Multiple Criteria Message Broadcasting and Forwarding Technique for Wireless Ad Hoc Networks

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Abstract - Broadcasting in ad hoc networks is an important primitive that has received little systematic research. Broadcasting introduces unnecessary retransmissions of same message. The total number of transmissions (forwarding nodes) is generally used as the cost criterion for broadcasting. In this paper we have introduced a XOR based solution for multiple criteria broadcasting, which is simpler than any other prior published works. Our proposed broadcasting algorithm provides faster network coverage, k-hop distant information retrieval, heuristic choice of forwarding nodes and relatively successful termination criteria which reduces broadcast redundancy more effectively. Simulation results of applying these solutions show performance improvements with compared to well-known dominant pruning and total dominant pruning algorithms.

Keywords - Self-organized wireless networks, forwarding node, heuristic, dominant pruning, total dominant pruning.

1. Introduction

Broadcasting process has extensive application in mobile ad hoc wireless networks [1] where reduced redundant broadcasting technique is the key challenge for efficient routing with fast network coverage.

In this paper, a new broadcast algorithm has been proposed known as XOR based approach. An algorithm based on this technique utilizes neighbourhood information more effectively for Single Data Single Source (SDSS), Multiple Data Single Source (MDSS) and Multiple Data Multiple Source (MDMS), which is known as heuristic approach for forward node selection. Simulation results of applying this algorithm show performance improvement with compared to existing Dominant *Pruning* [3] and *Total Dominant Pruning* [2] algorithms used for broadcasting in wireless self-organized network. In addition, a relatively successful termination criterion is also discussed.

The rest of the paper is organized as follows: Section 2 discusses related works. Section 3 explains our proposed algorithm in details. Section 4 shows the simulation results of the proposed algorithm as well as the comparison compared to DP [3] and TDP [2]. Section 5 describes the conclusion and outline of future works.

2. Related Works

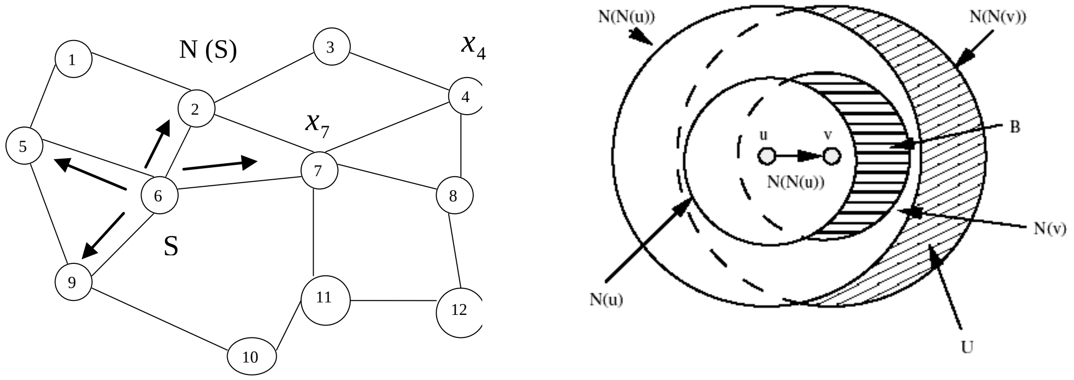
Several works & studies have been performed for broadcasting in wireless self-organized networks. Among the works performed for reducing broadcast redundancy in Ad hoc wireless networks, the efficient and attractive works are Dominant Pruning (DP) and Total Dominant Pruning (TDP).

2.1 The Dominant Pruning (DP)

Here, a simple graph, G =(V, E) is used to represent an ad hoc wireless network, where V represents a set of wireless mobile hosts (nodes) and E represents a set of edges. An edge (u,v) indicates that both *u* and *v* are within their transmitter ranges. The circle around a host *u* corresponds to the transmitter range of host *u.* All the hosts in the circle are considered the neighbours of host *u.* A host can obtain its neighbourhood information by periodically sending an update message. Here, N(*u*) represents the neighbour set of *u* (including *u*)(figure 1(b)). N(N(u)) represents the neighbour set of N(u).

2.1.1 Dominant Pruning Algorithm

1) Node v uses N(N(v)), N(u) and N(v) to obtain U(u,v)=N(N(v)) – N(u) –N(v) and B(u,v)=N(v)-N(u).



(a) **(b)**

Figure 1: (a) A simple network model, (b) Neighbor sets of DP and TDP

2) Node v then calls the selection process to determine F(u,v). Here F(u,v) represents the forwarding nodes' list.
3) Let F(u,v)=[ ] (empty), Z= φ (empty) and K $\cup S_i$ = N(v_i) ∩ U(v,n) for v ∈ B(u,v).
4) Find set S_i whose size is maximum in *K* .(In case of a tie, the one with the smallest id *i* is selected.)
5) F(u,v)=F(u,v) || v, Z=Z ∪ S_i ,K = K - S_i and S_j =S_j - S_i for all S_j ∈ K
6) *If Z=U(u,v), exit; otherwise go to step2.*

2.2 The Total Dominant Pruning

If node v can receive a packet piggybacked with N(N(u)) from node u, the 2-hop neighbour set that needs to be covered by *s v*' forward node list *F* is reduced to U(v,n)=N(N(v))-N(N(u)). The total dominant pruning algorithm uses the above method to reduce the size of *U* and, hence, to reduce the size of *F*. The region N(N(v)), N(N(u)), N(v) *and* N(u) are shown in figure 1(b).

2.2.1 The Total Dominant Pruning (TDP) Algorithm

1) Node v uses N(N(v)), N(u) and N(v) to obtain U(v,n)=N(N(v))-N(N(u)) and B(u,v)=N(v)-N(u).
2) Node v then calls the selection process described above to determine F(u,v). Here F(u,v) represents the forward nodes' list.

3. Proposed Broadcasting Algorithm

3.1 Single Data Single Source (SDSS)

The key features of our proposed approach for SDSS mechanism by considering a simple network model like Figure 1 are highlighted below:

- SDSS selects a forwarding node based on highest number of neighbour nodes not yet received any data packet.
- Initially all nodes are assigned a status bit 0 and the forwarding node selected by SDSS which is ready to broadcast data is assigned a status bit 1.
- Such forwarding of Single Data from Single Source is accomplished by XOR-ing[Binary addition in modulo-2 arithmetic with no carries] [Table 1] status bits of two adjacent nodes S & N(S) where S is the source and N(S) is the neighbour node of S at a certain time [Figure 1].
- Zero (0) resultant of XOR operation for both end calculation [N(S)$\oplus$S] directs to local broadcast termination and collectively considered as global termination in SDSS.

Table 1: Broadcast Decision Table

S	N(S)=N(S) ⊕ S	Value	Broadcast?
6	$x_2 = x_2 \oplus x_6$	$0 \oplus 1 = 1$	Yes
	$x_5 = x_5 \oplus x_6$	$0 \oplus 1 = 1$	Yes
	$x_7 = x_7 \oplus x_6$	$0 \oplus 1 = 1$	Yes
	$x_9 = x_9 \oplus x_6$	$0 \oplus 1 = 1$	Yes
2	$x_1 = x_1 \oplus x_2$	$0 \oplus 1 = 1$	Yes
	$x_3 = x_3 \oplus x_2$	$0 \oplus 1 = 1$	Yes
5	$x_6 = x_6 \oplus x_5$	$1 \oplus 1 = 0$	No

To decide the termination state, we have to check the final status bit of each node. If it becomes finally like below, the global termination occurs.

x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}
1	1	1	1	1	1	1	1	1	1	1	1

3.2 SDMS, MDSS and MDMS

Our work for multiple criteria broadcasting introduces the technique of selecting a forwarding node as located at the optimal position that introduces the shortest delay to transmit data packet to the sink node. According to Beacon-Less outing (BLR) [6], the node which computed the shortest forwarding delay is considered to forward the data packet first. Our optimal position based forwarding of the data packet is dependent on the nodes' coordinate geometrical positions $\vec{P}_{x(i)}, \vec{P}_{y(i)}, \vec{P}_{z(i)}$ with respect to sink node. Distance between two neighbour nodes within same sensing area is - $D_r = \sqrt{(P_{x(i)} - P_{x(i-1)})^2 + (P_{y(i)} - P_{y(i-1)})^2 + (P_{z(i)} - P_{z(i-1)})^2}$. Every time the minimum D_r is computed for a node located closer to the sink node is chosen as the next hop. Upon reception of any data packet, the only available information an intermediate node has is its current, previous and destination node's position in its packet header as well as status bits computed by XOR based approach. All intermediate nodes just replace the previous node's position by their current position in the header.

3.2.1 Proposed Algorithm for SDMS, MDSS, MDMS

In case of multiple data multiple criteria such as - Single Data Multiple Source (SDMS), Multiple Data Single Source (MDSS) and Multiple Data Multiple Source (MDMS) status bit field will be indexed as 1,2,3…m where m is the number of data packets generated. Like as SDSS, we propose the following algorithm for SDMS, MDSS and MDMS.

Initialization

Let S be the source, X_i be the status bits, where i $\neq$ S. Initially, transmitting node status bit $T_N(SB)$ is set to 1 [Data Packet Id $T_N(DPI)$] and receiving node status bit $R_N(SB)$ is also set to 1 [Data Packet Id $R_N(DPI)$]. $T_N(DPI) \oplus R_N(DPI)$ = 1.Node List L = $\{S\}$.

Forward node selection and broadcasting

Repeat until L $\neq$ $\in$

F= SelectForwardNode(L)

If $T_N(SB) \oplus R_N(SB) \neq 0$ AND $T_N(DPI) \oplus R_N(DPI) \neq 0$

L= L-$\{F\}$, W= $\{\ \}$

Find all neighbor N(F) of F

W= W $\cup$ N(F)

L = L $\cup$ W

Else L=$\in$

Pseudo code for SelectForwardNode(L)

Let B_i be no of nodes not received message

For all nodes N_i in the list L

Count $B_i = N_i \oplus N(N_i)$ =1

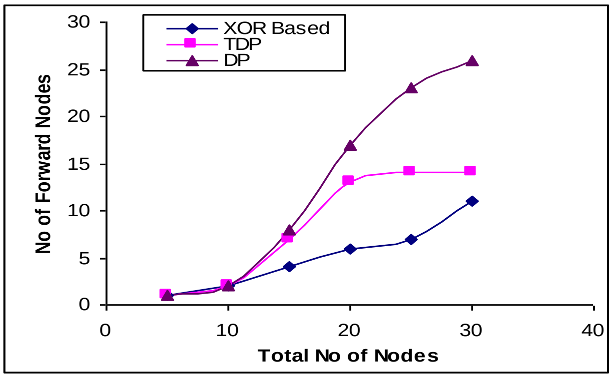
V= max (B_i)

Return V.

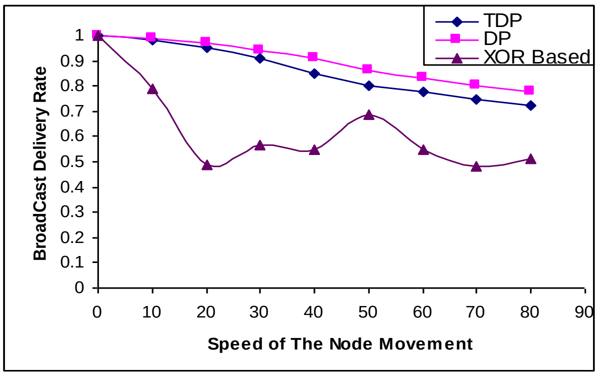
4. Simulation Results

Our implementation by considering a network model like Figure 1 for SDMS, MDSS, MDMS shows better performance than DP and TDP. According to Figure 2 (A2) below, the broadcast delivery rates of XOR based approach for both transmitter ranges of 25 with 100 nodes, is less than the DP and TDP. As the broadcast rate is less, so the probability of redundancy is comparatively less.

Figure 2 (A1) shows the comparison of proposed method with dominant pruning and total dominant pruning algorithms which yields less number of forward nodes in comparison with them that reduces broadcast redundancy in a wireless ad hoc network.



A1.



A2.

Figure 2: A1. Comparison of proposed XOR based algorithm with DP & TDP for fixed source. **A2.** Broadcast Delivery Rate in Dynamic Environment vs Speed of The Node Movement for Transmitter Range= 25, with Number of Nodes= 100.

5. Conclusion and Future Work

In this paper, we have presented a simplified XOR based approach for reducing broadcast redundancy with faster network coverage in wireless ad hoc network. Simulation shows better performance than DP and TDP. Our proposed algorithm provides the relatively successful termination criteria for SDSS, SDMS, MDSS, and MDMS. For future plan, we have planned to reduce the data packet overhead while retrieving the n–hop distant information. We shall try to provide guarantee for collision free transmission with comparatively higher probability.

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