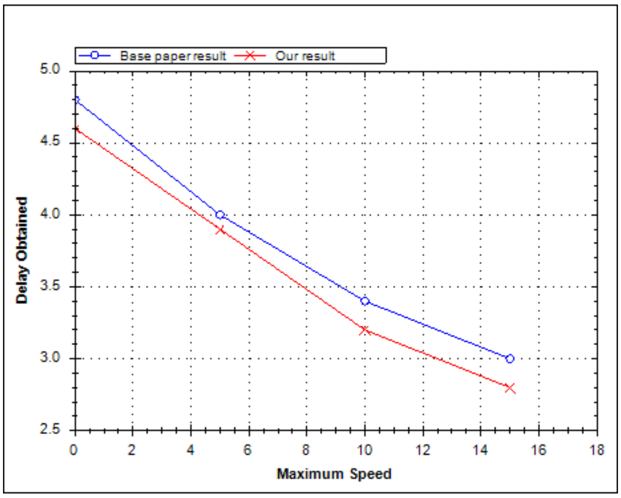

Fig 4. Delay obtained vs. maximum speed

The x-axis is the maximum speed set in the random waypoint mobility model and the y-axis is the delay obtained for at least 500 runs. Figure 4, shows the average delay of Algorithm decreases as mobility increases.

V. Conclusion and Future Work

The hybrid approach has been implemented and their performance has been compared on the basis of ratio of broadcasting nodes and algorithm's delay. The proposed algorithm has reduced the average ratio of broadcasting nodes by 34.56% than the local broadcast algorithm and 29.88% than the ratio-6 approximation. The proposed hybrid algorithm has reduced the average delay by 21.95% than the local broadcast algorithm and 41.95% than the Liu's algorithm. The ratio of broadcasting nodes in the proposed hybrid algorithm in terms of maximum speed is 5.89% less than the local broadcast algorithm result. The algorithm's delay in terms of maximum speed is 4.80% less than the local broadcast algorithm result. The results presented in the paper can be enhanced by having nodes with different

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transmission rates. Also the nodes can be distributed in 3D space in order to improve the packet delivery ratio and the algorithm delay can be reduced using local broadcast algorithms.

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BIOGRAPHY

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