PNR: New Position based Routing Algorithm for Mobile Ad Hoc Networks

Hossein Ashtiani, Shahpour Alirezaee, seyed mohsen mir hosseini, HamidKhosravi

***Abstract*—** An ad hoc network (MANET) has no fixed networking infrastructure, and consists of mobile nodes that communicate with each other. Since nodes are mobile, Routing in ad hoc network is a challenging task. Efficient routing protocols can make better performance in such networks. Many protocols have been proposed for ad hoc networks which the most common types are: Ad hoc on-demand Distance Vector (AODV), Dynamic Source Routing (DSR), Optimized Link State Routing (OLSR). In this paper, we introduce a new Position and Neighborhood based Routing (PNR) algorithm for mobile ad hoc networks which uses GPS and new algorithm to reduce the overhead caused by position update messages. We also compare our scheme with DSR, AODV, OLSR for two metrics: packet delivery ratio and end-to-end delay. We use GlomoSim [1] to evaluate these protocols.

***Keywords*—** ad hoc network**,** DSR, AODV, OLSR, PNR, source routing**,** Random way point model.

I. Introduction

MANETs consist of mobile nodes that communicate with each other without any infrastructure and are named as infrastructure-less networks [2]. Nodes in these networks carry out both network control and routing duties; they generate user and application traffics. Topology of ad hoc networks is dynamic; therefore, routing in such networks is much difficult, especially for highly dynamic ad hoc networks. Normal routing protocols which are used in wired networks are not efficient, so, in the past years, many protocols have been designed for ad hoc networks.

Routing protocols are divided into two categories: proactive, reactive. The most popular ones are AODV, DSR (reactive), OLSR (proactive). Reactive protocols like DSR, and AODV find the routes only when requested and data need to be transmitted by the source host; These protocols generate low traffic and routing overhead but because they must first determine the route, delay increases, especially, if the information is not available in caches. Reactive protocols are suitable for energy-constrained conditions. They use distance-vector routing algorithms. On the contrary, Proactive protocols like OLSR are table driven protocols and use link state routing algorithms. Proactive protocols generate high traffic and routing overhead to keep the information up-to-date, but have less delay and can be used when bandwidth and energy resources are enough [3]. Because of high mobility of the nodes, the route update may be more frequent than the route requests and some of bandwidth is wasted due to most of the routing information is never used. So both reactive and proactive protocols are suitable for some special scenarios. So, design a routing algorithm that has better performance for a special scenario is an important issue in mobile ad hoc networks (MANETs).

Some works have been done to evaluate different position based routing algorithms like [12][13][14] [15], but this paper contains a new position based approach for mobile ad hoc networks that has better end-to-end delay and good packet delivery ratio.

The rest of the paper is organized as follows. Section II is a description of most common routing protocols which we use to compare PNR with them. In section III we describe our routing algorithm (PNR). In section IV different scenarios that used for evaluation is introduced. Section V shows the simulation result. The conclusion and future works are also concluded in section VI.

II. Description of Routing Protocols

A. AODV

AODV is a reactive protocol that reduces number of broadcasts by establishing routes on demand basis. This protocol does not maintain the whole routing information of all nodes in the network [4]. For Route Discovery a route request packet (RREQ) is broadcasted whenever a node have a packet to transmit to the destination. It continues forwarding till an intermediate node which has recent route information about destination or the destination itself receive this packet. Then the intermediate node or the destination will send a Route Reply (RREP) message to the source by reverse path of RREQ, therefore AODV uses symmetric link. During forwarding a packet a node records in its tables from which the first copy of the request came. It is needed for establishing reverse path for RREP message. The intermediate nodes are allowed to inform the effected sources from link breakage. Link failure can be due to node’s movement or exhausting the energy. When source node receives the Route Error packet (RERR) packet, it can initiate route again if still needed. We can conceptualize propagation of RERR packet in AODV as a tree whose root is the node at that point of failure and the effected sources that receive the error packet as leaves [5][6]. To prevent route loops, AODV uses sequence number

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maintained at each destination to determine how much fresh the routing information is [4]. The sequence numbers are carried by all routing packets[7]. A node is active if it sends, receives or forwarding packets for that route and if there is at least one data packet transmitted through this route with in a fixed time interval[4]. AODV has much less overhead than simple protocols that keep the entire network information from source to destination. Hello messages are responsible for the route maintenance.

B. DSR

DSR is another reactive protocol. The main feature of DSR is source routing. DSR is specially designed for multi-hop ad hoc networks and reduces bandwidth usage by eliminating periodic messages. In this protocol the packet includes a complete list of the all nodes which it should be forwarded towards them. DSR has two major mechanisms : “Route Discovery”, “Route Maintenance”[8]. During Route Discovery, a source node broadcasts a RREQ message; and each intermediate node that receive this packet will rebroadcast it, unless it is the destination or it has route to the destination in its route cache. Such a node will send a RREP message to the source [9]. The route which RREP packet carries, is cached in source node for future use. If link failure occur then a route error packet (RERR) will be sent to the source to notify it. The source node then removes that routes consisting failed link from its cache and if there is a new route to that destination in its cache, it will replace it instead of previous one; otherwise it will reinitiate route discovery. Both Route discovery and Route maintenance are on demand. It is loop free because the sender can avoid duplicate hops in the routes selected. Unidirectional link and asymmetric routes are supported by DSR.[10].

C. OLSR

Optimized Link State Protocol (OLSR) is a proactive protocol, therefore due to it’s proactive nature the routes are always available when they are needed [11]. OLSR uses hop-by-hop routing. It uses MPR (Multi Point Relays) flooding mechanism to broadcast and flood Topology Control (TC) messages in the network. This mechanism takes advantage of controlled flooding by allowing only selected nodes (MPR nodes) to flood the TC message. Each node selects an MPR to reach its two-hop neighbors. OLSR uses topology discovery/diffusion mechanism by periodic and triggered Topology Control (TC) messages. TC messages are generated by MPR nodes and carry information about MPR selectors nodes. Neighbor sensing is done by using periodic broadcast of Hello messages. These messages are one-hop broadcasts (never forwarded) that carry neighbor type and neighbor quality information.

III. Position and Neighborhood based Routing (PNR)

A. Architecture

In our routing approach, to bootstrap the network, all nodes initiate a full flooding throughout the network. Taking into consideration the network size, initial floods sent out by each node can be adjusted. A node maintains its list of neighbor nodes by periodically broadcasting Hello messages. By specifying a time period named as “Neighbor Expiry time”, if a node does not receive Hello message from a neighbor node for a period exceeding “Neighbor Expiry time”, it assumes the link is lost. Each node can determine its own position using a GPS. The position of other nodes determined through flooding. When a node moves more than a specified distance (it is adjustable for different network size), it sends out a flooding message with its new position. The entire network is divided into neighborhoods (quadrants) for the purposes of optimized flooding. Taking into consideration the network size, the size of the neighborhood can also be specified. The neighborhoods are organized in a hierarchical manner. Each higher level neighborhood is partitioned into 4 smaller lower level neighborhoods. To illustrate, consider a system with top level neighborhoods A and B. Within A, we define four more neighborhoods Aa, Ab, Ac and Ad. Within B, we define Ba, Bb, Bc and Bd. Similarly, within Aa we define Aa1, Aa2, Aa3 and Aa4. Flooding messages are also sent out when a node crosses a quadrant boundary.

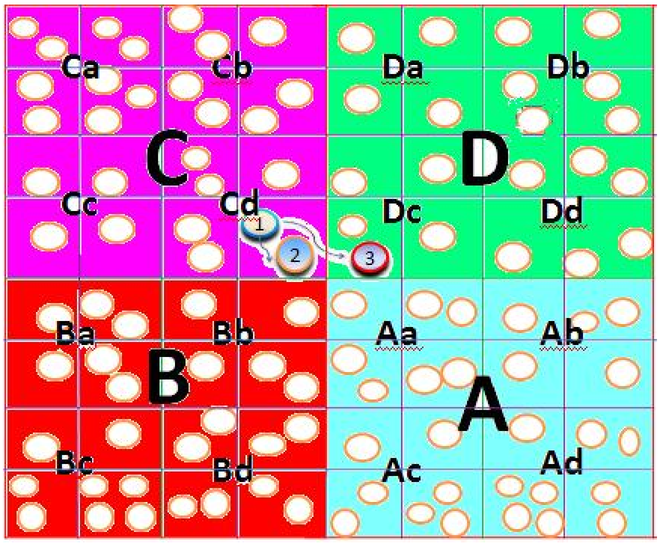

Fig. 1 a simple hierarchical manner for neighborhood definition. Node 1 lies in the same neighborhood as node 2, so, it maintains the exact location of node 2. Node 3 lies in neighboring quadrant, it only maintains summarized information about location of node 2.

To reduce the overhead caused by flooding updates, the scope of the flooding is limited. When a node sends a position update, only nodes that "**need to know**" about the change receive the flood. Also, When a node receives a flooding message from another node, it maintains the position information of the node based on the quadrant the node lies in. If the node lies in the same quadrant as this node, it maintains the exact location of the node. However, if the node lies in a neighboring quadrant, it only maintains summarized information about the location of the node. For example, if a node in quadrant A receives a flood from a node in quadrant B, it maintains the location of the node as located in quadrant B (instead of the exact position). Each node knows the neighborhood that it belongs to using its location information and the knowledge of the neighborhood definitions. When a node needs to send out a position update due to distance moved within its own quadrant, it only sends out the flooding message to nodes within its own quadrant. When a node moves to a new quadrant, it determines the highest level on which the neighborhood crossing occurred. If the node has moved from neighborhood Aa1 to Aa2, then it will generate a flood scoped to neighborhood Aa. Similarly, if a node moves from neighborhood Aa1 to Ab1, then the node will initiate a flood with scope equal to neighborhood A. Our routing scheme follows a based on the shortest distance to destination. Each node that receives the data packet considers which of its neighbor node is closest to the destination and picks that neighbor to forward the packet to. To avoid loops, neighbor nodes that have already been traversed are omitted. Sometimes when forwarding packets based on shortest distance, it can lead to blocked routes where there are no new nodes to forward the packet to. For forwarding packet in this situation, the packet is returned to the previous hop where a new next hop selection can be made.

IV. EVALUATION AND COMPARISON

To evaluate the performance of our routing approach we compare it with three common routing algorithms (DSR, AODV, OLSR). We used two scenarios for this purpose that described in table 1 and table 2. The used attributes for our algorithm is also shown in table 3:

Table 1-Simulation parameters scenario 1

Simulation time	600 seconds
Area	1500×500 m²
Node placement	Random
Mobility pattern	Random way point
Speed	20 m/s
Pause time	0, 50, 100, 200, 300, 400, 500, 600
Application	CBR
Packet size	512 bytes
Packet transmission rate	3 packet/sec
Data rate	2 Mbps
PHY	802.11b
#of connections	10, 30
Num of nodes	50

Table 2- Simulation parameters scenario 2

Simulation time	400 seconds
Area	1800×800 m²
Node placement	Random
Mobility pattern	Random way point
Speed	20 m/s
Pause time	0, 50, 100, 200, 300, 400
Application	CBR
Packet size	512 bytes
Packet transmission rate	3 packet/sec
Data rate	2 Mbps
PHY	802.11b
#of connections	10, 30
Num of nodes	100

Table 3- PNR routing attributes

Neighbor Expiry Time	5 sec
Number of initial floods	1
Distance to send out position update	100 meter
Hello interval (seconds)	Uniform(4.9,5.0)

V. SIMULATION RESULT

We use two performance metrics to evaluate these four routing protocols (AODV, DSR, OLSR, PNR):

A. *End-to-End Delay (second)*

The end-to-end delay parameters are simulated here for 50 and 100 mobile nodes with different packet sizes and two different CBR sources, as shown in figures (2 , 3, 4, 5):

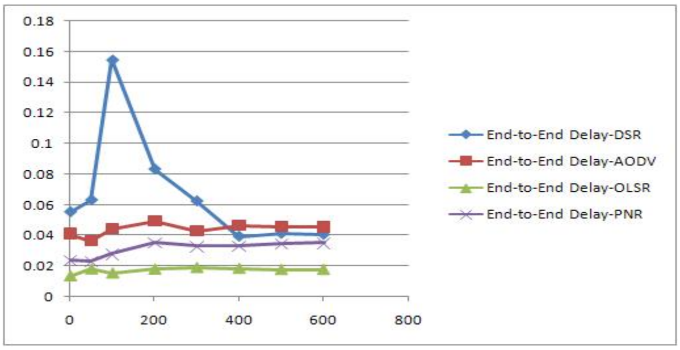

Fig. 2 end-to-end delay – 50 nodes with 10 CBR sources

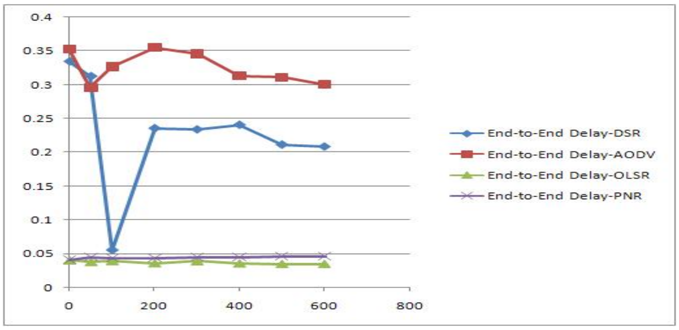

Fig. 3 end-to-end delay - 50 nodes with 30 CBR sources

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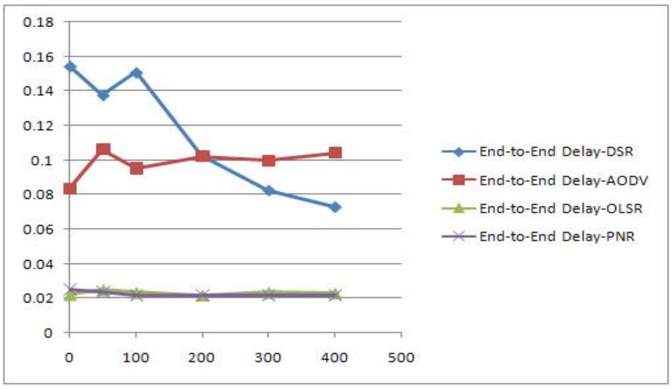

Fig. 4 end-to-end delay - 100 nodes with 10 CBR sources

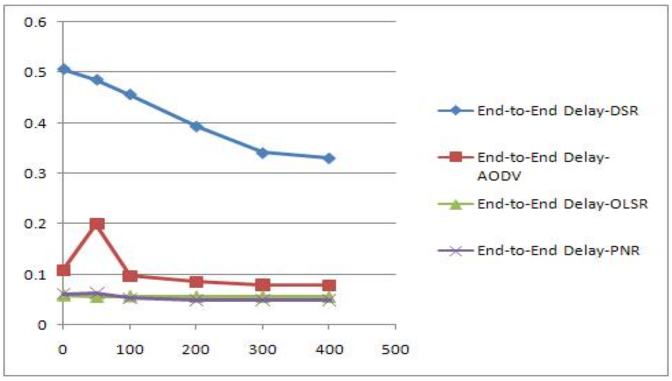

Fig. 5 end-to-end delay - 100 nodes with 30 CBR sources

From figure 2 to 5, it is shown that PNR has better end-to-end delay than reactive protocols because a node maintains its list of neighbor nodes by periodically broadcasting Hello messages.

B. Packet Delivery fraction

We also compare the packet delivery. Comparison shows good performance for this metric, as from figure 6, 7, 8, 9 the performance of PNR is well enough when comparing with AODV and DSR. Also its packet delivery ratio is better than OLSR. When the number of CBR sources increases, packet delivery of PNR and AODV are near each other but PNR also shows less change than AODV comparing to situation with 10 sources.

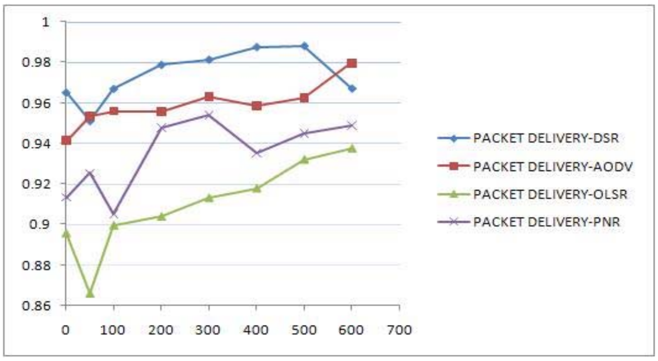

Fig. 6 packet delivery ratio– 50 node with 10 CBR sources

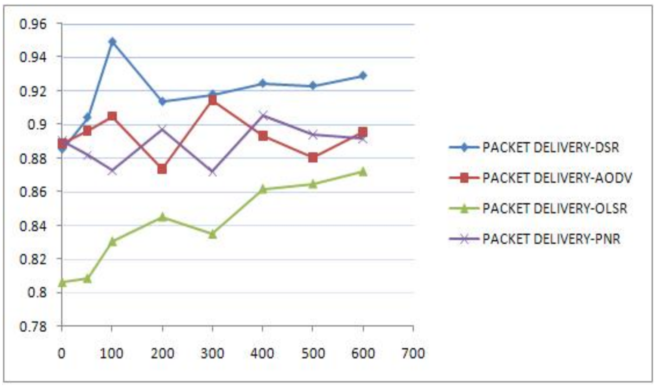

Fig. 7 packet delivery ratio– 50 node with 30 CBR sources

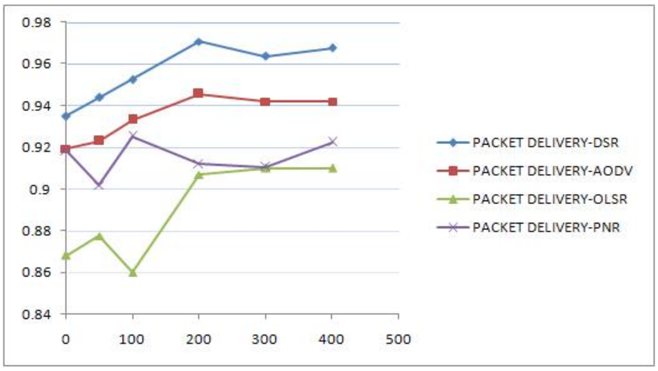

Fig. 8 packet delivery ratio– 100 node with 10 CBR sources

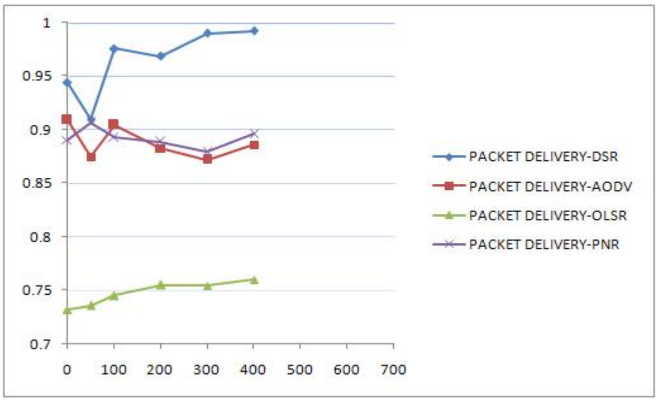

Fig. 9 packet delivery ratio– 100 node with 30 CBR sources

VI. Conclusion

The algorithm presented here has better end-to-end delay than reactive protocols. Also, it has acceptable packet delivery ratio comparing with reactive protocols. When the number of CBR connections increases the packet delivery ratio graph of PNR and AODV are near each other. Unlike AODV it shows less changes for packet delivery when number of CBR sources increases. The packet deliver of PNR also is better than OLSR especially when the number of CBR sources is 30.

Recommendations for future studies that can improve the reliability of this kind of work include the following:

i) We only studied networks with random waypoint model for mobility. Using other mobility models like random walk,… can improve this work in terms of real-life applications.

ii) This study included only 10, 30 CBR sources for mobile ad hoc networks. Increasing the number of sources to 50, 60,… or using VBR (variable bit rate) sources will show different result for ad hoc routing protocols.

iii) Additional ad hoc routing protocols like ZRP, DYMO,… could be added to this study for more comprehensive performance evaluation.

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