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A Preemptive Link State Spanning Tree Source Routing Scheme for Opportunistic Data Forwarding in MANET

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***Abstract*—**Opportunistic Data Forwarding (ODF) has drawn much attention in mobile adhoc networking research in recent years. The effectiveness of ODF in MANET depends on a suitable routing protocol which provides a powerful source routing services. PLSR is featured by source routing, loop free and small routing overhead. The update messages in PLSR are integrated into a tree structure and no need to time stamp routing updates which reduces the routing overhead.

***Keywords*—**Mobile ad hoc network (MANET), Opportunistic data forwarding (ODF), Preemptive link state spanning tree routing (PLSR), Depth First Search (DFS).

I. Introduction

MOBILE ad hoc network (MANET) [1] is a collection of wireless mobile nodes which dynamically forms a temporary network without the use of any existing network infrastructure. The nodes within the range communicate with each other. Mobile adhoc networks are used in various fields like military, emergency, conferencing, earth quakes, floods etc. Broad cast nature in mobile adhoc networks has drawn much attention in the research community in recent years. Opportunistic data forwarding (ODF) [2] represents one of the most promising solutions to this initiative. Routing protocols in MANETs are usually categorized as proactive and reactive. Many routing protocols in MANET are fundamentally derived from two algorithms distance vector and link state routing.

The Destination Sequenced Distance Vector (DSDV) [3] protocol is a proactive routing algorithm. Each node maintains the routing table with all possible destinations within the network and the number of required hops to reach the destination. Each destination assigns a sequence number in order to find out stale routes and prevent routing loops. The routing table is periodically updated and advertised to each of the node's current neighbors to maintain consistency.

OLSR [4] is proactive routing protocol. Initially nodes have routing tables and they update their routing tables time to time. It is based on the link-state algorithm. Each node maintains the topology information of network and sending this information from time to time to neighbors. The uniqueness of OLSR is that it minimizes the size of control messages and rebroadcast by using the MRP (Multipoint Relaying). The basic concept of MPR is to reduce the loops of retransmissions of the packets. Only MPR nodes broadcast route packets.

Although many routing protocols have been proposed for MANETS, e.g., DSDV and OLSR are not suitable for opportunistic data forwarding because they cannot support source routing and they incur too much overhead. Hence more appropriate routing protocols are required to support opportunistic data forwarding in MANETs.

In this paper a definite preemptive link state spanning tree source routing PLSR scheme for opportunistic data forwarding for MANET is proposed. PLSR make use of the hop count information to investigate the broadcast nature, improve the efficiency and spatial use in opportunistic data forwarding. By using the tree structure network topology information is efficiently exchanged, hence the overhead get reduced.

II. Literature Survey

DSR [5] is an on demand adhoc network routing protocol composed of two parts: Route Discovery and Route maintenance. A distinct feature of DSR is that it uses route cache strategy to reduce routing messages in the whole network. Every host holds a route cache table which updates periodically to get the later information about the network. DSR has since been extended to meet different objectives. Flow ID is used to identify the route in the network as in [6]. Explicit signals are used to inform the upstream nodes when detecting broken links to better utilize the cached routes in [7]. It experiences longer delay and the route reply messages may be lost so it is not suitable for opportunistic data forwarding.

In STAR [8] every node maintains a tree structure for a network and adopts a tree update strategy that is neither proactive nor reactive. Instead it uses a lazy approach where update messages will only be transmitted when the local tree structure is considered sufficiently inferior to the original optimum. In this all the tree updates are performed differently and the link states are time stamped. It provides source routing with less overhead but it needs additional information in routing update to avoid loops which must be prevented in opportunistic data forwarding.

Moreover, only differential update is considered in both schemes, the topology may be inaccurate or even unusable. Hence more appropriate routing protocols are required to support opportunistic data forwarding in MANETs.

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III. Design of PLSR

A. DFS Spanning Tree Creation

In this preemptive link state spanning tree source routing protocol (PLSRP) [9] every node has a depth first spanning tree of the entire network. Nodes periodically broadcast tree structure information to the best of its knowledge. A node can expand its scope of knowledge about the network based on the information it has been collected from its neighbours. Then this knowledge is exchanged among all the neighbouring nodes in the next iteration.

The operation of PSRP is iterative and distributed among all the nodes in the network. At the beginning the node "a" is aware of the existence of its neighbours by listening to their hello packets. There it is able to construct DFS spanning tree (DFST) rooted at itself within N(a) denoted by Sa with "a" as centre node. In each subsequent iteration, nodes exchange their DFS spanning trees with their neighbours. Node "a" has received a number of routing messages from its neighbours. To update its own DFST, node "a" combines the most recent information from all neighbours. It then broadcasts this tree to its neighbours.

Let T_a be the DFST of node which has received updates in recent iterations for each neighbour b ε N(a).

Node "a" construct a graph

$$G_a = S_a \bigcup_{b \in N(a)} (P_b - a)$$

Then node "a" calculates a DFST of G_a denoted D_a and places D_a in the routing packet to broadcast to its neighbours.

In a single update interval this update of DFST happens multiple times. So that, a node can quickly incorporate a new routing information. When a new tree is received from a neighbour D_a is modified. Routing bas a higher priority and nodes process the packet in a better manner. Since one routing message is always sent per update interval the communication overhead is not increased.

Let N hops be the network diameter. After N iterations each node in the network has constructed a DFST of the entire network rooted to itself. The amount of information that each node broadcasts in an iteration is O(|A|) and the algorithm converges in at most N iterations.

B. Pruning the neighbor

When a neighbour node is lost its network connectivity is removed called pruning the neighbour.

Consider node "a". Let the neighbour be b. The procedure for pruning the neighbour is invoked when

- data packet has not been received from neighbour for sometime
- data packet to node "b" is failed
- Node "a" does the following

1. Update

$$D(a) = D(a) - \{b\}$$

2. Construct the Graph as

$$G_a = S_b \cup \bigcup_{c \in N(a)} (D_c - a)$$

3. Build the DFST D_a

The built tree D_a is not broadcasted immediately to all nodes instead it avoids sending data packets through lost neighbours.

C. Shaping of Update Messages

There are two types of messages. Full updated messages which contain the entire binary tree. Short messages contain the difference between the current and previous states of nodes routing. The basic idea is to send the full updated messages more frequently than the shorter messages.

Further routing is shaped in two aspects. First, tree representation of full and short messages is compressed to halve the size of the message. Second every node has to maintain a constant DFST as the network changes so that the messages are even shorter.

1) Full Updated Messages

The DFST information stored at a node is to be broadcasted to its neighbours. To do that first the general rooted tree is converted into binary tree of same size of nodes. Then the binary tree is serialized using a bit sequence of 34 bits. The binary tree is scanned layer by layer. First the IP address of the node is included in the sequence. In addition two more bits are appended to indicate if it has a left and/or right child.

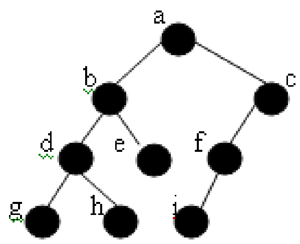

Fig. 1 Binary Tree

The above tree is represented as a11b11c10d11e00f10g00h00i00.

2) Short Messages

The difference between two DFST can be represented by the set of nodes that changed their parents. A tree is used to package the set of loose edges. As a result the short messages contain a few small trees and its size is smaller. The size of the message depends on the number of edges it includes.

3) Fixed DFST

When there are changes the DFST is altered as little as possible. Modification is done when a neighbour is lost or it reports a new tree.

Consider node "a" and its DFST D_a. When it receives an update from its neighbour b, denoted D_b, first it removes the subtree of D_a rooted at "b". Then it incorporates the edges of D_b for a new DFST.

DFST of (D_a – b) U D_b may not contain all edges for "a" to reach every other node. So, union graph is constructed:

$$(D_a - b) \cup \bigcup_{c \in N(a)} (D_c - a)$$

When node a's neighbour b is lost it removes the edge(a,b) but it makes use of its network structure information of b; because, b may be within the range of one of a's neighbours.

Hence D_a should be updated to a DFST of

$$(D_a - b) \cup (D_b - a) \cup \bigcup_{c \in N(a)} (D_c - a)$$

IV. Performance Evaluation

Opportunistic data forwarding is simulated in ns-2 using preemptive link state spanning tree routing scheme. The scenario is with 50 nodes deployed in 1100 x 1100 sq.m square area with velocity set to 0,4,8,12,…32(m/s).

The routing overhead of PLSRP, OLSR and DSDV are measured by varying the node velocity.

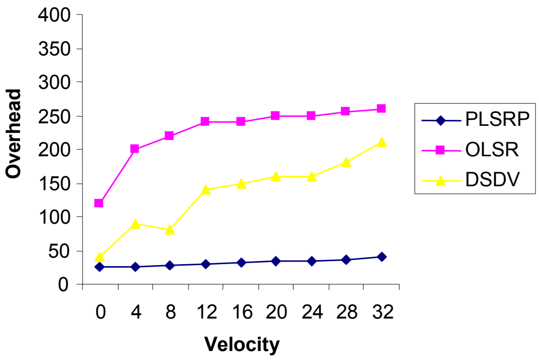

Fig. 2 Overhead vs node velocity

It is observed in Fig. 2 that as the velocity increases the overhead of all the protocols comes down. PLSRP has only a very small fraction of the overhead of OLSR and DSDV. In contrast, both OLSR and DSDV's overhead increases with node mobility.

The packet delivery ratio of PSRP, OLSR and DSDV is studied. Again their relative performance is similar as shown in Fig. 3 Packet delivery ratio of PSRP is always 70% even when V_{max} = 32. Packet delivery ratio drops gradually as the node velocity increases.

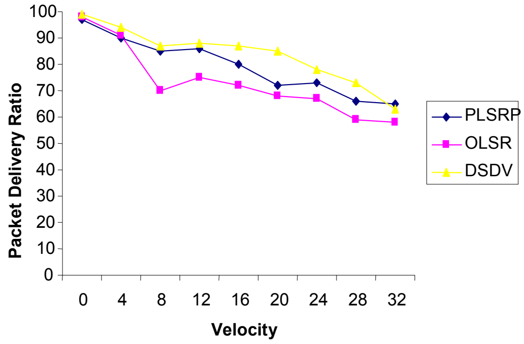

Fig. 3 Packet delivery ratio vs node velocity

It is obvious that the proposed scheme possess much lower overhead and higher packet delivery ratio.

V. Conclusion

Opportunistic data forwarding is achieved using preemptive link state spanning tree routing scheme (PLSRP). The overhead in PLSRP is greatly reduced by using full update message and short message with compressed tree representation. Performance study shows that PLSR outperforms other routing protocols OLSR and DSDV.

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