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Efficient Broadcast Algorithms To Reduce number of transmission Based on Probability Scheme

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***Abstract*—Two main approaches to broadcast packets in wireless ad hoc networks are static and dynamic. In the static approach, algorithms determine the status (forwarding/nonforwarding) of each node proactively based on local topology information and a globally known priority function. In the dynamic approach, local algorithms determine the status of each node based on local topology information and broadcast state information. Using the dynamic approach that local broadcast algorithms can achieve a constant approximation factor to the optimum solution when position information is available. We design a local broadcast algorithm in which the status of each node is decided "on-the-fly" and prove that the algorithm can achieve both full delivery and a constant heuristic to the optimum solution without using position information. In this paper we improve the transmission via probability scheme through reduce the number of transmission.**

Index Terms—Mobile ad hoc networks, connected dominating set, broadcasting, constant heuristic.

I. Introduction

Wireless ad hoc networks have to support applications, in which it is required to have wireless communications among a variety of devices without relying on any infrastructure. In ad hoc networks, wireless devices are simply called nodes and also have limited transmission range. Therefore, each node may directly communicate with only those within its limited transmission range. A node requires other nodes to act as routers in order to communicate with out-of range destinations to broadcast packets. Broadcasting is one of the basic operations in wireless ad hoc networks, where a node circulates a message to all other nodes in the network. Broadcasting in ad hoc networks cause more challenges than the one in wired networks for two reasons: node mobility and insufficient system resources [1].

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Because of the diversity in node movement patterns, there is no single optimal scheme for all situations in ad hoc networks. Tree-based schemes such as *minimal connected dominating set* (MCDS) [2] are better in reducing resource consumption in a low mobility environment. A set of nodes form a Dominating Set (DS) if every node in the network is either in the set. A DS is called a Connected Dominating Set (CDS) if the sub graph induced by its nodes is connected. On the other hand, any CDS can be used for broadcasting a message only nodes in the set are required to forward. Therefore, the problems of finding the smallest 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 NP hard even when the whole network topology is known [3], [4].

Williams and Camp [2] divided broadcast methods into four types: simple flooding, probability based methods, neighbor knowledge based methods and area based methods. When a packet is broadcast via simple flooding, it is forwarded by every node in the network exactly once. Simple flooding makes sure the coverage, but it also has the largest *forward node set* and may cause network congestion and collision. Simple flooding is the only way to reach the full coverage in high mobility location. That is, the broadcast packet is assured to be received by every node in the network, providing there is no packet loss created by collision in the MAC layer. This can be accomplished through flooding, in which every node transmits the message after receiving it for the first time. However, flooding can force a large number of redundant transmissions, which can result in major waste of constrained resources such as power and bandwidth. In wide-ranging, not every node is required to transmit the message in order to distribute it to all nodes in the network. Probability and area-based methods [5] are proposed to solve the so-called *broadcast storm problem*. In these schemes, each node will estimate its potential input to the overall broadcasting before forwarding a relay packet. If the estimated contribution is lower than a given threshold, it will not transmit the packet. These methods generate smaller forward node sets than simple flooding. Neighbor-knowledge-based methods are based on the following scheme: To avoid flooding the entire network, a small set of forward nodes is preferred. The challenge is to select a small set of forward nodes in the absence of global network information. It has been proved that finding the smallest set of forward nodes with global network information is NP-hard. In the absence of global network information, this problem is even more challenging.

Heuristic methods are normally used to balance cost in collecting network information and in decision making and effectiveness in deriving a small connected dominating set. Neighbor-knowledge-based algorithms can be further divided into *neighbor-designating* methods and *self-pruning* methods. In neighbor-designating methods [5], the forwarding status of each node is determined by its neighbors. Basically, the source node picks a division of its 1-hop neighbors move forward nodes to envelop its 2-hop neighbors.

This forward node register is piggybacked in the transmit packet. Each node in turn designates its own forward node list. Most neighbor-designating methods use similar heuristics. In *multipoint relaying*, the complete 2-hop neighbor set shall be covered, since it is independent of any particular broadcasting. In *dominant pruning* only a limited 2-hop neighbor set shall be covered by taking the advantage of routing history information; nodes that are also the 1-hop neighbors of the previous visited node are excluded in the current coverage. An efficient algorithm is proposed, where not only the 1-hop neighbors but also some of the 2-hop neighbors of the last visited node are excluded from the current set to be covered. In self-pruning, each node makes its local decision on forwarding status: forwarding or non-forwarding. Although these algorithms are based on similar ideas, this comparison is not recognized or discussed in depth. Fair comparison of these algorithms is complicated by the need of in-depth understanding of the effect of the underlying mechanisms, such as neighborhood information gathering, piggybacking routing history in relay packets, type of priority value to establish a total order among mobile hosts, etc.

Using local information such as k-hop neighborhood information for a small k, the forward node set is selected during a distributed and local pruning method. The forward node set can be constructed and maintained through either a proactive process (up-to-date) or a reactive process (on-the-fly) [6]. In a reactive process, the result at each node can be postponed so that it has higher chance of becoming a non-forward node by overhearing its neighbors' forwarding behavior. Different implementations of probability self-pruning based on k-hop neighborhood information are discussed, and their performances are compared during simulation.

The rest of the paper is organized as follows: In Sections 2 and 3, we analyze the power of local broadcast algorithms based on the position information and dynamic approach, respectively. In Section 4, we use to explain the probability to bring heuristic way to find the path. In section 5, simulation to confirm the analytical results presented in Section 4. Finally, we conclude the paper in Section 6.

II. USING POSITION INFORMATION

In broadcast algorithm, the situation is based on the static approach that may desire to know whether to use location information that can help us to yield a small heuristic factor. A constant heuristic factor is not achievable if position information is available.

In wu Algorithm [7], partitions the network area into square cells. To save energy, at every time the algorithm selects one node in each cell as active and puts other nodes in the cell to sleep. The set of active nodes must form a CDS in order to preserve network connectivity and coverage. To guarantee this, the proposed algorithm in [7] assumes that the side length of each square cell is $R/\sqrt{5}$, where R is the radio transmission range. However, this is not enough to guarantee connectivity, because some square cells may not include any node. Under some conditions, the set of nodes constructed by selecting one node in each nonempty set form a CDS. These conditions can be relaxed at the price of selecting more than one yet a constant number of nodes in some nonempty cells. Therefore, the result can be used to expand the work where some cells may contain no working sensor due to failure, a non uniform distribution of sensors and sensor mobility. In [8], authors use a network partitioning approach in designing broadcast protocols for dense mobile ad hoc networks. To handle mobility, the proposed broadcast protocols in [8] rely on the distribution of nodes as opposed to the majority of existing broadcast protocols that rely on frequently changing communication topology.

III. BROADCASTING USING THE DYNAMIC APPROACH

Using the dynamic approach, the status of each node is determined "on-the-fly" as the broadcasting packet propagates in the network. In neighbor-designating broadcast algorithms, each forwarding node selects a subset of its neighbors to transmit the packet and in self-pruning algorithms each node determines its own status based on a self-pruning condition after receiving the primary or several copies of the message. It was recently proved that self-pruning broadcast algorithms are able to guarantee both full delivery and a constant approximation factor to the optimum solution (MCDS) [9]. However, the proposed algorithm in [9] uses position information in order to plan a strong self-pruning condition. In the previous section, we observed that position information can simplify the problem of reducing the total number of broadcasting nodes. Position information may not be practical in some applications. If both full delivery and a constant approximation factor can be achieved when position information is not available. Design a probability broadcast algorithm and show that the algorithm can achieve both full delivery and constant heuristic only using connectivity information. Before broadcasting a packet, find the probability ratio to transmit the packet at the minimum transmission. Probability can calculate by using bandwidth of a node, distance between nodes and signal length. Estimating the probability for each node will lead to find the accurate path with minimum transmission and cost.

Algorithm1. The proposed probability algorithm executed by a node *x*

1: Extract ids of the broadcasting node and the selected node from the received message *m*
2: **if** *x* has broadcast the message *m* before then
3: Reject the message
4: **end if**
5: **if** *x* receives *m* for the first time **then**
6: Create and fill the list $List_x(m)$
7: Check for probability threshold
8: **end if**
9: Update the list $List_x(m)$
10: Remove the information added to the message by the previous broadcasting node
11: if $List_x(m) \neq 0$; then
12: Select an *id* from $List_x$ (m) and add it to the message
13: Schedule the message (*only update the selected *id* if *m* is already in the queue*)
14: $List_x$ (m) (* $List_x(m) = 0$ in this case*)
15: **if***x* was selected then
16: Schedule the message
17: Update the probability value of each node
18: **else**
19: Remove the message from the queue if *x* has not been selected by any node before
20: **end if**

The proposed algorithm observes the following:

1. *X* discards a received message *m* if it has broadcast *m* before.
2. If *x* is selected to forward the message, it schedules a broadcast and never removes the messages from the queue in future. However, *x* 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 $List_x$ (m).
3. Suppose *x* has not been selected to forward the message by time *t* and the $List_x$ (m) becomes empty at time *t* after an update. Then at time *t*, it removes the message from the MAC layer queue if the message has been scheduled before and is still in the queue.
4. If $List_x$ (m) $\neq 0$ then *x* select a node from $List_x$ (m) $\neq 0$ to forward the message and add the *id* of the selected node in the message. The selection can be done randomly or based on a criterion. For example, *x* can select the node with the minimum *id* or the one with maximum battery life-time.
5. If *x* has been selected to forward and $List_x$ (m) =0 it does not select any node to forward the message. This is the only case where a broadcasting node does not select any of its neighbors to forward the message.

IV. Probability Broadcast Algorithm

One direction to optimize neighbor-designating is to take a probabilistic approach. In order to broadcast, a node in the network broadcasts a message with probability *p* and takes no achievement with probability $1 - p$. The possibility of applying a fact well studied in percolation theory and random graphs. A *phase transition* is a basis for selecting *p*. A certain threshold for *p*, in graphs of an assured size for random graphs and lattices of a certain density for percolation, an *infinite spanning cluster* abruptly appears instead of a set of finite clusters. An *infinite spanning cluster* is an unbounded connected element, which if transposed to a MANET would translate in the very high probability of the existence of a multi-hop path between any two nodes within the network. Probabilistic broadcast for neighbor-based in MANETs, have not done so within the context of phase transition. To the contrary of [10], focus on pure neighbor based in order to know the variations in performance due solely to the parameters simulating realistic MANET environments. Results provide a general understanding of the behavior to be expected from probabilistic flooding.

A *phase transition* is a phenomenon where a system undergoes a sudden change of state: small changes of a given parameter in the system induce a great shift in the system's global performance. This abrupt transition occurs at a specific value *pc* called the *critical point* or *critical threshold*. Below *pc* the system is said to be in a *subcritical phase* the global performance is non-existent. Above *pc* the system is in a *supercritical phase* and the global property may be almost surely observed. It would be extremely cost-efficient to observe phase transition in a probabilistic broadcasting algorithm within all or known subsets of topologies [11]. The probability algorithm estimates the potential value by using the bandwidth, transmission range and distance between the nodes. The proposition within such cases would be that there exists a certain probability threshold *pc* <1 at which the relay message will almost surely reach all nodes within multihop broadcast reach. Broadcasting with a probability *p* > *pc* will not provide any significant improvement.

V. Simulation Results

The design of a probability broadcast algorithm based on the dynamic approach (Algorithm 1) that can achieve both full delivery and a constant heuristic factor to the optimum solution without using position information. Figure 1 shows that the range of transmission is high when we using the probability algorithm for more number of nodes compared to the neighbor designating algorithm. In neighbor designating algorithm there may be a chance for data loss whereas broadcasting packets. So by using the approach of probability, it may reduce the number of transmission inorder to avoid the data loss during transmission.
Figure 1 set the transmission range to 8 m and varied the total number of nodes from 25 to 300. 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.

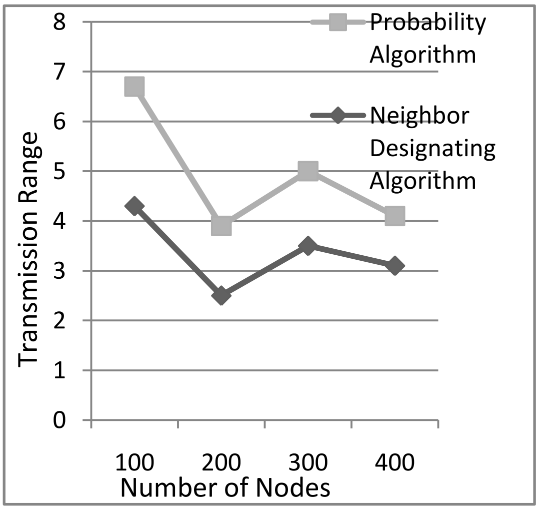

Fig 1: Transmission range versus No of nodes

Figure 1 set the transmission range to 8 m and varied the total number of nodes from 25 to 300. 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.
Figure 2 shows the average delay of probability algorithm with flooding algorithm. To get these results, fixed the transmission range to 50 m and varied the number of nodes from 50 to 1500. The average delay of our broadcast algorithm is less percent of that of flooding algorithm.

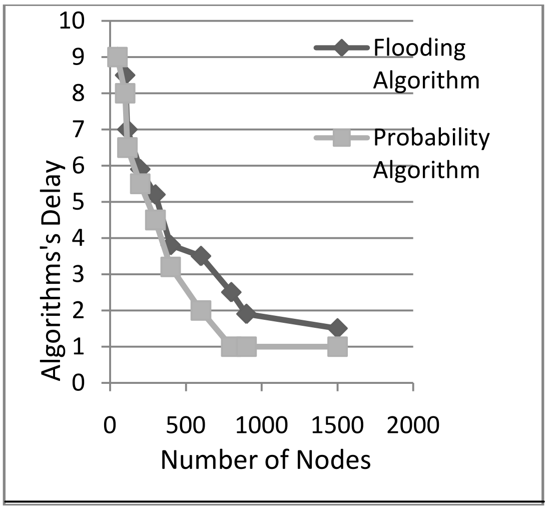

Fig 2: Number of nodes versus Algorithm's delay

Figure 2 shows the efficiency of using probability approach in broadcast algorithm to deliver the packets from source to destination with low delay compared to other algorithms.

VI. Conclusion

In this paper, we explore capabilities of local broadcast algorithms to reducing the total number of transmissions that are required to achieve full delivery with no data loss. Local broadcast algorithms based on the static approach cannot guarantee a small sized CDS if the position information is not available. In probability approach, without using the position information, can achieve a constant heuristic factor and full delivery without packet loss. This approach is more efficient to reducing the number of transmission inorder to relay the packets to the destination. The proposed algorithm based on the dynamic approach can be extended to the case where nodes have different transmission ranges or when the network is modeled using the quasi-local unit disk graph model.

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