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# A Fast and Reliable Tree based Proactive Source Routing in Mobile Adhoc Network

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**Abstract:** ***Mobile Ad hoc Network (MANET) is the emerging technology used for various applications such as battlefield communications, emergence operations, search and rescue and disaster relief operations. It consist a group of mobile nodes. The most salient research challenges in this area include end to end data transfer, link access control and security. In order to improve the data transfer between these mobile nodes, many routing protocols are proposed. Opportunistic data forwarding has drawn much attention in the research community of multi hop wireless networking. Opportunistic routing in MANET is a challenging one. Use of efficient routing methods which supports opportunistic routing in MANET will give better throughput with minimum delay and overhead. Here, a tree based proactive source routing called PSR is described that integrates proactive routing and opportunistic data forwarding. It provides low routing overhead and delay without reducing the overall throughput. To maintain source routing, every node keeps a BFST of the entire network rooted at itself. The tree structure is periodically updated by broadcasting these information towards neighbour nodes to keep pro-activity in routing. Routes are updated and unwanted nodes are removed from the tree structure without affecting delay in communication. An efficient tree based PSR is proposed which have the following features. Routing overhead in PSR will be reduced by using streamlined differential update methods. Delay in path identification of PSR can be reduced by using shortest path algorithm. Control packet overhead at higher level nodes can be reduced by using mobile sink node.***

**Keywords: BFST, Mobile ad hoc networks, Opportunistic routing, Proactive source routing, Streamlined differential update.**

## 1. Introduction

Mobile Ad hoc Network (MANET) is a kind of wireless network in which nodes are highly mobile in nature. These nodes can act as either a router as well as a host according to their role in the path identification process. They can form different topologies according to their movement within the network. Nodes can communicate with each other by using routing information kept in their routing modules. No any fixed base station infrastructure or centralized administration is required to control and monitor the nodes in MANET [1]. They use intermediate nodes to forward data in between source node and destination node. Routing is thus challenging in such network. Such type of network application is mainly used in battlefield communications, emergency operations, search and rescue and disaster relief operations. Ensuring the data packet delivery and adaptability over dynamic topologies are the two major issues in MANET routing [2]. If there is a path from a source to destination at a certain period of time, then the data should be delivered through that path. If any change occurs, then it must be adapted towards the change. So maintaining the communication among nodes within MANET will be a complicated one. The most salient research challenges in this area include end-to-end data transfer, link access control and security.

Network layer gets more priority than others within MANET. Therefore many routing protocols were discovered in this area according to various needs and enhancement. Two important operations done in network layer are routing and data forwarding. Routing means to identify a path from a specific source to destination and maintaining a path up to the end of data transmission between those nodes. While data forwarding means take the data from one link and put it on the other. Efficiency of these two operations will lead to better working of a routing protocol. Routing in MANET can be mainly classified as proactive and reactive. In proactive, there is a route information should be kept in all nodes in the network so that they can easily pick up the path from any point without going to finding out it. While in reactive, if there is a data transmission is required between two nodes, then only route discovery process begins. Compared to proactive, delay in communication is very high. Routing overhead will be very high in proactive than reactive since route information is updated periodically. Combinations of these routing mechanisms are termed as hybrid routing. Nowadays, proactive becomes more economic in real time application.

### 1.1 Opportunistic Data Forwarding

Opportunistic routing [3] provides a way to utilize the fully broadcasting nature of the wireless channel. All the nodes will get a chance to participate in a data transmission mechanism. It determines the forwarder only after it receives the data packet. Since it broadcasts data packets at every hop, routing overhead will be very high than traditional routing.

## 2. Related works

Researches are always being conducted to improve the efficiency of the routing techniques in MANET. The previous study includes various routing protocols which provide opportunistic data forwarding in MANET. S. Biswas and R. Morris [4] proposed EXOR (Extremely Opportunistic Routing). A cooperative communication based routing. Here nodes can overhear all packets on the air. Therefore a multitude of nodes can forward a packet which is included in the forwarder list. EXOR forwards batches of packets in order to reducing the communication cost. When a source node S wants to transmit a data packet towards a destination node D, S broadcasts that packet to its neighbour nodes. These neighbours collectively perform an algorithm to select a best forwarder from the forwarder list. Node that is closest to the destination will get highest priority in the forwarder list. Forwarder again broadcasts the packet to its neighbours and selection of a forwarder to next hop transmission also done. These processes will be repeated until 90 percent of packets get delivered. Remaining packets should be transmitted using traditional routing.

S. Chachulski et al. [5] proposed a protocol named MORE (MAC-independent Opportunistic Routing and Encoding). MORE randomly mixes the packets then forwards. It avoids duplication in transmitting a data packet. Here source first broadcast all the packets. Router then creates random linear combinations of these packets. So they become coded packets. Sender attaches a header to every data packet which contains code vector, batch ID, source and destination IP address and forwarder list. Sender transmits the coded packets until it reaches an acknowledgement from destination. Then it takes packets from next batch and again starting the same process. Finally, the arrival of a new batch from the sender causes a forwarder to flush all buffered packets with batch IDs lower than the active batch. Destination decodes the packet using code vector. MORE not require node coordination and preserves spatial reuse.

S. Yang et al. [6] proposed a routing protocol named POR (Position based Opportunistic Routing). Here data transmission is done as same as EXOR. In addition, it uses location information of the destination node to limit the flooding range. For this purpose, it uses a GPS like equipment. The reduction in control packets and the almost stateless nature of POR underscore its excellent scalability. When an intermediate node receives a packet with same packet ID as before, then it will drop that packet from its packet list. Forwarder list creation and data transmission are taking place in the similar manner of EXOR. In addition, every node maintains a forwarding table for each destination of the packets that it has sent or forwarded. At every time it checks the table before checking the forwarder list. If a destination path is available from table, then that path will be used. By using GPS equipment, communication cost is comparatively high.

Z. Wang et al. [7] proposed CORMAN (Cooperative Opportunistic Routing in Mobile Ad hoc Network). It is a powerful extension of extremely opportunistic routing to reduce delay and overhead. Use of a proactive source routing will give complete routing information of all nodes in the network. This route information can be updated periodically through beacon messages. CORMAN gives two additional features compared to EXOR in order to increase the efficiency of the routing protocol which are termed as large scale live update and small scale retransmission. Large scale live update refers to a way in which intermediate nodes can have the ability to update the forwarder list using its current knowledge from that node to corresponding destination node. Small scale retransmission means to retransmit missed packets during transmission by using nodes that are not in the forwarder list. It ensures the reliability of the communication.

## 3. Proposed work

In this section a new and efficient opportunistic data forwarding routing method is introduced which is the enhanced version of the method, proposed by Z. Wang et al. in [8]. In [8] a tree based proactive source routing (PSR) is proposed which enables opportunistic data forwarding in MANET. A tree concept is used in a proactive source routing protocol. It considers routing problems such as overhead and delay in MANET with limited resources. Every node will have to keep routing information of all the other nodes in the network in the form of a BFST [9]. So every node will have its own BFST's routed at itself. These BFSTs are created by using breadth first search algorithm by distance basis. Selecting any node as root node and then apply BFS algorithm for getting a rooted tree including all nodes in the network. Nodes exchange these information periodically by broadcasting towards neighbour nodes. Based on these information a node can update its BFST in a more detailed way. Updated information will be passed at the end of every iteration. This supports both source routing and opportunistic data forwarding in mobile ad hoc network.

The design phases of the proposed system are explained as follows. The whole process consists of six major steps as shown in figure 1. The steps are Neighbour identification and neighbour list generation, General tree creation and binary tree conversion, Path identification, Data transmission, Tree updation and path updation, and control packet overhead reduction.

### 3.1 Neghbour identification & neighbour list generation

The network can be modeled as undirected graph G = (V, E), where V is the set of nodes (or vertices) in the network, and E is the set of wireless links (or edges). Two nodes u and v are connected by edge e = (u; v) 2 E if they are close to each other and can directly communicate with given reliability. Given node v, use N(v) to denote its open neighbourhood and N[v] denotes closed neighbourhood of v. The neighbor information is collected by broadcasting hello messages to all nodes in the network. The nodes which are located within the transmission range of every node send back a reply message. By using this information, a neighbor list is generated including the location information and distance between the neighbor nodes.

### 3.2 General tree creation & binary tree conversion

Spanning tree of the connected undirected graph is a connected sub graph in which there are no cycles. Here connected means every node is reachable from every other node and undirected means edges do not have an associated direction. It will be created using breadth first search algorithm.

- Step 1: Select a random node as initial node
- Step 2: By using a queue, add the vertices that are adjacent to the route node within the range
- Step 3: Add corresponding edge connecting these nodes to a list
- Step 4: Visiting adjacent nodes of these latter node that is not visited yet and does not form any cycle
- Step 5: Add these nodes and edges to corresponding list and mark them as visited

- Step 6: Repeat step 4 and 5 until all nodes in the network get visited
- Step 7: Return all vertices and edges from the list

In order to reduce the control packet length in PSR, convert the general rooted tree into corresponding binary tree of the same size. It will be done on the basis of left-child right-sibling method which is commonly known as compact tree representation. Root of the binary tree will kept as same of original rooted tree. When processing a node, first include its IP address in the sequence and then append two more bits to indicate if it has the left and/or right child. Fig 1 depicts this mechanism. The size of the update message is a bit over half than traditional approach, where the message contains a discrete set of edges. An example for the conversion process is given below.

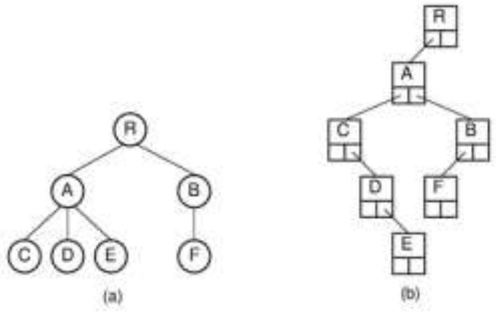


**Figure 1:** Binary tree conversion

### 3.3 Path identification

The identification process used in PSR [8] requires more energy consumption and relatively high delay on route discovery process. For avoiding these problems a shortest path algorithm is introduced. The algorithm used to finding a path between two nodes (or vertices) in a network such that the number of hop counts between end nodes is minimized.

- Step 1: Select the source and destination nodes for finding shortest path between them
- Step 2: Set the maximum hop count value and transmission range
- Step 3: Find out forwarder node which is farthest from source node and nearest to destination node within the transmission range and highest energy
- Step 4: Repeat step 3 until it reaches the destination point
- Step 5: Return the corresponding path from source to destination with minimum hop count value

Algorithm returns the minimum hop count path from source to destination. So the overall energy consumption is reduced. Since the transmission range taken here is maximum, the amount of packet drops also reduced. Tree based routing used in PSR has more delay in route discovery process. By using this shortest path algorithm delay also reduced.

### 3.4 Data transmission

Data can be sending by using the path discovered by shortest path algorithm. By using this way, more number of packets will be reached at the sender within a period of time. By adjusting the transmission range of a given node as maximum, a reliable data transmission could be possible without losing any data.

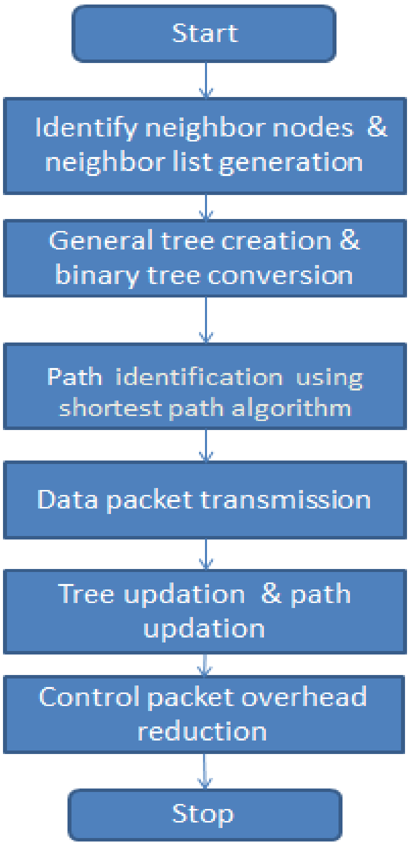


**Figure 2:** Framework of the proposed system

### 3.5 Tree updation & path updation

Since it uses proactive routing method, exudation of BFSTs taking place periodically. These updated information is broadcasted at the end of every iteration so that neighbouring nodes also get updated by using these modified BFSTs. Path from a specific source to destination can be calculated by using shortest path algorithm. This path will no longer remain as stable due to the high random movement of nodes in the network. So the identified route is not remaining stable at the end of communication. It may get changed at any time depending on the movement of nodes. At that time shortest path algorithm should call again and again to get updated path.

When a neighbour node is seemed to be lost, then the all information contributed by that node towards the network should be removed from the list. This procedure is called neighbourhood trimming. This procedure will be triggered when any of the two conditions are met. Either no any message is received from that neighbour node for a period of time or data transmission to that node reports a failure. As a result, remove the sub tree rooted at the lost node first. Then update the tree by adding possible changes. These updated BFST does not broadcast immediately. Because multiple neighbour trimming procedures may occur within a period. So in order to reduce the excessive messaging, at the end of time period, all calculated BFSTs send simultaneously towards the network.

### 3.6 Control packet overhead reduction

When a node gets an updation from any of its neighbour node, it first removes the sub tree rooted at that neighbour node. Then append the changed version of that sub tree into the original position. Here updating and then broadcasting only this portion of the tree rather than updating and broadcasting the whole tree. Suppose a neighbour node moved away from a node V, only its information like corresponding vertex and connecting link will be removed. This notification will broadcast towards network to inform the updation so that neighbour nodes can remove the details of that node from their BFSTs. By this way reduction of control packet overhead may achieve. Send full update messages less frequently than shorter or differential update messages. Shorter messages mean the difference between current and previous knowledge about a node’s route information. The result may be a single edge, a set of edges or a group of edges pointing towards a single parent like small sub trees. By sending only these difference messages will reduce the packet overhead. By using a mobile sink node control packet overhead produced at higher level nodes during tree update mechanism will be reduced to a minimum. For this, first higher level nodes sending a request packet to mobile sink node. Mobile node then collecting data from corresponding child nodes and then passes to source or root node.

## 4. Results and Analysis

Implementation is done by using a well-known network simulator 2 version 2.34. Simulation is done by using IEEE 802.11 as the medium access protocol, nodes are mobile and each node uses 220m as the transmission range and the carrier sensing range is about 550 m. Total 42 nodes are deployed in a network whose size is 1150 ×800 meter square. The proposed fast and reliable tree based proactive source routing is compared with the existing PSR. Control packet overhead, end to end delay, energy consumption and amount of packet drops are used as parameters.

Once the modification is done it is found that the energy consumption and delay due to tree based routing in PSR is reduced since, path discovery process is done by using shortest path algorithm. The graphical results show that control packet overhead at higher level nodes reduced by using mobile sink node for collecting these packets and send to root node. The amount of packet drops also reduced by using shortest path routing since it sets transmission range as maximum. The overall throughput is improved by enhancing the above described parameters. Corresponding results are shown below.

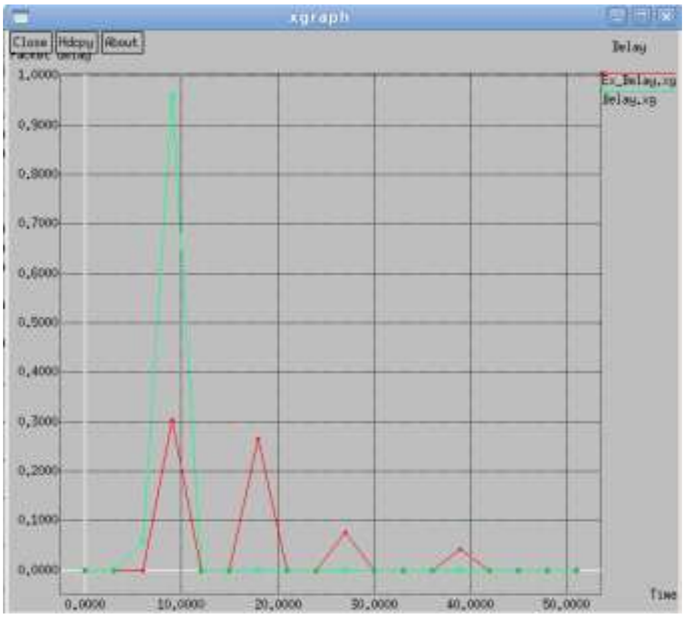

**Figure 3:** Delay in route discovery comparison

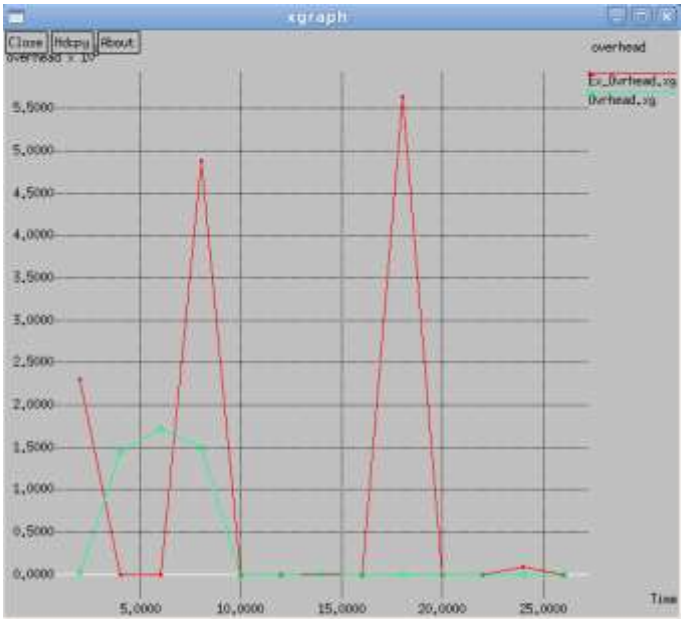

**Figure 4:** Overhead comparison

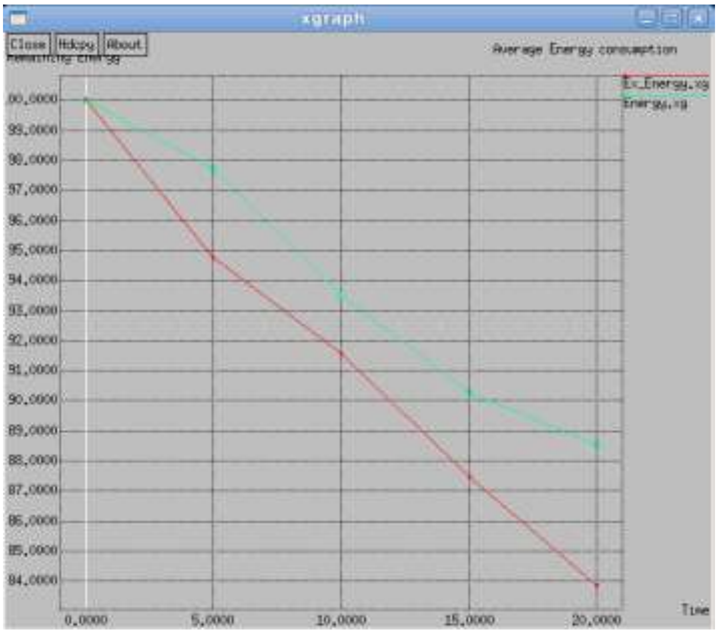

**Figure 5:** Average energy consumption comparison

## 5. Conclusion

PSR has been motivated by the need to support opportunistic data forwarding in MANETs. It integrates proactive source routing and opportunistic data forwarding. Such a protocol should provide more topology information than baseline protocols. Each node maintains a breadth-first search spanning tree of the network rooted at itself. This information is periodically exchanged among neighbouring nodes for updated network topology information. Route update procedure updates the routes When network topology changes. Neighbourhood trimming procedure removes nodes which are going out of station. By converting the rooted tree into a binary tree, control packet length was minimized. Other methods like stable BFST may help to reduce the routing overhead in PSR. Delay in routing and energy consumption are reduced by adding shortest path algorithm in PSR. Communication reliability will ensure by reducing the amount of packet drops and control packet overhead can be reduced by using mobile sink node into the network. Its communication cost is only linear to the number of nodes in the network.

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