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Local Broadcast Algorithm Using Static and Dynamic Approach in Wireless Ad-Hoc Networks

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Abstract

Broadcast is the process of sending a message from one node to all other nodes in an ad hoc network. It is a fundamental operation for communication in ad hoc networks. It allows for the update of network information and route discovery as well as other operations. The simplest form of broadcast in an ad hoc network is referred to as blind flooding. As all nodes participate in this broadcast, blind flooding suffers from the broadcast storm problem. This problem results in redundant rebroadcasts, medium contention and packet collision. So in order to reduce broadcast redundancy with high delivery ratio under high transmission error rate is a major challenge. A simple broadcast algorithm, called double-covered broadcast (DCB), takes the advantage of broadcast redundancy to improve the delivery ratio in an environment that has rather high transmission error rate. In this algorithm, forwarding nodes are selected in such a way that the sender's 2-hop neighbors are covered and the sender's 1-hop neighbors are either forwarding nodes or non-forwarding nodes covered by at least two forwarding neighbors. The acknowledgement is received by the sender as the confirmation of their reception of the packet. If the sender does not detect all its forwarding nodes' retransmissions, it will resend the packet until the maximum number of retries is reached. Simulation results show that the proposed broadcast algorithm provides good performance under a high transmission error rate environment.

Introduction

The ad hoc network enables wireless communications between participating mobile nodes without the assistance of any base station. Two nodes that are out of one another's transmission range need the support of intermediate nodes, which relay messages to set up a communication between each other.

The broadcast operation is the most fundamental role in Ad hoc network 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 or dominated by this transmitting node". On the negative side, one transmission may interfere with other transmissions, creating the exposed terminal problem where an outgoing transmission collides with an incoming transmission and the hidden terminal problem where two incoming transmissions collide with each other.

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. The fact that only a subset of nodes forward the broadcast message and the remaining nodes are adjacent to the forwarding nodes can be used to reduce the broadcast congestion but still fulfill the broadcast coverage. An Ad hoc network 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. Basically, forwarding nodes form a connected dominating set (CDS).

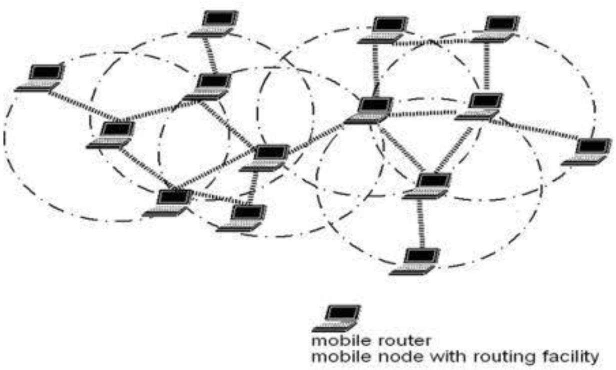


Fig 1.1 Ad-hoc network

A dominating set (DS) is a subset of nodes such that every node in the graph is either in the set or is adjacent to a node in the set. If the sub graph induced from a DS of the network is connected, the DS is a CDS.Finding a minimum connected dominating set in a given graph is NP-complete, in a unit disk graph, it has also been proved to be NP-complete. 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.

Existing System

In general, a reliable communication needs some feedback from receivers. Many approaches are provided for reliable communications in wired networks. The basic categories of reliable communication schemes are sender initiated and receiver initiated approaches. In the sender-initiated approach the receiver returns a positive ACK to the sender for each message it receives. The sender needs to maintain all records for each receiver to confirm the success of the delivery. Only missing packets are retransmitted by the sender, either to individual requested receivers or to all receivers. The drawback of this scheme is that the sender may become the bottleneck of transmission when simultaneous ACKs return. Moreover, the amount of records that the sender must maintain may also grow large. In the receiver-initiated approach the receiver is responsible for reliable delivery.

Each receiver maintains receiving records and requests repairs via a negative acknowledgement (NACK) when errors occur. Several strategies can be applied to the receiver initiated approach, such as sender-oriented, flat-receiver oriented ,and hierarchical-receiver-oriented approaches. The problem of the receiver-initiated approach is the long end-to-end delay since the sender must wait for the next broadcast packet to determine whether the previous one is successfully delivered or not. Therefore, it can be applied only when the sender has many packets to send. The source starts a broadcast operation by sending a message to all its neighbors and waiting for the ACKs from its neighbors. When it receives all these ACKs, it sends a message asking the neighbors to propagate the message one more hop to their own neighbors. The neighbors of the source forward the message to their neighbors and send the ACKs back to the source when they receive all ACKs from all their own neighbors, and so forth. The scheme incurs too much communication overhead and needs stable linkages for Ad hoc networks.

Proposed System

Double dominating set

The concepts of double dominating set and total double dominating set are provided by some researchers in an attempt to provide a degree of robustness to the network. The double dominating set is a set S - V if every node not in S is dominated by at least two nodes in S. The total double dominating set is a set S - V if every node of V is dominated by at least two nodes in S. A centralized tree search type algorithm is applied to construct the double dominating set and some theoretical bounds are given. The three heuristic algorithms are provided to construct a double dominating set and many related parameters are measured by simulations. The proposed DCB algorithm also provides a double dominating set. Unlike algorithms proposed, this double dominating set is built incrementally when the broadcast packet is disseminated throughout the network. Moreover, the generated double dominating set is also connected.

Methodology

Forwarding node set selection process

We assume that each node v knows its 2-hop sub graph G2 (v) = (N2 (v), E2 (v)). A forwarding node v uses the FNSSP-DC (Algorithm 1) to determine its forwarding node set F(v): v uses the FNSSP algorithm (Algorithm 2) to find F(v) in H(v) to cover N2(v) – {v}.

Unlike the MPR algorithm, where only nodes in H2(v) need to be covered by forwarding node set F(v), the FNSSP-DC algorithm guarantees that v’s 2-hop neighbor set N2(v) (excluding v itself) is completely covered by v’s forwarding node set F(v). Since v also transmits the packet to cover H (v), any nonforwarding node in H (v) is covered twice.

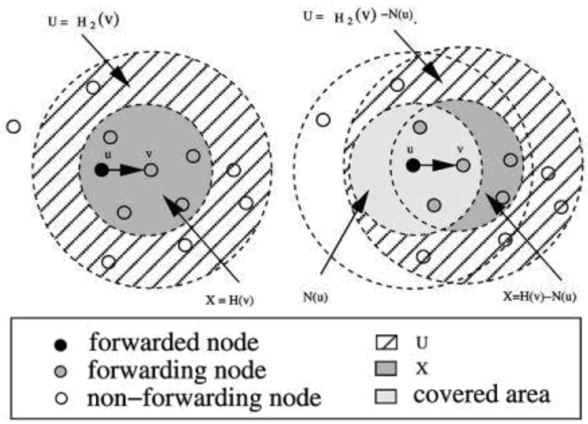


Fig 3.1 Illustration Of The Forwarding Nod Set Selection Process Of Two Algorithms

Algorithm

The double-covered broadcast (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).
- Twait: the predefined duration of a timer for a node to overhear the retransmission of its forwarding nodes.
- R: the maximum number of retries for a node.

The DCB algorithm works as follows

1. When a node s starts a broadcast process, s uses the FNSSP-DC algorithm to select its forwarding node set F(s) and broadcasts the packet P together with F(s).

2. When a node v receives P from an upstream sender u, it records P. v also updates its X(v) = X(v)-N(u) and U(v) = U(v)-N(u)-N(F(u)-fvg).Note that X(v) and U(v) are initialized to H(v) and H2(v). Then, v checks whether it is a designated forwarding node of u. If not, v drops the packet and stops the process, otherwise, v further checks whether P is ever received. If P is a new packet for v, v uses the FNSSP-EDC algorithm to compute its forwarding nodes F (v) and sends P with F(v). If v has already received P from another node, v will not forward P, but send an ACK to u to confirm the reception so that u will not retransmit the same packet at a later time.

When the sender u broadcasts P, it waits for a predefined duration Twait to overhear the retransmission of its forwarding nodes. If u overhears a retransmission packet from its forwarding node v, u regards this as an ACK from v. u may receive explicit ACKs from some of its forwarding nodes to confirm the reception. If u does not overhear all of its forwarding nodes when the timer expires, it assumes that the transmission failure has occurred for this packet. u then determines a new F(u) to cover the rest of the uncovered U(u) and resends the packet until the maximal number of retries R is reached. The algorithms that determine the F(u), such as Resend or Reselect, will be discussed in the next subsection.

1. When source s wants to broadcast P, it uses the FNSSP-DC to find F(s) and broadcasts P(s, F(s)).
2. When node v receives P (u, F (u)) from u,
   v records P (u, F(u)).
   Updates X (v) = X (v) - N (u) and
   U (v) = U (v) - N (u) - N (F (u) – (v)).
   if v 2 F (u) then

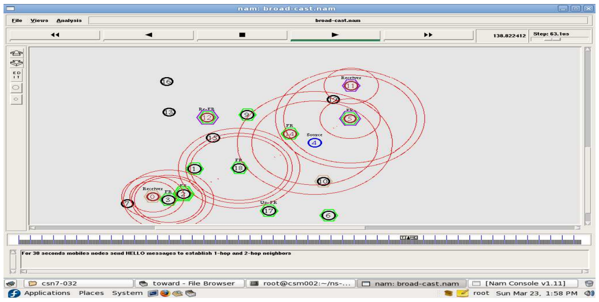
if the packet has not been received before then
v uses the FNSSP-EDC to find F (v) that covers
U (v) and broadcasts P (v, F (v)).
else
v sends an ACK to u to confirm the reception of
P and drops the packet.
end if
else
v drops the packet.
end if

3. When node u has sent the packet, it starts a timer Twait and overhears the channel. After Twait is expired, if u does not overhear all nodes in F(u) to resend P or to send ACKs, u retransmits P until the maximal number of retries R is reached. In Algorithm 5, a forwarding node will forward the packet if it receives the packet for the first time.

Simulation Results And Analysis

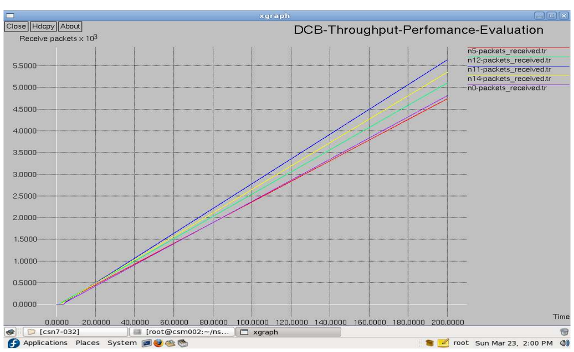
Sensitivity to network size

The network has low mobility, where Vmax is 1 meter per second (m=s), and low transmission error rate (Perr = 1%). The data traffic load CPR is 10 packets per second (pkt=s), the hello interval THELLO is 1 second (s), and the waiting time Twait is 50 milliseconds (ms).We identify the effect of network size n to each metric.The network under this environment can be considered a static error-free network. Most of the packet losses come from transmission collisions.



Sensitivity to transmission error rate

The performance of the algorithms under different transmission error rates. In this case, n = 100, Vmax= 1m=s, CPR=10 pkt=s, THELLO=1s, and Twait=50ms. We change the transmission error rate Perr from 1 percent to 20 percent to see its effect on each metric.When Perr increases, the delivery ratio drops for all algorithms. But, the DCBs are much better than AHBP-EX and BF when Perr increases. The RB has a similar delivery ratio to DCBs even when Perr is high, but the forwarding ratio of RB is much higher than DCBs and AHBP-EX, as is the overhead.The end-to-end delay of DCB is longer than AHBP-EX and BF due to the retransmission mechanism. As we can see, RB has the largest value for forwarding ratio, overhead, and end-to-end delay. From this simulation, we conclude that DCBs outperform AHBP-EX and BF when Perr becomes high. This is due to the retransmission mechanism of DCB. Compared with RB, DCB uses much less broadcast overhead to provide a comparable delivery ratio while RB needs the high forwarding ratio, large overhead, and long end-to-end delay to reach a high delivery ratio.

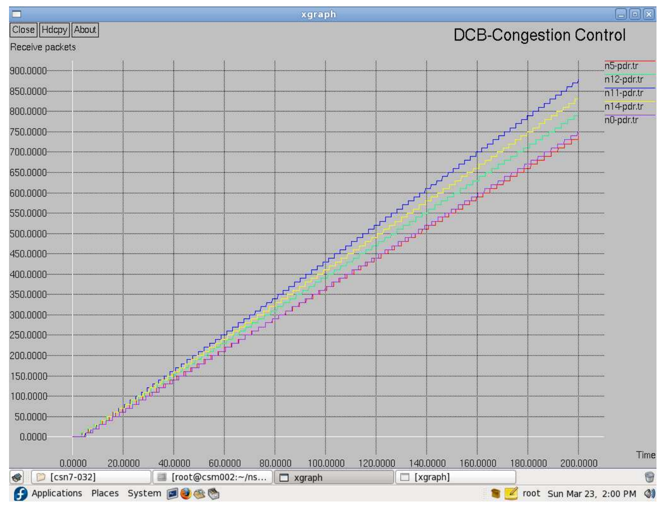


Sensitivity to mobility of the node

The effect of the node's mobility on the performance of broadcast operation. In this case, n = 100, CPR = 10 pkt=s, Perr = 1%, THELLO = 1 s, and Twait = 50 ms. We change the maximum speed of each node Vmax from 1 to 40m=sto show the effect of the node's mobility to each metric. The delivery ratios of BF and RB are almost 100 percent while those of DCBs and AHBP-EX drop as the node's mobility increases. DCBs are even a little worse than AHBP-EX when the node's mobility increases. DCBs and AHBP-EX have almost the same forwarding ratio and their value decreases as the node mobility increases. The value of forwarding ratio for the BF and RB is always close to 100 percent.

Sensitivity To Number Of Retries

We test the performance of the DCB under different values of R. In this case, n = 100, Vmax = 1 m=s, CPR = 10 pkt=s, THELLO = 1 s, and Twait = 50 ms. RTmax is set from 0 to 3. The transmission error rate Perr is changed from 1 to 20. The delivery ratio can be improved when a retransmission mechanism is applied (comparing between the curves of "DCB-SD, retry=0" and "DCB-SD, retry=1"). On the contrary, increasing the number of retries (comparing between the curves of "DCB-SD, retry=1" and "DCB-SD, retry=2") only slightly improves the delivery ratio, or can even decrease the delivery ratio (comparing between the curves of "DCB-SD, retry=1" and "DCB-SD, retry=3"),



Conclusions

A 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 nonforwarding nodes so that retransmissions can be remarkably suppressed when transmission errors are considered. The simulation results show that the double-covered broadcast algorithm has high delivery ratio, low forwarding ratio, low overhead, and low end-to-end delay for a broadcast operation under a high transmission error ratio environment.

From the simulation, we observe that the DCB is sensitive to the node's mobility. When the node's mobility increases, the delivery ratio of the DCB drops significantly.

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