

Position Based Routing in Mobile Ad-Hoc Networks: An Overview

¹Simardeep Kaur, ²Anuj K. Gupta

¹RIMT IET, Punjab, India

²Dept. of CSE, RIMT IET, Punjab, India

Abstract

The mobile ad hoc networks are used now days due its several advantages over the other networks. Several protocols are used for wireless ad hoc networks such as reactive protocols proactive protocols for finding routes. Hybrid protocols are used which combines the advantages of both reactive and proactive protocols. The position based routing protocols are also the part of hybrid routing protocol. The position based routing protocols uses GPS to find the availability of routes. In this paper various protocols for position based routing in mobile ad hoc networks are discussed.

Keywords

Mobile Ad-Hoc Networks, Position based Routing, GPS, Hybrid Protocols

I. Introduction

Infrastructure less wireless network is a network of mobile nodes without having any central controller. In wireless communication systems, there is a demand for the rapid deployment of independent mobile users. Significant examples include establishing survivable, efficient, dynamic communication for emergency/rescue operations, disaster relief efforts, and military networks. Such network scenarios cannot rely on centralized and organized connectivity, and can be conceived as applications of Mobile Ad Hoc Networks. The usage of physical positions of the nodes can considerably improve the efficiency of routing techniques for mobile ad hoc networks. This mainly leads to a much reduced routing overhead and an increased packet delivery rate. Position-Based Routing is possible through the availability of small inexpensive GPS receivers and techniques for finding the relative coordinates based on signal strengths.

II. Mobile Ad-Hoc Networks

A MANET is an autonomous collection of mobile users that communicate over relatively bandwidth constrained wireless links. Since the nodes are mobile, the network topology may change rapidly and unpredictably over time. The network is decentralized where all network activity including discovering the topology and delivering messages must be executed by the nodes themselves i.e. routing functionality is incorporated into mobile nodes. The set of applications for MANETs is diverse, ranging from small and static networks that are constrained by power sources to large-scale mobile highly dynamic networks. The design of network protocols for these networks is a complex issue. Regardless of the application, MANETs need efficient distributed algorithms to determine network organization, link scheduling, and routing.

III. Challenges in MANET Routing

Determining viable routing paths and delivering messages in a decentralized environment where network topology fluctuates is not a well-defined problem. While the shortest path (based on a given cost function) from a source to a destination in a static network is usually the optimal route, this idea is not easily extended to MANETs. Factors such as variable wireless link

quality, propagation path loss, fading, multiuser interference, power expended, and topological changes, become relevant issues. The network should be able to adaptively alter the routing paths to alleviate any of these effects.

IV. Types of Routing Protocols

There are different types of routing protocols for mobile ad hoc networks. Some of them are based on topology and other protocols are position based. Each protocol has its own significance depending upon the area of its application. Some of the protocols for mobile ad hoc networks are discussed in this paper. There are three main categories of routing protocols ie. proactive protocols, reactive protocols and hybrid protocols. The hybrid protocols combine the advantages of both reactive and proactive protocols. The position based routing protocols comes under hybrid routing protocols.

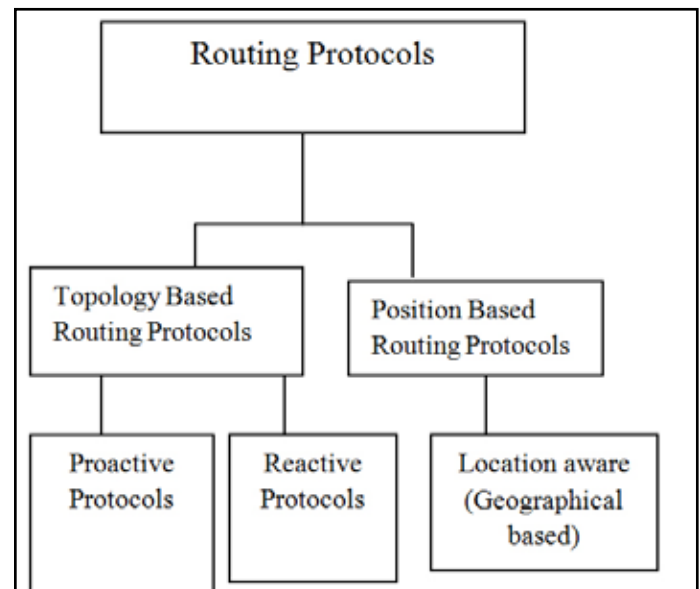


Fig. 1: Different Routing Protocols for Mobile Ad-Hoc Networks

A. Proactive Routing Protocols

In this type of routing protocol, each node in a network maintains one or more routing tables which are updated regularly. Each node sends a broadcast message to the entire network if there is a change in the network topology. However, it incurs additional overhead cost due to maintaining up-to-date information and as a result; throughput of the network may be affected but it provides the actual information to the availability of the network. Distance Vector (DV) protocol, Destination Sequenced Distance Vector (DSDV) protocol, are the examples of Proactive protocols.

B. Reactive Protocols

In this type of routing protocol, each node in a network discovers or maintains a route based on-demand. It floods a control message by global broadcast during discovering a route and when route is discovered then bandwidth is used for data transmission. The main advantage is that this protocol needs less routing information but

the disadvantages are that it produces huge control packets due to route discovery during topology changes which occurs frequently in MANETs and it incurs higher latency. The examples of this type of protocol are Dynamic Source Routing (DSR), Ad-hoc On Demand Routing (AODV).

C. Hybrid Routing Protocols

Hybrid routing algorithms aim to use advantages of table driven and on demand algorithms and minimize their disadvantages. Position based routing algorithms that are classified in the hybrid routing algorithms category include the properties of table driven and on demand protocols and are usually interested in localized nodes. Localization is realized by GPS that is used to determine geographical positions of nodes. Position changes which occur because of nodes mobility in MANET cause changes in routing tables of nodes. The GPSs, which are embedded in nodes, are used to update information in tables in position-based algorithms. That makes position-based algorithms different from the table driven and on demand algorithms. Multi Point Relaying (MPR) based algorithms, position based algorithms, Directional Routing Algorithm (DIR), most Geographic Distance Routing (GEDIR) are few examples of hybrid routing protocols

D. Position Based Routing Protocols

Position-based routing algorithms eliminate some of the limitations of topology-based routing by using additional information. A location service is used by the sender of a packet to determine the position of the destination and to include it in the packet's destination address. Position-based routing thus does not require the establishment or maintenance of routes. Location services can be classified according to how many nodes host the service. The position information can be collected in different ways. It can be collected from the direction and strength of the received wireless signals and through interfacing with a low-power Global Positioning System (GPS) and a satellite updating the positions of the nodes by sending signals to this GPS device.

V. Packet Forwarding Strategies

There are three main packet-forwarding strategies used for position-based protocols.

- Greedy forwarding
- Restricted directional flooding
- Hierarchical approaches.

A. Greedy Forwarding

In this approach the protocols do not establish and retain paths from source to the destination instead; a source node includes the estimated position of the recipient in the data packet and selects the next hop depending on the optimization criteria of the algorithm i.e. the closest neighbor to the destination. Each intermediate node selects a next hop node until the packet reaches the destination. In order for the nodes to be able to do this, they periodically broadcast small packets (called beacons) to announce their position. Such an approach is scalable and flexible as it does not need route discovery and maintenance with the topology change. It has the disadvantage because the periodic beaconing creates lot of congestion in the network and consumes node's energy. The greedy routing may not always find the best possible route, even it may fail to find a path between source and destination when one exists. An example of this problem is shown in fig. 2. The circle around S shows the transmission range of S. Note that there is a valid path from S to D. The problem here is that S is closer to

the destination D than any of the nodes in its transmission range; therefore greedy forwarding will reach a local maximum from which it cannot recover. Generally, greedy forwarding works well in dense networks, but in sparse networks it fails due to voids (regions without nodes).

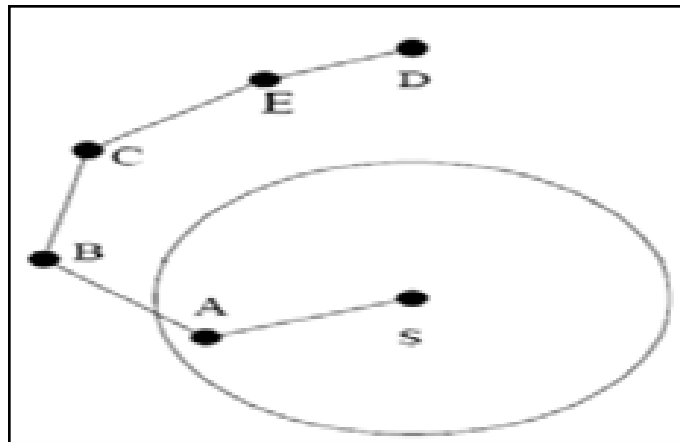


Fig. 2: Greedy Routing Failure Example

B. Restricted Directional Flooding

In restricted directional flooding, the sender broadcasts the packet (whether the data packet or route request packet) to all single hop neighbors towards the destination. The node which receives the packet, checks whether it is within the set of nodes that should forward the packet (according to the used criteria). If yes, it will retransmit the packet. Otherwise, the packet will be dropped. In restricted directional flooding, instead of selecting a single node as the next hop, several nodes participate in forwarding the packet in order to increase the probability of finding the shortest path and get robust against the failure of individual nodes and position inaccuracy.

B. Hierarchical Approaches

The third forwarding strategy is to form a hierarchy in order to scale to a large number of mobile nodes. Some strategies combine the nodes location and hierarchical network structures by using the zone based routing. Others use the dominating set routing. Some others present a two level hierarchy within them; if the destination is close to the sender (in number of hops), packets will be routed based on a proactive distance vector. Greedy routing is used in long distance routing.

VI. Position Based Routing Protocols

A. Location-Aided Routing (LAR)

Ko and Vaidya presents the LAR protocol which utilizes location information to minimize the search space for route discovery towards the destination node [1]. LAR aims to reduce the routing overhead for the route discovery and it uses the Global Positioning System (GPS) to obtain the location information of a node. LAR essentially describes how location information such as GPS can be used to reduce the routing overhead in an ad hoc network and ensure maximum connectivity. Location-Aided Routing is an example of restricted directional flooding routing protocols; however, partial flooding is used in LAR for path discovery purpose. Hence, LAR proposes the use of position information to enhance the route discovery phase of reactive Ad-Hoc routing approaches.

B. Most Forward Within Distance (MFR)

Some greedy position-based routing protocols, such as Most Forward within distance R (MFR), try to minimize the number of hops by selecting the node with the largest progress from the neighbors, where progress is defined as the projection of the distance of the next hop from the sender on the straight line between the sender and the destination. As other greedy forwarding protocols, MFR has the shortcomings of either not guaranteeing to find a path to the destination or finding a path which is much longer than the shortest path. Moreover nodes periodically should broadcast beacons to announce their positions and enable other nodes maintain a one-hop neighbor table. MFR is the only progress-based algorithm competitive in terms of hop count. However, choosing the node with the largest progress as the next hop will increase the probability that the two nodes disconnected from each other before the packet reaches the next hop. So, the packet drop rate increases greatly, especially in highly mobile environments. Such a situation is very common due to neighbor table inconsistency.

C. Distance Routing Effect Algorithm for Mobility (DREAM)

Basagni et al. proposed the DREAM protocol which used the node location information from GPS systems for communication [2]. DREAM was a part proactive and part reactive protocol where the source node sends the data packet "in the direction" of the destination node by selective flooding. The sender will broadcast the packet towards nodes in a limited sector of the network; to all single hop neighbors towards the destination. DREAM algorithm is a proactive protocol that uses a limited flooding of location update messages. Since DREAM uses the restricted directional flooding to forward data packets themselves, there will be multiple copies of each packet at the same time. This increases the probability of using the optimal path; however, it decreases its scalability to large networks with a high volume of data transmissions and makes it more suitable for applications that require a high reliability and fast message delivery for infrequent data transmissions.

D. Greedy Perimeter Stateless Routing (GPSR)

GPSR, by Karp and Kung proposed a protocol that used the location of the node to selectively forward the packets based on the distance. [3] The forwarding was carried out on a greedy basis by selecting the node closest to the destination. The best path was also calculated through a node which was farther in geometric distance from the destination. A well known right hand rule was applied to move around the obstacle and resume the greedy forwarding as soon as possible.

E. Dynamic Route Maintenance (DRM) for Geographic Forwarding

Chou et al. proposed a dynamic scheme to be used in geographic forwarding algorithms in MANETs [4]. In beacon based protocols, each mobile node transmits periodic beacons to its neighbors to update and maintain its routing table. The beacons are generally forwarded at fixed intervals of time. During low mobility, a longer interval would be the best as it would reduce control overhead while providing accurate location information. However, in cases of higher mobility, determining an appropriate beacon interval is rather difficult. In DRM, beacon interval and route information are carried out dynamically. Based on the node's mobility information, its beacon interval is computed while the route management function updates the routing table entries. The DRM algorithm is applied to GPSR forwarding algorithm.

F. Improvements to location-aided Routing Through Directional Count Restrictions

Colagrosso et al. aimed to reduce the control packet overhead by reducing duplicate route formation of packets [5]. The enhancements were proposed to the LAR Box algorithm which was based on count restriction of rebroadcasts.

G. Adaptive Location Aided Mobile Ad-Hoc Network Routing (ALARM)

The Adaptive Location Routing (ALARM) algorithm, by Boleng and Camp, used feedback for adaptation and location information for performance improvements [7]. The use of location information increased efficiency of the protocol.

H. A Region-Based Routing Protocol for Wireless Mobile Ad-Hoc Networks (REGR)

The REGR protocol, proposed by Liu et al. [6]. It created a pre-routing region between the source and the destination there by controlled the flooding of route request packets within this region. For the discovery of the optimal routes there was a correct selection of the region, which was not too small.

I. Location Aided Knowledge Extraction Routing for Mobile Ad-Hoc Networks (LAKER)

Li and Mohapatra The LAKER protocol, by Li and Mohapatra, minimized the network overhead during the route discovery process by decreasing the zonal area in which route request packets were forwarded. [8] During this process, LAKER extracted knowledge of the nodal density distribution of the network and remembered a series of "important" locations on the path to the destination. These locations were named as "guiding routes" which simplified the route discovery process.

J. A Location-Based Routing Method for Mobile Ad-Hoc Networks

Blazevic et al. proposed Terminode Routing, which combined a location-based routing protocol called Terminode Remote Routing (TRR) and a link state routing called Terminode Local Routing (TLR). [9] TRR was used for nodes located some distance away from the source node, while TLR was used for local nodes. Terminode routing also used a unique flooding scheme called Restricted Local Flooding (RLF) for flooding control packets during route discovery.

K. On-Demand Geographic Path Routing (OGPR)

Giruka and Singhal proposed a geographic path routing protocol which used greedy forwarding i.e. reactive route discovery and source based routing instead of a location service to find the position of the destination. [10] It used a reactive route discovery and source based routing. It was a hybrid protocol which incorporated the effective techniques of other well known routing protocols for MANETs. OGPR constructed geographic paths to route packets between a source and a destination node.

L. Secure Position-Based Routing

Protocol Song et al. proposed a Secure Geographic Forwarding (SGF) algorithm which provided source authentication, neighbor authentication, and message integrity [11]. It was attached with a Secure Grid Location Service (SGLS) to enable any receiver to verify the correctness of the location messages. SGF used both greedy and directional flooding methods.

M. Sociological Orbit Aware Location Approximation and Routing (SOLAR)

Ghosh et al. first proposed a macro level mobility framework termed ORBIT [12]. It was a deterministic orbital movement pattern of mobile users along specific places called hubs. The movement pattern was based on the fact that most mobile nodes are not truly random in their movements but actually move around in an orbit from hub to hub. Each hub may be a rectangle and movement may take place either inside a hub or in between hubs. Example orbital models discussed are random orbit, uniform orbit, restricted orbit, and overlaid orbit

N. Load Balanced Local Shortest Path (LBLSP) Routing

Carlsson and Eager proposed a distributed routing algorithm which used both Local Shortest Path (LSP) and Weighted Distance Gain (WDG) to finalize the forwarding node. The two non-Euclidian distance metrics provided load balanced routing around obstacles and hotspots.

O. Geographic Landmark Routing (GLR)

The GLR algorithm, by Na and Kim, solved the blind detouring problem and the triangular routing problem in MANETs.[20] The blind detouring problem occurs when a packet arrives at a dead-end when the next node is blindly selected.

P. Implementation Framework for Trajectory Based Routing (TBR)

Yuksel et al. study various implementation issues of TBR in this work. A proposed method encodes trajectories into packets at the source node before sending them to the destination [21]. Bezier curves are utilized as possible path trajectories to efficiently forward the packets. These curves provide flexibility in the greedy forwarding of TBR with the possibility of multiple types of curves.

Q. Secure Position Aided Ad-Hoc Routing (SPAAR)

It uses position information in order to improve the efficiency and security of mobile Ad-Hoc networks. It was designed for protecting position information in managed hostile environment where security is a primary concern and uses geographical information to make forwarding decisions, resulting in a significant reduction in the number of routing messages. It uses asymmetric cryptography to protect against malicious nodes (unauthorized nodes that attempt to disrupt the network) and attempts to minimize the potential for damage of attacks from compromised nodes (authorized nodes those have been overtaken by an adversary).

R. Location Area Based Ad-Hoc Routing for GPS-Scarce Wide-Area Ad-Hoc Networks (LABAR)

LABAR is a combination of proactive and reactive protocols, since a virtual backbone structure is used to update location information between G nodes (in a proactive manner), while user packets are relayed using directional routing towards the direction zone of the destination [22].

VII. Advantages of Position Based Routing Protocols

Routing protocols that use node position information to assist with routing are known as position-based routing protocols. In such protocols, global routing decisions are made using local knowledge of neighboring nodes and position information about the destination node. Recent research has shown that position-based routing protocols are good alternatives for topology based

routing protocols in large and dense MANETs. Position-based routing protocols avoid the flooding of control traffic by using location information. One of the main advantages of position-based routing protocols is that they appear to scale well with increasing network size since they do not need to maintain or communicate large routing tables. Another advantage relates to the intelligent use of power. Ad-hoc networks of sensors are characterized by a battery limited power budget. Position information about neighboring nodes can be used to help modulate the transmitted power and extend the useful lifetime of a sensor network

VIII. Comparison of Various Routing Protocols

Here is the comparison of different routing protocols. Mobility (DREAM) DREAM is a multi-path, location-aware routing protocol. In DREAM, each node knows its geographical coordinates through a Global Positioning System (GPS). The coordinates are periodically exchanged between each node and stored in a routing table. The advantage of exchanging location information results in less bandwidth consumption resulting in good scalability of this protocol. Location Aided Routing (LAR) is an improvement to flooding algorithms to reduce overhead due to flooding. The aim of LAR is to send the route requests only to a particular area expected to include the destination thereby decreasing overhead. MFR has the shortcomings of either not guaranteeing to find a path to the destination or finding a path which is much longer than the shortest path. LABAR a novel ad hoc routing approach for large-scale ad hoc networks using a combination of virtual backbone and directional routing approaches. LABAR does not require all nodes in the ad hoc network to be precisely aware of their geographical location, i.e. to be equipped with GPS receivers, it is sufficient if only a subset of the nodes is enabled to determine their location. SPAAR is a routing protocol designed for a high-risk MANET environment. In particular, SPAAR satisfies the security requirements of the managed hostile environment by using protected position information to reduce routing overhead and increase the security of routing. AODPR protocol ensures the anonymity of both route and nodes and the robustness against the target-oriented attack and several others. This protocol is applicable to networks with any density of nodes.

Metric	Type	Rob- ustness	Scalabi- lity	Packet Overhead
MFR	Greedy (Progress)	Medium	High	Low
LAR	Restricted Directional Flooding	Low	Medium	Medium
DREAM	Restricted Directional Flooding	High	Medium	Medium
AODPR	Restricted Directional Flooding	Low	Medium	Medium
LABAR	Hierarchical	High	High	Low
SPAAR	Restricted Directional Flooding	Low	Medium	High

Fig. 3: Comparison of Different Routing Protocols

IX. Conclusion

This paper is a survey of new and improved position based routing methods in Mobile Ad-hoc Networks. Position based routing has several advantages over the earlier protocols and some disadvantages like the problem of designing location update schemes to provide accurate destination information. Although many protocols have been proposed, still there is a need for the development of an efficient routing protocol with greater throughput and performance. By the use of position based routing protocols the ad hoc networks can become more robust and efficient.

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Anuj Kumar Gupta is working as associate professor RIMT-IET, Mandi Gobindgarh. He is pursuing PhD (CSE) and having a teaching experience of more than ten years. He has attended a number of National as well as / International Conferences and editorial board members of the various reputed International journals. He is member of reviewer committee in renowned International journals & conferences.

His current area of research is mobile ad hoc networks.



Er. Simardeep kaur is a student of M.TECH CSE in RIMT-IET Mandigobindgarh. She is pursuing her thesis in Mobile Ad hoc networks.