DESIGN OF A BROADCAST ALGORITHM FOR RELIABILITY IN MOBILE AD HOC NETWORKS

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Abstract:*The main challenges in MANET are reliability, bandwidth and battery power. Broadcasting is important in MANET for routing information discovery. 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 algorithm 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 the forwarding nodes must satisfy the following two requirements: i)The sender's 2-hop neighbors are covered and ii)The sender's 1-hop neighbors are either forwarding nodes or non-forwarding nodes covered by atleast two forwarding neighbors. The retransmission 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 matrices 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.*

Keywords: *broadcast, forwarding node, mobile ad hoc networks,reliability*

I. INTRODUCTION

A mobile ad hoc network is a collection of mobile wireless nodes that combine to form a network without any infrastructure. 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. Thus a multi hop scenario occurs where the packets sent by the source host are relayed by several intermediate hosts before reaching the destination. Applications of MANETs occur in situations like military vehicles in battlefield or major disaster areas where networks need to be deployed immediately but fixed network structure 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 MANETs because of the broadcasting nature of radio transmission. The advantage is that if one node transmits a packet all it's neighbors can receive this message.

The problem considered here has the following characteristics.

First ***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.

Second ***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.

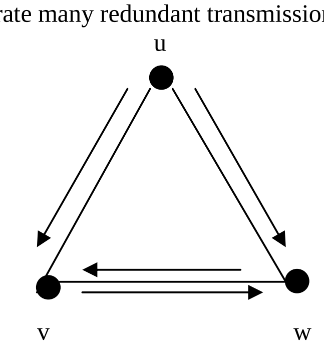

Fig.1

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 to each other. Apparently the last two transmissions are unnecessary. Redundant transmission may cause a serious broadcast storm problem in which redundant packets cause contention and collision.

Blind flooding also makes every node a forwarding node. If the forwarding nodes are not carefully designated they will trigger many retransmissions at the same time which may 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 ie. 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 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 MANETs.

II. RELATED WORK

There are mainly two approaches for classifying the broadcasting algorithms :i) probabilistic and ii)deterministic. The probabilistic approach provide good stochastic results ,but do not guarantee full coverage of the network. 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.

The neighbor designating broadcast algorithm 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 MPRs are selected as the forwarding nodes to propagate link state messages. The MPRs are selected from 1 hope neighbors to cover 2 hop neighbors. Forwarded nodes are not considered for a node to select its MPRs and therefore , the entire set of 2 hop neighbors must be covered.

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

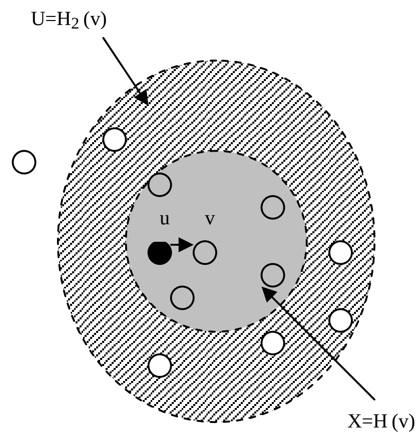

Fig.2

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=H2(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 U {w} , U = U-N(w) , X= X - {w}.
4. Repeat steps 2 and 3 until U becomes empty.

Lim and Kim [6] 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.

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 $U = H_2(v) - N(u)$

III. 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: i) They cover all the sender's 2 hop neighbors and ii) the sender's 1 hop neighbors are either forwarding nodes or non-forwarding nodes covered by at least two forwarding nodes (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 its forwarding nodes, and rebroadcast the packet as a new sender. The retransmission 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 node's 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 matrices such as balancing the average transmission 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)

The algorithm is 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 updates 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_w and overhears the channel. After T_w 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.

IV. COMPARISON WITH FNSSP ALGORITHM

To evaluate the packet delivery simulation is done with 20 nodes with the source node transmitting 1000 packets to the destination node. Each packet is transmitted with an interval of one second and is of size 512 bytes. As it can be seen from the fig.3 packet delivery ratio is more with DCB. Pause time indicates the extend of mobility.

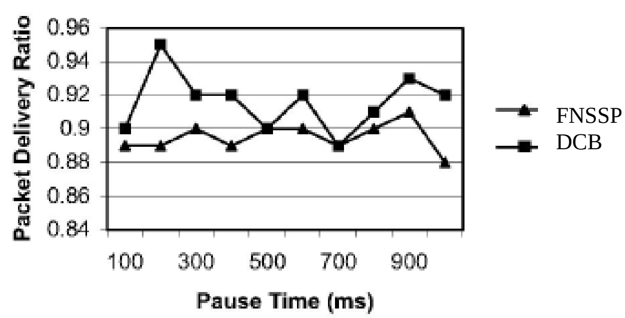

Fig. 3

V. CONCLUSIONS AND FUTURE WORK

The proposed double-covered broadcast algorithm is simple and provides a high delivery ratio while suppressing broadcast redundancy. This could be 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 non-forwarding nodes so that retransmissions can be remarkably suppressed when transmission errors are considered. The DCB provides full reliability for all forwarding nodes but not for non-forwarding nodes. In order to provide full reliability for all non-forwarding nodes , uses the NACK mechanism such that a non-forwarding node will send a NACK message when the node notices a packet loss during the continuous broadcasting transmissions. The future work is to investigate the strategies of applying the NACK mechanism and the effects when the NACK mechanism is applied

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