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Minimizing the Overhead caused due to dynamic nodes in Mobile Ad-hoc Networks using Zone routing protocol

Levina Tukaram, Profesor
Dept of Computer Science &Engg,
Alpha College of Engineering
Bangalore, India.
levinajunias@gmail.com

Asha K H Asst profesor
Dept of Computer Science & Engg ,
Alpha College Of Engineering
Bangalore, India
asha.kh06@gmail.com

Pundalik Chavan AsstProfesor
Dept of Computer Science & Engg
Alpha College Of Engineering
Bangalore, India.
pundalik.chavan29@gmail.com

Abstract: Opportunistic data forwarding has become a interesting topic in the multi-hop wireless networking. Opportunistic data forwarding is not used in mobile ad hoc networks (MANETs) due to the lack of an efficient lightweight proactive strong source routing scheme. Proactive Source Routing uses Breadth First Spanning Trees (BFSTs) and maintains more network topology information to facilitate source routing. Although it has greatly reduced overhead than traditional link state (LS)-based routing protocols and reactive source routing protocols, the computational and memory overhead involved in maintaining BFSTs to reach every node in the denser networks will be high. In this paper Zone-based Proactive Source Routing Protocol is proposed. Zone routing protocol (ZRP) uses partition based routing. The ZRP make use of source routing inside a zone and on-demand routing outside the zone. This approach combines the advantages of both proactive and zone based routing protocols. The simulation shows that the Z-PSR i.e. zone based proactive source routing protocol performs better compared to PSR.

Keywords: *PSR, BFST, LS, Source routing, Ad-hoc Network, TORA.*

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I INTRODUCTION

Mobile ad-hoc network (MANET) is a self-configurable wireless Communication network. It represents complex distributed systems that contain various wireless mobile nodes that can freely move and dynamically self-organize into arbitrary and temporary ad-hoc network topologies. It allows people and devices to seamlessly internetwork in areas without pre-existing communication infrastructure, e.g., battlefield communications, emergency operations, disaster recovery environments. A great deal of research results have been published since its early days in 1980s [1]. The salient research challenges in this area are end-to-end transfer, link access control, security, and providing support for real-time multimedia streaming [2]. In the research on MANETs, the network layer has received a considerable amount of attention. Hence large number of routing protocols with differing objectives for various specific needs have been proposed in this network [3].

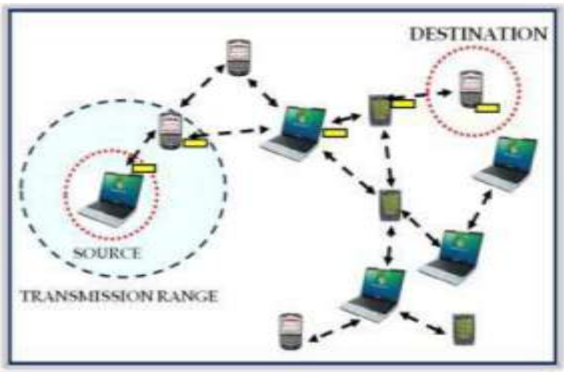

Fig 1: Mobile Ad-hoc Network

Figure 1 shows an example of mobile ad-hoc network and its communication technology. As shown in Figure, an ad hoc network might consist of several home-computing devices, including laptops, cellular phones, and so on. Each nodes in the network will be able to communicate directly with other node that resides within its transmission range., each node needs to use intermediate nodes to relay the messages hop by hop for communicating with nodes that reside beyond this range.

Opportunistic data forwarding utilizes the broadcast nature of wireless communication links [4] and data packets are handled in a multi-hop wireless network. In traditional IP forwarding, the inter mediate nodes looks up a forwarding table to find a dedicated next hop, but Opportunistic data forwarding broadcasts the data packet and allows potentially multiple downstream nodes to act on the packet. One of the initial works on opportunistic data forwarding is selective diversity forwarding by Larsson [5]. In this paper the transmitter sends the packet to multiple receivers and selects best forwarder from these receivers which successfully receives the data and requests the selected node to forward the data. The overhead in this approach is more and it should be reduced before it can be implemented in practical networks. This issue was addressed in the seminal work on ExOR [6], which outlines a solution at the link and network layers. In Ex OR, all the nodes in the work are enabled to overhear all packets on the air and therefore, more number of node scan potentially forward a packet, provided that all the nodes should be included in the *forwarder list* which is carried by the packet. The contention feature of the medium-access-control (MAC) sub layer effectively utilized and hence the forwarder which is very much closer to the destination will access the medium. Therefore, the MAC sub layer can determine the actual next-hop forwarder to utilize the long-haul transmissions in a better way.

A lightweight *proactive source routing* (PSR) *protocol* is proposed to facilitate opportunistic data forwarding in MANETs. In PSR, all nodes maintains a breadth-first search spanning tree of the network which rooted at itself. This information of the spanning tree is frequently exchanged among neighbouring nodes for updated network topology. Accordingly PSR allows a node to have full-path information from other nodes in the network, while the communication cost is only linear to the number of the nodes. This support s both source routing and conventional IP forwarding. But the computational and memory overhead involved in maintaining the BFSTs to reach every node in the denser networks will be high.

In this paper, Z-PSR (Zone based proactive source routing protocol is proposed which is lightweight, source routed, uses Breadth First Spanning Trees and is based on PSR[8] and ZRP[9].

II. Paper Related Work

Routing is the process of establishing path and forwarding packets from source node to destination node. MANET routing protocols could be broadly classified into three major categories: proactive, reactive and hybrid as shown in Figure 2.

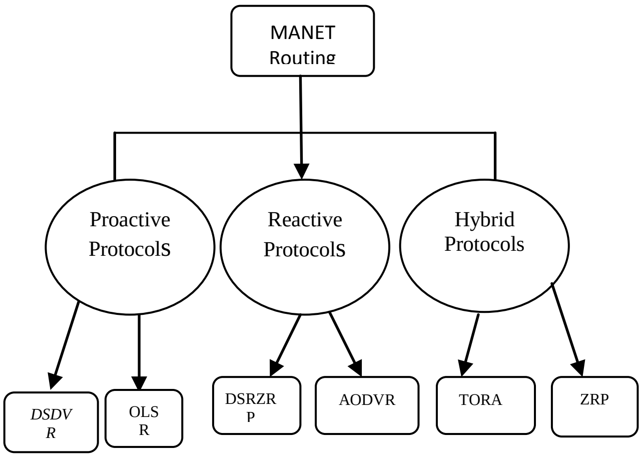

Fig 2. Routing Protocols in MANETs

A. *Temporally Order Routing Algorithm*

TORA is a source initiated on-demand routing protocol which uses a link reverse algorithm and facilitates loop free multipath routes to the destination node.

In TORA each node maintains its neighboring node information and also has ability to partitions. TORA has the unique property of limiting the control packets to a small region during the configuration process initiated by a path break. Here the distance metric used in TORA is nothing but the length of the path or the height from the destination. Height of the node is denoted by H(N) from the destination[16]

TORA performs 3 main functions

i) Establishing Routes
ii) Maintaining Routes
iii) Erasing Routes

The route establishing is performed ,when a node requires a path to destination but it does not have any directed link so this function process the establishment of a destination oriented directed a cyclic graph(DAG) using Query/Update mechanism.

Example when a source node has data packet to be transmitted to the destination, q Query packet is originated by source node with destination address added to it. This query packet is forwarded by intermediate nodes and reaches the destination node or any other nodes which found route to he destination the node that terminates (source node)the query packet replies with an update packet containing its distance from the destination

The distance node originates an update packet. Each node receives the update packet sets its distance to a value higher than the distance of the sender of the updated packet.

By this path is obtained it is considered to exist as long as path is available, irrespective of the path length changes due to the reconfigurations that may takes place during the data transmission.

Suppose an intermediate node discovers that the route to the destination node is invalid, it changes its distance value to a higher value than its neighbours and originates an update packet. The neighbouring node receives the update packet reverse the link between source and neighbouring of the intermediate node and forwards the update packet, this will update the DAG corresponding to distance node .If the node deletes a partition, it originates a clear message which erase the existing path information in the partition related to the destination. TORA incurs less control overhead, concurrent detection of partition and subsequent deletion of routes will results in temporary oscillation and transient loop.

B. *On-Demand Routing Protocols*

On-Demand routing is a popular routing category for wireless ad hoc routing. The following design idea is that each node tries to reduce routing overhead by sending routing packets when a communication is awaiting. On demand routing is a accepted routing category for wireless ad-hoc routing. The design follows routing packets when a communication is awaiting. Example includes Ad-hoc on demand distance vector Routing (AODV) Associativity-based Routing (ABR) Dynamic Secure routing (DSR) and TORA.

Among the many proposed protocols AODV & DSR have been extensively evaluated in the MANET literature are being consider by the MANET IETF working group has the leading standardization. The Ad-hoc Distance vector AODV routing protocol is an improvement over DSDR is a Secure initiated routing scheme capable of both uni-cast & multicast routing. AODV establishes a required rout only when it is needed .It uses an improved version of the distance vector algorithm to provide on-demand routing. AODV offers quick convergence when a network topology changes because of any node movement or link breakage .In such cases AODV notifies all node so that they can invalidate the routing using the lost node or link loop-free AODV is self-casting and handles large numbers of mobile nodes .It allows mobile nodes to respond to link breakages and changes in network topology in a timely manner.

AODV can also form multicast trees that connect multicasting group members. The trees are composed of group members and the nodes needed to connect them.

III. Problem Definition

Proactive Source Routing (PSR)

PSR uses Table driven approach and it is the base for the newly proposed Zone-based proactive source routing protocol. So it's required to know the working of PSR to understand Zone Routing Protocol (ZRP). A lightweight proactive source routing (PSR) protocol facilitates Opportunistic data forwarding in Mobile Ad-hoc Networks. To facilitate source routing PSR maintains more network topology information than distance vector (DV) routing [ ]. The breadth-first spanning tree(BFST) of the entire network rooted at itself is provided by PSR to every node of the network. To facilitate this, nodes periodically broadcasts the tree structure which has built from to entire network in every iteration. anode can expand and refresh its knowledge about the network topology by constructing a deeper and more recent BFST, Based on the information collected from neighbours during the most recent iteration. This routing information will be distributed to the neighbours in the next round of operation. Thus, this routing scheme allows a node to have full-path information to all other nodes in the network. The communication cost of PSR is linear to the number of nodes and hence both source routing and conventional IP forwarding is supported by PSR.

The detail of PSR is described in the following three sections. Before that we will review some graph-theoretic terms used here. The network is modelled 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). The edge connected by two nodes u and v is denoted as $e = (u, v) \in E$ if they are close to each other and if they can directly communicate with a given reliability. Given node v, $N(v)$ is used to denote its open neighbourhood, i.e., $\{u \in V \mid (u, v) \in E\}$. Similarly, $N[v]$ is used to denote its closed neighbourhood, i.e., $N(v) \cup \{v\}$. (Refer [14] for other graph-theoretic notions)

A. ***Route Update***

The update operation of PSR is iterative and distributed among all nodes in the network due to its proactive nature. Node v is only aware of the existence of itself at the beginning. Therefore, only single node is there in its BFST, which is root node v. It is able to construct a BFST within N[*v*], by exchanging the BFSTs with the neighbours, i.e., the star graph which is denoted by Sv and centered at *v*. Nodes exchange their spanning trees with their neighbours, in each subsequent iteration.

Towards the end of each operation interval, from the perspective of node v, it has received a set of routing messages from its neighbors packaging the BFSTs. The most recent information from each neighbour is incorporated by node *v* to update its own BFST. At the end of the period, it then broad casts this tree structure to its neighbours. Formally, *v* has received the BFSTs from some of its neighbours. Node *v* has a BFST which contains received updates in recent previous iterations and it is denoted by *Tu*, cached for each neighbor $u \in N(v)$. The union graph constructed by node *v*

$$G_v = S_v \cup\_u \in N(v)(T_u - v). \quad (1)$$

Here, $T - x$ denotes the operation of removing the subtree of T rooted at node x. Some special cases are, $T - x = T$ if x is not in T, and $T - x = \emptyset$ if x is the root of T. Then, node$v$ calculates a BFST of Gv, which is denoted $T\ v$, and places Tv in a routing packet to broadcast to its neighbours.

C. ***Neighbourhood Trimming***

When a neighbour is deemed lost, its relevant information from the topology repository which is maintained by the detecting node and also its contribution to the network connectivity should be removed. This process is called neighbourhood trimming. Consider the node v. The neighbour trimming procedure is triggered at v about neighbor u either by the following cases:

1) For a given period of time. Neither routing update nor receiving data packet from neighbour node.

2) A data transmission to node u has failed, as reported by the link layer.

C. Streamlined Differential Update

In PSR, The "full dump" routing messages are interleaved with "differential updates." The basic design is to send the complete update messages frequently than shorter messages containing the difference between the current and previous knowledge of a node's routing module. The routing update is further streamlined in two new avenues. First, we use a compact tree representation in full-dump and differential update messages to halve the size of these messages. Second, every node attempts to maintain an updated BFST as the network changes so that the differential update messages are even shorter.

IV. Proposed System

Zone Routing Protocol (ZPR)

As proactive routing uses excess bandwidth to maintain routing information, while reactive routing involves long route request delays. Reactive routing also inefficiently floods the entire network for route determination. The Zone Routing Protocol (ZRP) aims to address the problems by combining the best properties of both approaches. ZRP can be classed as a hybrid reactive/proactive routing protocol.

In an ad-hoc network, it can be assumed that the largest part of the traffic is directed to nearby nodes. Therefore, ZRP reduces the proactive scope to a zone cantered on each node. In a limited zone, the maintenance of routing information is easier. Further, the amount of routing information that is never used is minimized. Still, nodes farther away can be reached with reactive routing. Since all nodes proactively store local routing information, route requests can be more efficiently performed without querying all the network nodes.

Despite the use of zones, ZRP has a flat view over the network. In this way, the organizational overhead related to hierarchical protocols can be avoided. Hierarchical routing protocols depend on the strategic assignment of gateways or landmarks, so that every node can access all levels, especially the top level. Nodes belonging to different subnets must send their communication to a subnet that is common to both nodes. This may congest parts of the network. ZRP can be categorized as a flat protocol because the zones overlap. Hence, optimal routes can be detected and network congestion can be reduced. Further, the behavior of ZRP is adaptive. The behavior depends on the current configuration of the network and the behavior of the users.

V. Design Architecture of the Zone Routing Protocol

The routing zone has a radius r expressed in hops. The zone thus includes the nodes, whose distance from the node in question is at most r hops. An example routing zone is shown in Figure 3, where the routing zone of S includes the nodes A–I, but not K. In the illustrations, the radius is marked as a circle around the node in question. It should however be noted that the zone is defined in hops, not as a physical distance.

The nodes of a zone are divided into peripheral nodes and interior nodes. Peripheral nodes are nodes whose minimum distance to the central node is exactly equal to the zone radius r. The nodes whose minimum distance is less than r are interior nodes. In Figure 3, the nodes A–Fare interior nodes, the nodes G–J are peripheral nodes and the node K is outside the routing zone.

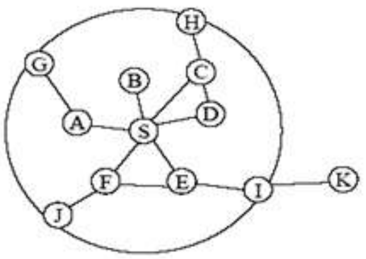

Fig 3. Routing zone of node S with zone radius β=3

The node H can be reached by two paths, one with length 2 and one with length 3 hops. The node is however within the zone, since the shortest path is less than or equal to the zone radius. The number of nodes in the Fig 3 routing zone can be regulated by adjusting the transmission power of the nodes. Lowering the power reduces the number of nodes within direct reach and vice versa. The number of neighboring nodes should be sufficient to provide adequate reach ability and redundancy. On the other hand, a too large coverage results in many zone members and the update traffic becomes excessive. Further, large transmission coverage adds to the probability of local contention.

ZRP refers to the locally proactive routing component as the Intra-zone Routing Protocol (IARP). The globally reactive routing component is named Inter-zone Routing Protocol (IERP). IERP and IARP are not specific routing protocols. Instead, IARP is a family of limited-depth, proactive link-state routing protocols. IARP maintains routing information for nodes that are within the routing zone of the node. Correspondingly, IERP is a family of reactive routing protocols that offer enhanced route discovery and route maintenance services based on local connectivity monitored by IARP. The fact that the topology of the local zone of each node is known can be used to reduce traffic when global route discovery is needed. Instead of broadcasting packets, ZRP uses a concept called border casting. Border casting utilizes the topology information provided by IARP to direct query request to the border of the zone. The border cast packet delivery service is provided by the Border cast Resolution Protocol (BRP). BRP uses a map of an extended routing zone to construct border cast trees for the query packets. Alternatively, it uses source routing based on the normal routing zone. By employing query control mechanisms, route requests can be directed away from areas of the network that already have been covered.

In order to detect new neighbor nodes and link failures, the ZRP relies on a Neighbor Discovery Protocol (NDP) provided by the Media Access Control (MAC) layer.NDP transmits “HELLO” beacons at regular intervals. Upon receiving a beacon, the neighbor table is updated. Neighbors, for which no beacon has been received within a specified time, are removed from the table. If the MAC layer does not include a NDP, the functionality must be provided by IARP.

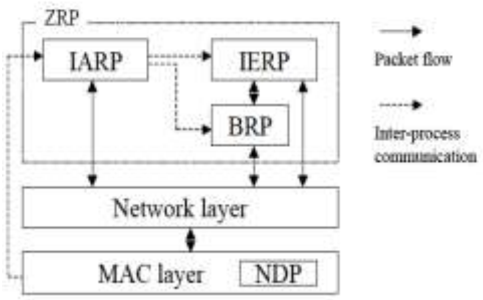

Fig 4. ZRP Architecture

The relationship between the components is illustrated in Figure 4. Route updates are triggered by NDP, which notifies IARP when the neighbour table is updated. IER Puses the routing table of IARP to respond to route queries.

BRP gets the queries from the IERP. Then BRP uses the routing table of IARP to guide route queries away from the query source.

VI Protocol Design and Implementation

The new routing protocol proposed in this paper is named as Z-PSR. We are combining the advantages of both PSR and ZRP hence the name. Basic problems of PSR are discussed below.

In a denser network, the overhead involved in maintaining the BFST to reach every node in the network will become high in case of PSR. The time taken to search for a route from the set of BFSTs is also high. Even though PSR is reducing the overhead in terms of communication bytes, it fails to reduce the computational overhead and memory overhead incurred by each node in finding out the route. This results in high energy consumption.

The objectives of the new routing protocol are as follows
1. Develop a routing protocol which minimizes the computation overhead in searching for a route.
2. The protocol should decrees size of the memory occupied by each BFST.
3. The protocol should locate route to the destination with minimum delay.
4. The minimize energy consumption compared to the existing PSR protocol.

The following steps can be used to meet the objectives.

1. Each node will maintain a BFST of its one hop or two hop neighbours only, as opposed to PSR where every node needs to maintain BFST to reach every other node in the network.
2. Whether to maintain one hop or two hop neighbours BFST is decided based on parameter radius. If radius = 1, maintain BFST to reach one hop neighbours. If Radius =3, maintain BFST to reach three hop neighbours and so on. (Simulations in this paper has used radius 3)
3. When a node needs to send data to its one hop or two hop neighbours, it will use BFSTs maintained at that node. When it needs to send data to other nodes, (other than one/ two hop neighbours), it needs to send data to one of the two hop neighbour which will have BFST to reach the destination.
4. Which two hop neighbour will have the BFST to reach the destination? This is the challenge in this protocol. A node will be receiving BFSTs from all the nodes, but it need not store them. Periodically update messages also sent by the neighbouring nodes. So when a node needs to transmit data to a node which is not its one/two hop neighbour, it has to check the update from neighbours to check if it has a path to the destination. The BFST messages will be transmitted as a broadcast. So the protocol is actually following the concept of Link state vector algorithm, which says pass information about neighbours to all the nodes in the network.
5. Thus only when needed, the node will accept and process the broadcast messages carrying BFST of other nodes.
6. This reduces computation overhead and memory overhead maintaining the communication overhead at same level as PSR.

VII Result Analysis

Fig.5 shows the graphical result of length of the BFST to be stored at each node. It is clear from the graph that Z-PSR needs to store only shorter length BFSTs compared to PSR.[15]

Node Id	*PSR*	*Z-PSR*
3	40	10
2	11	16
4	20	16
6	15	14
9	45	28
12	75	30
13	105	32
15	135	30
17	165	20
20	195	37
21	225	36
23	255	34
25	285	10
27	315	46
29	345	48

Table1.Simulation Result for nodes vs Length of the BFST

Table2. Packet delivery ration		
Simulation in sec	*PSR*	*Z-PSR*
1	0.8	0.9
10	0.8	0.9
20	0.8	0.9
30	0.85	0.92
40	0.86	0.94
50	0.866	0.95
60	0.87	0.95
70	0.875	0.95
80	0.875	0.955
90	0.876	0.956
100	0.88	0.95
110	0.89	1
120	0.9	0.96
130	0.94	0.97
140	0.95	0.98
150	0.96	1

Table2. Packet delivery ration

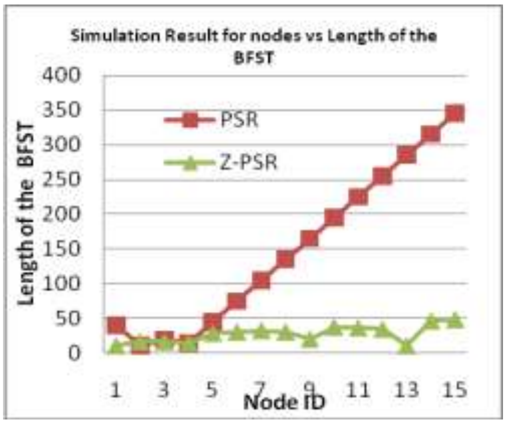

Fig.5 Length of BFST at each node

Below Fig.6 Shows the Packet delivery ratio, for both PSR and Z-PSR, Z-PSR maintains a 99.9% delivery ratio.

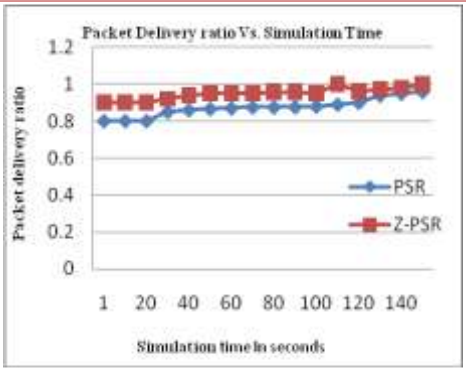

Fig.6. Packet Delivery ratio Vs. Simulation Time

Conclusion and Feature Work

Routing in ad hoc network is always a challenging one. This paper proposed a routing protocol based on two existing protocols ZRP and PSR. The simulations results show that the proposed protocol out performs the existing PSR protocol which acts as a base for this new protocol. Simulations can be extended to change the number of nodes, node mobility etc. The proposed ZRP minimizes the memory over head using reactive approach outside the zone since all the nodes does not manages BFS tree. The result indicates that the proposed protocol yields high performance when compared to the existing PSR protocol which is a base for the new protocol proposed. By changing the number of nodes, node mobility etc simulations can be extended. In future, the work can be extended in order to minimize the delay and the energy consumed in searching for a route and also extensive simulations can be done using ns2 simulator.

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