# On the reduction of broadcast redundancy in mobile ad hoc networks

**Conference Paper** · February 2000

DOI: 10.1109/MOBHOC.2000.869221 · Source: IEEE Xplore



Wei Peng
National University of Defense Technology

# On the Reduction of Broadcast Redundancy in Mobile Ad Hoc Networks

Wei Peng Xi-Cheng Lu
Department of Computer Science, Changsha Institute of Technology, Changsha, 410073, P.R.China
*Email: {wpeng, xclu@nudt.edu.cn }*

*Abstract* - **Flooding in mobile ad hoc networks has poor scalability as it leads to serious redundancy, contention and collision. In this paper, we propose an efficient approach to reduce the broadcast redundancy. In our approach, local topology information and the statistical information about the duplicate broadcasts are utilized to avoid unnecessary rebroadcasts. Simulation is conducted to compare the performance of our approach and flooding. The simulation results demonstrate the advantages of our approach. It can greatly reduce the redundant messages, thus saving much network bandwidth and energy. It can also enhance the reliability of broadcasting. It can be used in static or mobile wireless networks to implement scalable broadcast or multicast communications.**

## I. INTRODUCTION

Broadcast is expected to be performed frequently in *mobile ad hoc networks* (MANETs). It is an important operation in service discovery or route query in many on-demand (or reactive) routing protocols (e.g., DSR [1], AODV [2], ODMRP [3], etc.). It is a viable candidate for reliable multicast in MANETs with high mobility [4]. It is also an important communication means in many MANET applications. Intuitively, broadcast can be implemented by flooding, in which every node rebroadcasts a message when the message is received at the first time. Though flooding is simple, it consumes much network resources as it introduces a large number of duplicate messages. It leads to serious redundancy, contention and collision in mobile wireless networks, which is referred to *broadcast storm problem* [5].

In this paper, we propose a new broadcast approach that can efficiently reduce broadcast redundancy in mobile wireless networks. The approach is executed in a distributed manner. It utilizes only local topology information and statistical information of duplicate messages to avoid unnecessary rebroadcasts. It retains the merits of flooding, while introducing little control overhead. Simulation is conducted to compare the performance of the proposed approach and flooding. The simulation results show that broadcast redundancy can be reduced greatly by our approach.

## II. RELATED WORKS (extracted)

## III. OUR APPROACH

### A. Assumptions and Notations

We make the following assumptions in our broadcast algorithm:

- Omni-directional antenna is used and all mobile nodes have the same wireless transmission range. So, there exists a bi-directional link between two nodes if either is within another's radio coverage.
- The wireless channel is shared by all nodes and can be accessed by any node at random time. If a node transmits while one neighbor is receiving, collision may occur at the latter.

For node $u$, we denote its neighbor set as $N(u)$. The degree of node $u$ is denoted as $d(u)=|N(u)|$. The maximum degree of neighbors of node $u$ is denoted as $d_m(u)$. The *broadcast cover set* is defined as the set of nodes that have been covered by one previous transmission of a broadcast message. If a node is in the broadcast cover set of a message, it is believed that the node has received a copy of the message. For node $u$, its broadcast cover set for message $m$ is denoted as $C(u, m)$.

### B. Scalable Broadcast Algorithm

The main idea of our broadcast algorithm is that a node need not rebroadcast a message if all its neighbors have been covered by previous transmissions. To achieve this, a node should gather the local topology knowledge and the duplicate information. The broadcast algorithm can be divided into two parts: local neighborhood discovery and data broadcasting. Local neighborhood discovery is trivial as it can be fulfilled by any existing techniques. For example, nodes can exchange "hello" messages periodically with their neighbors. By including the neighbor information in "hello" messages, a node can learn the topology information within two hops.

A transmitter of a broadcast message is either the source or a node that performs rebroadcast. When a node receives a broadcast message, we assume that it can learn who is the transmitter. Then it can learn which nodes have been covered by this transmission by checking the neighbor list of the transmitter. Then these nodes (including the transmitter) are added into the broadcast cover set of the message. When making rebroadcast decision, the node checks the broadcast cover set of the message. If all its neighbors are in the set, then the rebroadcast operation is unnecessary and can be canceled.

The data broadcasting procedure is illustrated as follows.

1) For source $s$, it just broadcasts messages to all its neighbors and ignores duplicate messages received later.

2) For any other node, say $u$, when it receives a broadcast message $m$ from node $r$, it performs the following operations:

a) If $N(u) \subseteq N(r) \cup \{r\}$, then no rebroadcast need be performed and the duplications received later will be dropped.

b) Or else, if the message is received firstly, then let $C(u, m)=N(r) \cup \{r\}$, and schedule a rebroadcast by delaying the rebroadcast operation for a random period. In this period, any successive duplicates will be discarded, and at the mean time the information of the nodes covered by the transmissions will be recorded in the broadcast cover set.

That is, if $m$ is a duplicate, then let $C(u, m)=C(u, m) \cup N(r) \cup \{r\}$, and discard $m$.

c) After the delay period is expired, if $N(u) \subseteq C(u, m)$, then cancel the rebroadcast; or else, rebroadcast the message $m$. The duplicate messages received later will be ignored.

The choice of a right delay period will be the key to success for the proposed algorithm. A wise choice should be to let the node with more neighbors rebroadcast earlier, so that more nodes can be covered by one transmission. In this paper, we propose the following formula to calculate the rebroadcast delay while other more elaborate rules are possible. For node $u$, the delay time $T$ is calculated as follows:

$$T0 = (1+d_m(u)) / (1+d(u)); \quad (1)$$

$$T = U(\Delta \times T0) \quad (2)$$

where $d(u)$ is the degree of node u, $d_m(u)$ is the maximum degree of the neighbors of $u$, $\Delta$ is a small constant delay, and $U(x)$ is a function that returns a random number distributed uniformly between 0 and $x$.

### *C. Correctness (extracted)*

The following lemma ensures the correctness of the broadcast algorithm described above.

**Lemma 1** Assume no loss and no error occurs in the transmission of broadcast messages. Given a connected undirected graph $G=(V, E)$, each node except the broadcast source receives at lease one copy of any broadcast message in the algorithm described above.

*Proof*: (extracted)

### *D. Implementation Considerations (extracted)*

## IV. SIMULATION STUDY

We implement our broadcast algorithm (referred as SBA) and flooding in the network simulator *ns-2* and evaluate their performance through simulation. The physical and data link layer model is the same one used in previous works [6]. The mobility model implemented is one called "random waypoint" model [6]. The performance metrics we observe are Delivery Ratio and Delivery Cost. We only present the main simulation results that are shown in figure 1-3.

As shown in the figures, our approach can reduce the broadcast redundancy efficiently. Normally, about 60% duplicate messages can be saved comparing with that of flooding. The delivery ratio of flooding decreases with the increasing of the network size and the traffic load. The delivery ratio remains high for all pause times in both approaches, while our approach takes only about 30% broadcast cost to deliver messages to 97% receivers.

## V. CONCLUSION (extracted)

## REFERENCES


[1] J. Broch, D. B. Johnson and D. A. Maltz. The Dynamic Source Routing Protocol for Mobile Ad Hoc Networks. Internet Draft (work in progress), June 1999.

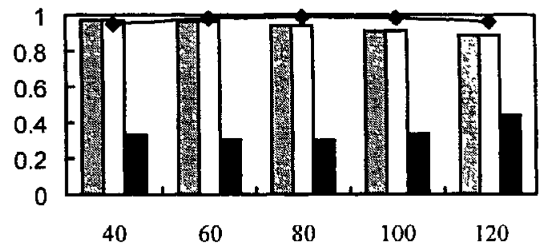
[2] C. Perkins. Ad Hoc On Demand Distance Vector (AODV) Routing. Internet Draft (work in progress), June 1999.

[3] Sung-Ju Lee, W. Su, M. Gerla. On-Demand Multicast Routing Protocol (ODMRP) for Ad Hoc Networks. Internet Draft (work in progress), June 1999.

[4] C. Ho, K. Obraczka, G. Tsudik, and K. Viswanath. Flooding for Reliable Multicast in Multi-Hop Ad Hoc Networks. DIAL M'99, August 1999.

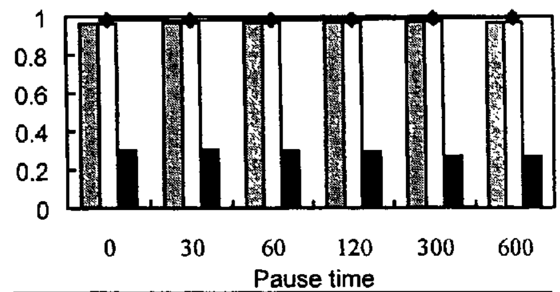
[5] Sze-Yao Ni, Yu-Chee Tseng, Yuh-Shyan Chen, and Jang-Ping Shen, The Broadcast Storm Problem in a Mobile Ad Hoc Network. Mobicom'99, August 1999.

[6] J. Broch, D. A. Maltz, D. B. Johnson, Y.-C. Hu, and J. Jetcheva. A Performance Comparison of Multi-Hop Wireless Ad Hoc Network Routing Protocols. Mobicom'98, October 1998.

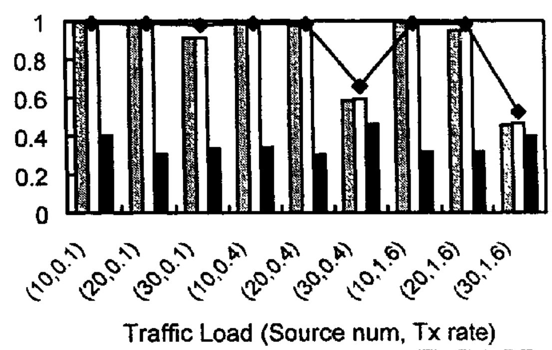

Delivery Ratio(flood) | Delivery Cost(flood) | Delivery Cost(SBA) | Delivery Ratio(SBA)

Figure 1 Delivery ratio and delivery cost as a function of network size




Delivery Ratio(flood) | Delivery Cost(flood) | Delivery Cost(SBA) | Delivery Ratio(SBA)

Figure 2 Delivery ratio and delivery cost as a function of pause time




Delivery Ratio(flood) | Delivery Cost(flood) | Delivery Cost(SBA) | Delivery Ratio(SBA)

Figure 3 Delivery ratio and delivery cost as a function of traffic load