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Reliability for broadcasting in Mobile Ad Hoc Networking Technology

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ABSTRACT

A Mobile Ad hoc Network is a collection of mobile wireless nodes that combine to form a network without any infrastructure. The main challenges in MANET are reliability, bandwidth and battery power. Broadcasting is important in MANET for routing information discovery. Broadcasting is the process in which a source node sends a message to all other nodes in MANET. The broadcast operation as a fundamental service in mobile ad hoc networks is prone to the broadcast storm problem if forwarding nodes are not carefully designated. This paper proposes a simple broadcast algorithm called double-covered broadcast which takes advantage of broadcast redundancy to improve the delivery ratio in an environment that has rather high transmission error rate. Only a set of selected nodes will forward the broadcast message. The selected nodes called forwarding nodes must satisfy the following two requirements: 1) the sender's 2-hop neighbors are covered and 2) the sender's 1-hop neighbors are either forwarding nodes or non forwarding nodes covered by at least two forwarding neighbors. The retransmissions of the forwarding nodes are received by the sender as the confirmation of their reception of the packet. The non forwarding neighbors do not acknowledge the reception of the broadcast. The proposed algorithm has many metrics such as balancing the average retransmission redundancy, avoid broadcast storm problem, recovering the transmission error locally and increasing the broadcast delivery ratio in a high transmission error rate environment.

Introduction

A Mobile Ad hoc network consists of wireless mobile nodes that cooperatively form a network without any infrastructure allowing an arbitrary collection to create a network on demand. Due to considerations such as radio power limitation, channel utilization, and power-saving concerns, a mobile host may not be able to communicate directly with other hosts in a single-hop fashion. In this case, a multihop scenario occurs where the packets sent by the source host are relayed by several intermediate hosts before reaching the destination host. Applications of MANETs occur in situations like battlefields or major disaster areas where networks need to be deployed immediately but fixed network infrastructures are not available. Broadcasting to all nodes in a network has extensive applications in mobile ad hoc networks. The broadcast operation is the most fundamental role in MANET s because of the broadcasting nature of radio transmission: when a sender transmits a packet all nodes within the sender's transmission range will be affected by this transmission. The advantage is that if one node transmits a packet all its neighbors can receive this message. This scenario is also referred to as "all neighborhood nodes are covered". The Broadcast problem refers to sending a message from one node to all other node in network. The problem considered here has the following characteristics.

The broadcast is spontaneous - Any mobile host can issue a broadcast operation at any time. For reasons such as the host mobility and the lack of synchronization preparing any kind of global topology knowledge is prohibitive. Little or no local information may be collected in advance. The broadcast is unreliable - A host may miss a broadcast message because it is temporarily isolated from the network and also acknowledgements may cause A Straightforward approach for broadcasting is blind flooding in which each node will rebroadcast the packet whenever it receives the packet for the first time. Blind Flooding will generate many redundant transmissions.

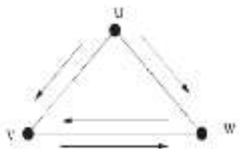

Fig.1

Fig.1 shows a network with three nodes. When node u broadcasts a packet both nodes v and w receive the packet. Then v and w will rebroadcast the packet to each other. Apparently the last two transmissions are unnecessary. Redundant transmission may cause a more serious broadcast storm problem in which redundant packets cause contention and collision.

Also in Blind Flooding (BF) where each node forwards the packet once and only once makes every node a forwarding node. If the forwarding nodes are not carefully designated they will trigger many retransmissions at the same time which might congest the network. This is referred to as the broadcast storm problem. A MANET consists of randomly distributed nodes that result in some regions of the network being very dense and others being very sparse. A careful selection of forwarding nodes i.e. selecting a similar number of forwarding nodes in both dense and sparse regions of the network not only reduces the density of the network but also balances the difference of the density among the different regions of the network. MANETs suffer from a high

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transmission error rate because of the high transmission contention and congestion. Therefore it is a major challenge to provide high reliability for broadcasting operations under such dynamic MANET s.

Related Work

Broadcasting algorithms can be classified into probabilistic and deterministic approaches .The probabilistic approaches provide good stochastic results, but do not guarantee full coverage of the network. On the contrary, the deterministic approaches provide full coverage of the network. In a typical neighbor-designating broadcast algorithm, each node v gets its 2-hop neighbor set $N_2(v)$ by including its neighbors in the HELLO message; thus, v can select a subset of nodes in its 1-hop node set H(v) to cover its 2-hop node set $H_2(v)$. In the neighbor-designating broadcast algorithm, the upstream node that has sent a broadcast packet is viewed as a forwarded node. A forwarding node is a downstream node designated by the current node that will forward the broadcast packet; a non forwarding node is a downstream node that is not designated to forward the packet.

Neighbor designating broadcast algorithms can be further divided into static and dynamic approaches. In a typical static approach, a node becomes an “active” forwarding node that will relay the broadcast packet if it is designated as a forwarding node by its lowest-ID neighbor. In a typical dynamic approach, if a node receives a new broadcast packet for the first time and is designated as a forwarding node, it will relay the packet. The dynamic Neighbor designating broadcast algorithms differ in how they select the forwarding node sets, although some of them were not initially designed for dynamic neighbor designating broadcast algorithms .In multipoint relays (MPR s) are selected as the forwarding nodes to propagate link state messages. The MPRs are selected from 1-hop neighbors to cover 2-hop neighbors. Forwarded nodes are not considered for a node to select its MPR s and, therefore, the entire set of 2-hop neighbors must be covered.

Specifically, v selects its forwarding node set F from all candidate neighbors

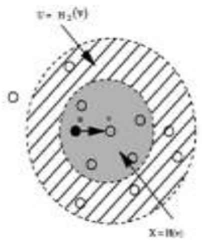

Fig .2

$X = H(v) = N(v) – \{ v \}$ to cover its uncovered 2-hop neighbors $U = H_2(v) = N_2(v) – N(v)$ with a simple greedy algorithm used in the set coverage problem as in fig.2. This forwarding node set selection process (FNSSP) algorithm (for node v) is described as follows,

1. Initially, $X = H(v)$, $U = H_2(v)$, and $F = ø$
2. Find w (in X) with the maximum effective neighbor degree $deg_e(w) = | N(w) \cap U |$
3. $F = F \cup \{w\}$, $U = U – N(w)$, $X = X – \{w\}$.
4. Repeat steps 2 and 3 until U becomes empty.

Lim and Kim [7] provided a dominant algorithm (DP). Compared to the MPR, the DP excludes the coverage of the forwarded node from the current node’s 2-hop neighbor set.

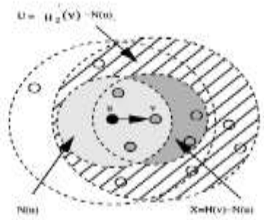

Fig .3

Supposing u is the last forwarded node and v is a designated forwarding node of u, v selects its forwarding node set from $X = H(v) – N(u)$ to cover 2-hop neighbor set $U = H_2(v) – N(u)$ as in Fig.3.

A Double - Covered Broadcast Algorithm

The proposed double-covered broadcast (DCB) algorithm works as follows: When a sender broadcasts a packet, it selects a subset of 1-hop neighbors as its forwarding nodes to forward the packet based on a greedy approach. The selected forwarding nodes satisfy two requirements: 1) they cover all the sender’s 2-hop neighbors, and 2) the sender’s 1-hop neighbors are either forwarding nodes or non forwarding nodes covered by at least two forwarding nodes (e.g., once by the sender itself and once by one of the selected forwarding nodes). After receiving a new broadcast packet, each forwarding node records the packet, computes it’s forwarding nodes, and rebroadcasts the packet as a new sender. The retransmissions of the forwarding nodes are overheard by the sender as the acknowledgement of the reception of the packet. The non forwarding 1-hop neighbors of the sender do not acknowledge the receipt of the broadcast. The sender waits for a predefined duration to overhear the rebroadcast from its forwarding nodes. If the sender fails to detect all its forwarding nodes retransmitting during this duration, it assumes that a transmission failure has occurred for this broadcast. The sender then resends the packet until all the forwarding nodes’ retransmissions are detected or the maximum number of retries is reached. The sender may miss a retransmission from a forwarding node, and therefore resends the packet. When the forwarding node receives a duplicated broadcast packet, it sends an ACK to acknowledge the sender.

The DCB algorithm has many metrics such as balancing the average retransmission redundancy, avoid broadcast storm problem, recovering the transmission error locally and increasing the broadcast delivery ratio in a high transmission error rate environment. The DCB algorithm uses the following symbols:

- F(v) : the forwarding node set of node v
- U(v) : the uncovered 2-hop neighbor set of node v
- X (v) : the selectable 1-hop neighbor set of node v
- P (v, F(v)) : a unique broadcast packet P forwarded by node v that attaches v ’s forwarding node set F (v)
- T_{wait} : the predefined duration of a timer for a node to overhear the retransmission of its forwarding node.
- R : the maximum number of retries for a node

The DCB algorithm as follows:

1.when source s wants to broadcast P, it uses the FNSSP to find F (s) and broadcast P (s , F (s)).

2.when node v receives P (u, F (u))
from u,

2.1.v records P (u, F (u))

2.2. v up dates the selectable 1-hop neighbor set node v and the uncovered neighbor set of node v

2.3. **if** v € F (u) **then**
if the packets has not been received before **then** v uses the FNSSP to find F (V) and broadcast P (v , F (v)).
else
v sends an ACK to u to confirm the reception of P and drops the packet.
end if
else
v drops the packet
end if

3. When node u has sent the packet, it starts a timer T_{wait} and overhears the channel. After T_{wait} is expired, if u does not overhear all nodes in F (u) to resend P or to send ACK s, u retransmits P until the maximal number of retries R is reached.

Expected Results

Reliability is improved by using double covered broadcast algorithm. With ACK this algorithm provides high reliability for no forwarding nodes and without ACK this algorithm provides less reliability for no forwarding nodes. While comparing these two, with ACK provides good performance under a high transmission error rate.

Conclusion

Finally, the proposed simple broadcast algorithm that provides a high delivery ratio while suppressing broadcast redundancy. This is achieved by only requiring some selected forwarding nodes among the sender's 1-hop neighbor set to forward the packet. The double-covered forwarding node set selection process provides some redundancy to increase the delivery ratio for no forwarding nodes. The DCB provides full reliability for all forwarding nodes but not for no forwarding nodes. In order to provide full reliability for all no forwarding nodes uses the NACK mechanism such that a no forwarding node will send a NACK message when the node notices a packet loss during the continuous broadcasting transmission.

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