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Geographic Routing in Manet-A Journey

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Abstract: *Emerging ubiquitous computing needs "anytime and anywhere" network connections. Mobile ad hoc networks are well suited for this application area because they are self-organizing networks without depending on any network infrastructure.We presents an overview of ad hoc routing protocols that make forwarding decisions based on the geographic positions of a packets destination. Other than the destinations position, each node need know only its own position and the position of its one hop neighbors in order to forward packets .So it is not necessary to maintain explicit routes, position-based routing does scale well even if the network is highly dynamic .This is major advantage in a mobile ad hoc network where the topology may change frequently .The main imperative for position based routing is that sender may obtain the current position of the destination. As a consequence, recently proposed location services are discussed in addition to position based packet forwarding strategies. We provide a qualitative comparison of the approaches in both areas and investigate opportunities for future work.*

Keywords: *Wireless Communication, Geographic Routing, Algorithm, Protocol Design, MANET.*

INTRODUCTION

Geographic routing (also known as geo routing or position based routing) is a routing principle that relies on geographic position information. It is mainly proposed for wireless networks and based on the idea that the source sends a message to the geographic location of the destination instead of using the network address. The idea of using position information for routing was first proposed in the 1980s in the area of packet radio networks [1] and interconnection networks.[2] Geographic routing requires that each node can determine its own location and that the source is aware of the location of the destination. With this information a message can be routed to the destination without knowledge of the network topology or a prior route discovery.

With the growing popularity of positioning devices (e.g., GPS) and other localization schemes, geographic routing protocols are becoming an attractive choice for use in mobile ad hoc networks. The underlying principle used in these protocols involves selecting the next routing hop from among a node's neighbors, which is geographically closest to the destination. Since the forwarding decision is based entirely on local knowledge, it obviates the need to create and maintain routes for each destination. By virtue of these characteristics, position-based routing protocols are highly scalable and particularly robust to frequent changes in the network topology.

Geographic Routing in Wireless ADHOC Networks

Geographic routing has become an efficient solution for communications and information delivery in wireless ad hoc networks where the position information of nodes is available. This chapter provides a comprehensive overview of basic principles, classical techniques, as well as latest advances in geographic routing. The chapter first presents in detail the topic of geographic unicast routing, where the presentation is focused on two operation modes of geographic forwarding, that is, greedy forwarding and void handling. The chapter

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also briefly introduces three advanced topics in geographic routing: geographic multicast, geocast, and trajectory-based forwarding.

Geographic Routing for Mobile ADHOC Networks

The emergence of the Mobile Ad Hoc Networking (MANET) technology advocates self-organized wireless interconnection of communication devices that would either extend or operate in concert with the wired networking infrastructure or, possibly, evolve to autonomous networks. In either case, the proliferation of MANET-based applications depend on a multitude of factors, with trustworthiness being one of the primary challenges to be met. Despite the existence of well-known security mechanisms, additional vulnerabilities and features pertinent to this new networking paradigm might render such traditional solutions inapplicable. In particular, the absence of a central authorization facility in an open and distributed communication environment is a major challenge, especially due to the need for cooperative network operation. In particular, in MANET, any node may compromise the routing protocol functionality by disrupting the route discovery process. In this paper, we present a route discovery protocol that mitigates the detrimental effects of such malicious behavior, as to provide correct connectivity information. Our protocol guarantees that fabricated, compromised, or replayed route replies would either be rejected or never reach back the querying node. Furthermore, the protocol responsiveness is safeguarded under different types of attacks that exploit the routing protocol itself. The sole requirement of the proposed scheme is the existence of a security association between the node initiating the query and the sought destination. Specifically, no assumption is made regarding the intermediate nodes, which may exhibit arbitrary and malicious behavior. The scheme is robust in the presence of a number of non-colluding nodes, and provides accurate routing information in a timely manner.

Geographic Routing Challenges and Design Issues in WSNs

Despite the innumerable applications of WSNs, these networks have several restrictions, such as limited energy supply, limited computing power, and limited bandwidth of the wireless links connecting sensor nodes. One of the main design goals of WSNs is to carry out data communication while trying to prolong the lifetime of the network and prevent connectivity degradation by employing aggressive energy management techniques.

Node Deployment

Node deployment in WSNs is application-dependent and can be either manual (deterministic) or randomized. In manual deployment, the sensors are manually placed and data is routed through predetermined paths.

Energy Consumption without Losing Accuracy

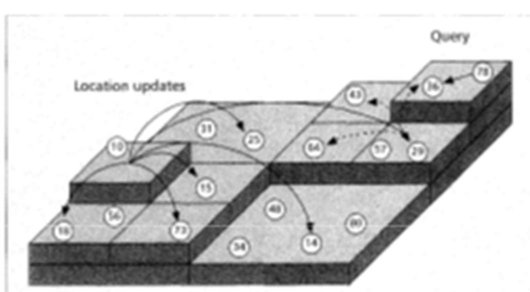
Sensor nodes can use up their limited supply of energy performing computations and transmitting information in a wireless environment. As such, energy-conserving forms of communication and computation are essential.

Data Reporting Method

Data reporting in WSNs is application-dependent and also depends on the time criticality of the data. Data reporting can be categorized as either time-driven, event driven, query-driven, or a hybrid of all these methods.

Various Techniques used in Geographic Routing

1. GLS and Geographic Forwarding



GLS is a new distributed location service which tracks mobile node locations. GLS combined with geographic forwarding allows the construction of adhoc mobile networks that scale to a larger number of nodes. GLS is a decentralized and runs on the mobile nodes

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themselves, requiring no fixed infrastructure. geographic forwarding that is similar to Cartesian routing [7]. Each node determines its own geographic position using a mechanism such as GPS [1]; positions consist of latitude and longitude. A node announces its presence, position, and velocity to its neighbors (other nodes within radio range) by broadcasting periodic HELLO packets.

In many ways the two facets of our system geographic forwarding and the GLS, operate in fundamentally similar ways. Geographic forwarding moves packets along paths that bring them closer to the destination in physical space, only reasoning about nodes with nearby locations at each step along the path.

The GLS protocol makes little effort to proactively correct out-of-date information when, for instance, a node crosses a grid boundary line. Proactive updates may reduce the incidence of query failures. However, the tradeoff is obvious-care must be taken not to consume too much bandwidth with the updates. An alternate strategy to address the same problem is to place less trust in locations obtained from distant location servers. Rather than trust a distant location server to pinpoint the order-1 square in which a node is located, a query could be moved to, for instance, the surrounding order-3 square. There the query can be restarted with the fresher information available in that square.

2. Normalized Advance Routing for Geographic Routing in Multihop Wireless Networks

We now introduce a new metric called normalized advance (NADV). Suppose we can identify the link cost Cost (n) of the link to neighbor n. Then the normalized advance of neighbor n is simply:

NADV (n) = ADV (n) / Cost (n)

Intuitively, NADV denotes the amount of advance achieved per unit cost. For example, suppose we know that only P succ (n) fraction of data transmissions to neighbor are successful. If we use 1/ P succ (n) as link cost, , which means the expected advance per transmission.

We now show the path optimality when using NADV. The goal of routing in this discussion is to minimize the sum of link costs along the found path. We make two assumptions: (1) we can _nd a node at an arbitrary point, and (2) link cost is an increasing convex function of distance (e.g., power consumption [12], [17]).

Geographic routing with NADV provides an adaptive routing strategy, which is general and can be used for various link cost types. We have presented techniques for link cost estimation. In the simulation experiments, the combination of NADV and cost estimation techniques outperforms the current geographic routing scheme. NADV also ends paths whose cost is close to the optimum.

However, if we consider multiple interdependent costs simultaneously, choosing the next hop based on one cost type may not be always the best choice for other costs.

3. Geographical Energy Aware Routing Algorithm

The Geographical and Energy Aware Routing (GEAR) algorithm, in routing queries to regions in proposed sensor-net applications. The process of forwarding a packet to all the nodes in the target region consists of two phases:

1. Forwarding the packets towards the target region:
   - 1.1. GEAR uses a geographical and energy aware neighbor selection heuristic to route the packet towards the target region. There are two cases to consider:
     - 1.1.1. When a closer neighbor to the destination exists: GEAR picks a next-hop node among all neighbors that are closer to the destination.
     - 1.1.2. When all neighbors are further away: In this case, there is a hole. GEAR picks a next-hop node that minimizes some cost value of this neighbor.
2. Disseminating the packet within the region:

Under most conditions, we use a Recursive Geographic Forwarding algorithm to disseminate the packet within the region. However, under some low density conditions, recursive geographic forwarding sometimes does not terminate, routing uselessly around an empty target region before the packet's hop-count exceeds some bound. In these cases, we propose to use restricted flooding.

Before we describe the above algorithms in detail, we state the assumptions of this work:

1. Each query packet has a target region specified in some way (for the description of the algorithm, we assume a rectangular region specification).

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2. Each node knows its own location and remaining energy level, and its neighbors' locations and remaining energy levels through a simple neighbor hello protocol.

   Note that a node can obtain its location information at low cost from GPS or some localization system [22, 18, 2, 7, 19], which presumably is already available due to the needs of sensor net applications.

3. The link is bi-directional, i.e., if a node hears from a neighbor Ni, then its transmission range can reach Ni. This is not an unreasonable choice as most MAC layer protocols, such as IEEE 802.11, assume symmetric links.

The proposed Geographic and Energy Aware Routing (GEAR) protocol uses energy aware and geographically informed neighbor selection to route a packet towards the target region. This strategy attempts to balance energy consumption and thereby increase network lifetime. Within a region, it uses a recursive geographic forwarding technique to disseminate the packet. The simulation results show that for an uneven traffic distributions, GEAR delivers 70% to 80% more packets than GPSR.

4. Cross-Link Detection Protocol

The Cross-Link Detection Protocol (CLDP), a planarization technique that cannot cause face routing to fail on any connected graph. As such, CLDP is also robust to arbitrary localization errors; we omit a detailed discussion herein for lack of space.

As a practical matter, other forwarding strategies also work perfectly on the CLDP-derived routable subgraphs, such as GPSR's combination of greedy- and perimeter-mode traversals , and GOAFR's improvement that uses ellipses to bound face traversals when possible [17]. Note further that greedy forwarding uses the full graph (including links marked ``non-routable'' by CLDP); only face routing uses the CLDP-derived routable subgraph during recovery from local maxima.CLDP is the first distributed planarization protocol that renders geographic routing correct on arbitrary graphs. Simulations and measurements on real testbeds indicate that CLDP is quite practical: it offers high delivery rates, low overhead, and fast convergence. In future, we plan to investigate CLDP's overhead and robustness on more dynamic topologies, as well as the effect of localization errors on CLDP's path stretch in deployment.

5. Adaptive Position Update

Adaptive Position Update (APU) strategy for geographic routing, which dynamically adjusts the frequency of position updates based on the mobility dynamics of the nodes and the forwarding patterns in the network. APU is based on two simple principles: 1) nodes whose movements are harder to predict update their positions more frequently (and vice versa), and (ii) nodes closer to forwarding paths update their positions more frequently (vice versa).

We begin by listing the assumptions.

1. All nodes are aware of their own position and velocity,
2. All links are bidirectional,
3. The beacon updates include the current location and velocity of the nodes, and
4. Data packets can piggyback position and velocity updates and all one-hop neighbors operate in the promiscuous mode and hence can overhear the data packets. APU employs two mutually exclusive beacon triggering rules, which are discussed in the following.

1. Mobility Prediction Rule

This rule adapts the beacon generation rate to the frequency with which the nodes change the characteristics that govern their motion (velocity and heading). The motion characteristics are included in the beacons broadcast to a node's neighbors.

2. On Demand Learning Rule

A node broadcasts beacons on-demand, i.e., in response to data forwarding activities that occur in the vicinity of that node. According to this rule, whenever a node overhears a data transmission from a new neighbor, it broadcasts a beacon as a response. We analyze the performance of the proposed beaconing strategy, APU. We focus on two key performance measures: 1) update cost and 2) local topology accuracy. The former is measured as the total number of beacon broadcast packets transmitted in the network. The latter is collectively measured by the following two metrics:

1. Unknown neighbor ratio-This is defined as the ratio of the new neighbors a node is not aware of, but that are within the radio range of the node to the total number of neighbors.
2. False neighbor ratio-This is defined as the ratio of obsolete neighbors that are in the neighbor list of a node, but have already moved out of the node's radio range to the total number of neighbors.

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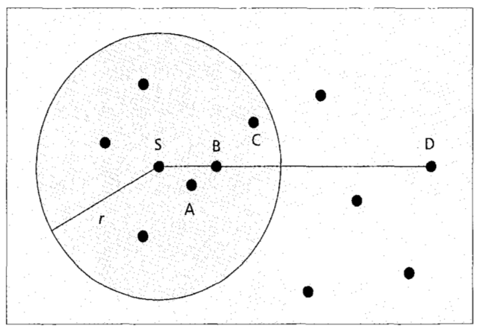
Our results indicate that the APU strategy generates less or similar amount of beacon overhead as other beaconing schemes but achieve better packet delivery ratio, average end-to-end delay and energy consumption. Future work includes utilizing the analytical model to find the optimal protocol parameters (e.g., the optimal radio range), studying how the proposed scheme can be used to achieve load balance and evaluating the performance of the proposed scheme on TCP connections in Mobile Ad hoc Networks.

6. Greedy Perimeter Stateless Routing

Greedy Perimeter Stateless Routing (GPSR), a novel routing protocol for wireless datagram networks that uses the positions of routers and a packet's destination to make packet forwarding decisions. GPSR makes greedy forwarding decisions using only information about a router's immediate neighbors in the network topology. When a packet reaches a region where greedy forwarding is impossible, the algorithm recovers by routing around the perimeter of the region. By keeping state only about the local topology, GPSR scales better in per-router state than shortest-path and ad-hoc routing protocols as the number of network destinations increases. Under mobility's frequent topology changes, GPSR can use local topology information to find correct new routes quickly.

Greedy Forwarding

GPSR, packets are marked by their originator with their destinations' locations. A forwarding node can make a locally optimal, greedy choice in choosing a packet's next hop. Specifically, if a node knows its radio neighbors' positions, the locally optimal choice of next hop is the neighbor geographically closest to the packet's destination. Forwarding in this regime follows successively closer geographic hops, until the destination is reached.

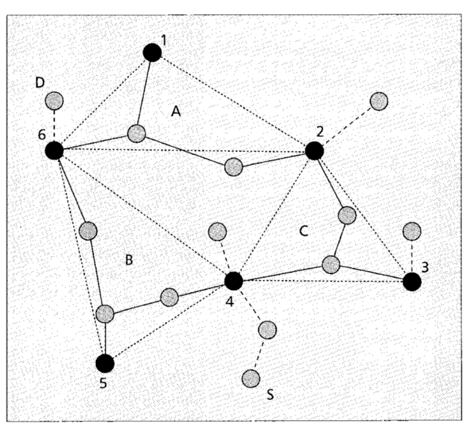


Perimeter Forwarding

This rule states that when arriving at node x from node y, the next edge traversed is the next one sequentially counterclockwise about x from edge (x;y). It is known that the right-hand rule traverses the interior of a closed polygonal region (a face) in clockwise edge order—in this case, the triangle bounded by the edges between nodes x, y, and z, in the order (y!x!z!y). The rule traverses an exterior region, in this case, the region outside the same triangle, in counterclockwise edge order.In future we hope to extend GPSR for hosts placed in three-dimensional space, beyond the flat topologies explored in this paper. A promising approach is to implement perimeter forwarding for 3-D volumes rather than 2-D faces.

7. Quorum –Based Location Services

The Concept of Quorum systems is well known information replication in databases and distributed systems. Information updates (write operations) are sent to subset (quorum) of available nodes and information requests are reffered to a potential different subset. When these subsets are designed such that their intersection is nonempty.



A Quorum

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Conclusion

In this paper we discussed Geographic routing and the various techniques, approaches involved in the system. The various techniques and approaches describe the periodic broadcasting of packets, sending the messages to the receiver present in the various geographic locations. Previous approaches by different authors have been discussed briefly.

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