Location Based routing protocols for wireless ad-hoc networks: A survey and comparison

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Abstract— Routing in Wireless Ad-hoc networks is a very exigent task. Conventional routing protocols are not appropriate for these networks due to inherent nature of such networks such as dynamic topology, no fixed infrastructure, resource constraints and lack of centralized control. One of the most promising routing schemes in ad-hoc networks is Geographic routing. In geographic routing, packets are routed based on location of destination. This paper surveys some of the existing geographic routing protocols highlighting their merits and demerits. Paper concludes by highlighting some areas of open research.

Keywords- Routing, Ad-hoc Networks, Geographic, Greedy Forwarding

I. INTRODUCTION

A mobile ad-hoc network is a mobile, multi-hop wireless network which is capable of autonomous operation. Ad hoc network is used to set up a short-lived network for a collection of nodes. Some of the challenges associated with ad-hoc network are no fixed infrastructure, dynamic topology, variable capacity wireless links, energy constrained nodes, no centralized control, scalability and bandwidth optimization [1]. Due to limited transmission range, these networks rely on multi-hopping i.e. packets are routed via several intermediate nodes to destination.

Most of the ad-hoc routing protocols are either reactive or proactive. In Proactive protocols, route is maintained between all the nodes in the network all the time. Reactive protocols create routes only when required. Topology based routing protocols waste valuable energy and communication resources and are not suitable for mobile ad-hoc networks. Geographic routing is an emerging field of research in ad-hoc networks. In geographic routing, source knows its own location, location of its neighbors and destination. The destination location is included in packet header. Geographical location of destination is used to guide the packets to destination [3].

Geographic routing is a Hop by Hop routing where decisions are made on each hop. Each node upon receiving the packet consults its neighbor table and selects the most promising neighbor as the next hop. This process repeats until packet reaches the destination [2]. As compared to conventional routing schemes, geographic routing need not maintain topology information. Thus, these routing schemes have low overhead. There is no need of flooding the packets in the network for route discovery and maintenance. Memory requirement of geographic routing is low. The end to end delays in geographic routing schemes is less because network reacts faster to changes and can easily adapt its path to make sure that packet reaches the destination. Geographic routing is suitable for all those applications that demand robust routing, high packet delivery ratio, low end to end delays, good network coverage and connectivity, long network lifetime and low processing and communication overhead.

The rest of paper is organized as follows: Section II discuss some of the geographic routing protocols. Section III discusses the problem of unrealistic assumptions in geographic routing protocols. Some of future research directions are presented in Section IV. Section V concludes the paper.

II. GEOGRAPHIC ROUTING PROTOCOLS

In this section, some of the popular geographic routing protocols are discussed. The simplest geographic routing schemes are Greedy routing and face routing. In *Greedy forwarding*, source send packet to a neighboring node which is geographically closer to destination than itself [4]. Hop count, residual energy, distance to destination, bandwidth or any combination of these can be the metric used to select next hop. This process repeats until packet reaches the destination or local maximum problem is encountered as shown in Figure 1. In local maximum problem, a packet reaches a node which has no neighbor that is closer to destination thus, packet is dropped. Such nodes are called stuck node or concave node. These concave nodes degrade the performance of geographic routing protocols. Although a path exist from source to destination but there is no node closer to destination in the transmission range of concave node. Several solutions have been proposed so far to counter this problem.

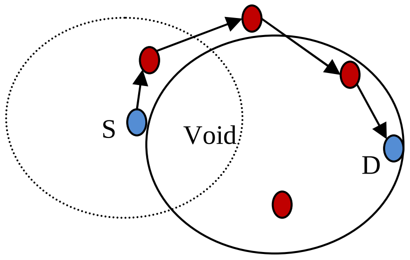

Figure 1: Greedy forwarding failure

Face routing [4] is an alternative to greedy forwarding. It is also called perimeter routing or compass routing. Planar sub- graph is constructed from non-planar graphs so as to make them suitable for face routing as shown in Figure 2. After obtaining planar sub-graph, face routing is applied by using right hand rule. It advances along the faces of planar graph and along the line joining source and destination [1]. Greedy forwarding is simple and efficient but it does not guarantee delivery. Face routing provides packet delivery assurance but is inefficient.

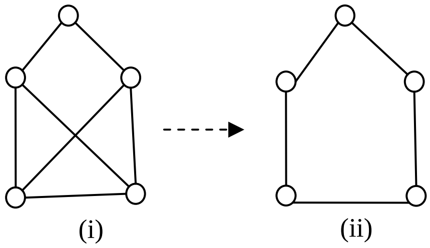

Figure 2: (i) Non-planar graph (ii) Corresponding planar graph

GDSTR (Greedy Distributed Spanning Tree Routing) [10]: In this routing scheme, spanning tree algorithm is used as a recovery procedure when packet gets stuck at local maxima. Information about all the child nodes is stored by parent in the form of spanning tree. If the destination is not present in any of the sub-tree of current node then packet is retransmitted to parent node. On the other hand, if destination is located in one of its sub-tree then packet is send to that child node. The whole idea is to cut down the number of trees that are to be traversed.

EAGPR (Energy Aware Geographic routing protocol) [9]: It is a greedy forwarding based geographic routing algorithm for multi-hop WSNs. Each node should have information about location and energy level of nodes within its transmitting range and destination location. Packet is forwarded to a node which is nearest to destination and whose maximum energy is above the set threshold. In this way, network lifetime is also increased.

BVGF (Bounded Voronoi Greedy forwarding) [13]: It is a geographic routing algorithm based on the concept of Voronoi diagrams. Network is modeled as a Voronoi diagram as shown in figure. The eligible candidates for next hop are the nodes whose Voronoi regions lie on the line joining the source and the destination. A packet is forwarded to a next hop candidate that is nearest to destination. The problem is that path between a particular source and destination will have same sequence of next hops, thus depleting their energy quickly than rest of the network. Protocol is prone to hot spot problem.

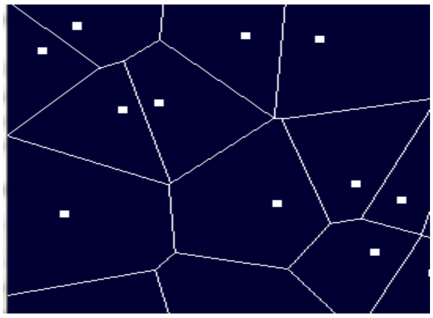

Figure 3: Voronoi Diagram

GEAR (Geographic and Energy Aware Routing) [7]: It is a localized energy efficient routing protocol for Ad hoc networks. Some localization hardware such as GPS [15] is used by nodes to know their positions. Nodes are also aware of the residual energy of their neighbors. There are two phases for forwarding the packets. In the first phase, packet is forwarded towards target region where estimated and learned cost values for each destination are maintained. In second phase, Recursive greedy forwarding is used to distribute packet within target region where packet is send to smaller sub-regions recursively as shown in Figure 3. Flooding can be used for sparse networks. The algorithm is not completely free from loops.

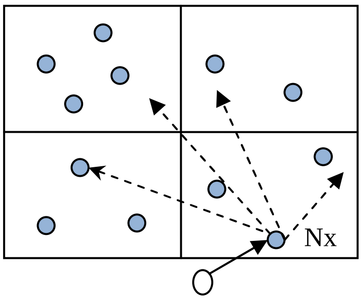

Figure 4: Recursive Greedy Forwarding

RGRP (Reactive Geographic Routing protocol) [8]: This algorithm coalesces reactive and geographic routing so as to provide an efficient and scalable routing scheme. Instead of using beacon messages it uses RREQ and RREP packets which perform some additional functions. These packets are broadcasted by source and destination to all the one hop neighbors. All the intermediate nodes only need to forward the packets thus; communication overhead of algorithm is low. Every time a node receives these packets, it forwards only those packets that arrive on shortest path and discard all others. As the algorithm is reactive there is no need to maintain neighbor tables for long time.

GAF (Geographic Adaptive Fidelity) [11]: The target region is divided into grid squares and every node associates itself with a particular grid on the basis of its locations. The basic concept is to turn off the redundant nodes while maintain basic network connectivity between all the nodes in the network. A node can be in three states namely, active, sleeping and discovery as shown in Figure 5. When a node is in sleep state then it turns its radio off so as to save energy. In discovery state, nodes transmit messages to know about other nodes in same grid. I active state, node broadcast messages containing its state information to other nodes in the same grid. At a particular time there should be only one node active in a grid. One of the attractive features of this algorithm is that if node density is high and grid size is small then it achieves remarkable improvement in network lifetime.

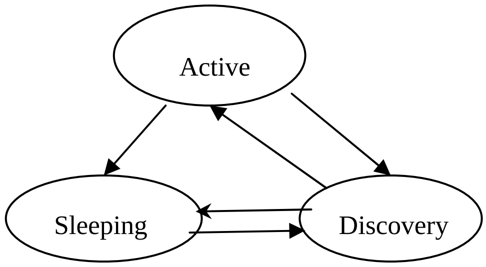

Figure 5: State Transition Diagram

The advantages of greedy and face routing can be combined to create hybrid greedy-face routing algorithms [13]. These protocols start in greedy mode but later on shift to perimeter routing when a concave node is encountered. The node at which the routing is switched must be decided judiciously. If it is switched too soon then another concave node may be encountered and shifting too late will make routing inefficient.

GPSR (Greedy Perimeter Stateless Routing) [5], is one of the earliest hybrid greedy face routing. . GPSR uses a beaconing algorithm to get location of neighbors. Each node broadcast a beacon periodically containing its own identifier and location. If a node doesn't receive a beacon from a neighbor in specified time interval, then that node is removed from its neighbor table. It uses face routing as a recovery procedure when packet get stuck at local maxima. Greedy forwarding again comes into action when the distance between the current node and destination is less than the node at which routing was switched to perimeter mode.

GOAFR (Greedy Other Adaptive Face Routing) [4] uses greedy forwarding until local maximum is reached; thereafter it uses OAFR routing so as to recover from concave node. Once switched to OAFR, it will run until packet reaches the destination, the first face is probed or disconnection is reached [3]. GOAFR+ is an enhanced version of GOAFR. Instead of traversing the full face boundary GOAFR+ maintain two counters right from the node where face routing was initiated and they contain the number of nodes traversed that are closer to destination and the number of nodes traversed that are away from the destination. The decision to switch to greedy mode is made when the number of nodes traversed that are away from destination is more than those nearer to destination. In this case algorithm revisits the previously traversed node that was nearest to destination and enters into greedy mode from that point. Algorithm is localized and scalable and guarantees delivery of packets.

III. PROBLEM OF UNREALISTIC ASSUMPTIONS

The success of geographic routing depends on how precise location information a node possess. Equipping each and every node in the network with GPS is not a solution. As GPS enabled nodes will not only increase the cost of network but also the power consumed by them will be also increase which will ultimately affect network lifetime. Moreover, GPS does not work indoors [15]. There are few GPS free localization schemes and research in this field is still growing. Due to Location inaccuracy, wrong neighbor may be selected as the next hop, may lead to false local maximum situations, packets may be dropped or packet may enter in routing loop.

Another unrealistic assumption is nodes fixed radio range described by UDG (unit disk graphs) [12]. Factors such as node heterogeneity, interference, presence of obstacles is not taken into account and thus, protocols relying on UDG often fail in practice [16].

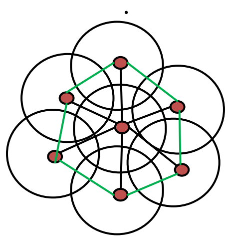

Figure 6: Unit Disk Graph Model

IV. OPEN ISSUES

As discussed in section III, dependency on UDG model is a serious problem in geographic routing schemes. Alternative models should be developed so that protocols can work efficiently in real world scenarios. The planarization techniques in face routing can work only for 2D environments. There is a need to design geographic protocols that can fulfill the demands of 3D networks. . Protocols can be designed in such a way that it can detect the dimensions and can work accordingly. Routing algorithms should consider the impact of localization errors while making routing decisions. One more problem in case of mobile networks is to decide when beaconing update messages should be sent. If updates messages are sent at fixed intervals then the probability that they contain stale information is high. This outdated information will have adverse impact on routing performance. Thus, there are few geographic routing protocols that can adapt themselves to node mobility without compromising the basic advantages offered by geographic routing.

V. CONCLUSION

In this paper, forwarding of packets in geographic routing schemes is further categorized into three schemes i.e. greedy forwarding, face routing and hybrid routing. Simplicity and efficiency are the alluring features of greedy forwarding but it does not guarantee packet delivery. On the other hand, face routing assures packet delivery but is inefficient. One more problem associated with face routing is the implicit assumption that a transmission radius of all nodes is equal. Hybrid routing protocols combine best of greedy and face routing at the expense of increasing the switching overhead. Table 1 highlights advantages and limitations of the protocols discussed in this paper.

Table 1: Comparison of various routing protocols

Routing Scheme	**Advantages**	**Limitations**
Greedy Forwarding	Simple, Efficient	No guaranteed delivery
Face Routing	Guaranteed delivery	Inefficient
GPSR	Suitable for dense mobile environments	High packet overhead
GEAR	Low processing overhead	Not free from loops
GOAFR	Scalable, guaranteed delivery	Switching overhead
EAGPR	Scalable, Low processing and packet overhead	Diffusion hole problem
GDSTR	Freedom from planarization algorithm	Not suitable for mobile networks
RGRP	Scalable, Low communication overhead	No guaranteed delivery
GAF	Low processing overhead	No guaranteed delivery
BVGF	Simple, Easy to understand	Overhead in determining voronoi partitions

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