Performance Estimation of Packet Delivery Ratio And Average End - To - Delay Using Geographic Routing Algorithms In MANETs

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Abstract— **In geographic routing, nodes need to maintain up to date positions of their immediate neighbors for making effective forwarding decisions. Episodic broadcasting of beacon packets that contain the geographic location coordinates to maintain neighbor positions. In periodic beaconing the node mobility and traffic patterns in the network is not attractive from both update cost and routing performance points of view. I propose 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: (i) 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 (and vice versa).I use well known geographic routing protocol, Greedy Perimeter Stateless Routing Protocol (GPSR), shows that APU can significantly reduce the update cost and improve the routing performance in terms of packet delivery ratio and average end-to-end delay.**

Index Terms— **Adaptive Position Update, Stateless Routing Protocol, Greedy Perimeter.**

I. INTRODUCTION

With the growing popularity of positioning devices (e.g. GPS) and other localization schemes [1], geographic routing protocols are becoming an attractive choice for use in mobile ad hoc networks [2], [3], [4]. The underlying principle used in these protocols involves selecting the next routing hop from amongst 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. Furthermore, since the forwarding decision is made on the fly, each node always selects the optimal next hop based on the most current topology.

Several studies [2], [5] have shown that these routing protocols offer significant performance improvements over topology-based routing protocols such as DSR [6] and AODV [7]. The forwarding strategy employed in the aforementioned geographic routing protocols requires the following information: (i) the position of the final destination of the packet and (ii) the position of a node's neighbors. The former can be obtained by querying a location service such as the Grid Location System (GLS) [8] or Quorum [9]. To obtain the latter, each node exchanges its own location information (obtained using GPS or the localization schemes discussed in [1]) with its adjacent nodes. This allows each node to build a local map of the nodes within its vicinity, often referred to as the local topology. However, in situations where nodes are mobile or when nodes often switch off and on, the local topology rarely remains static. Hence, it is necessary that each node broadcasts its updated location information to all of its neighbors. These location update packets are usually referred to as *beacons*. In most geographic routing protocols (e.g. GPSR [2], [10], [11]), beacons are broadcast periodically for maintaining an accurate neighbor list at each node. Position updates are costly in many ways. Each update consumes node energy, wireless bandwidth, and increases the risk of packet collision at the medium access control (MAC) layer. Packet collisions cause packet loss which in turn affects the routing performance due to decreased accuracy in determining the correct local topology (a lost beacon broadcast is not retransmitted). A lost data packet does get retransmitted, but at the expense of increased end-to-end delay. Clearly, given the cost associated with transmitting beacons, it makes sense to adapt the frequency of beacon updates to the node mobility and the traffic conditions within the network, rather than employing a static periodic update policy. For example, if certain nodes are frequently changing their mobility characteristics (speed and/or heading), it makes sense to frequently broadcast their updated position. However, for nodes that do not exhibit significant dynamism, periodic broadcasting of beacons is wasteful. Further, if only a small percentage of the nodes are involved in forwarding packets, it is unnecessary for nodes which are located far away from the forwarding path to employ periodic beaconing because these updates are not useful for forwarding the current traffic. In this paper, I propose a novel beaconing strategy for geographic routing protocols called Adaptive Position Updates strategy (APU) [12].

II. RELATED WORK

J. Hightower and G. Borriello. "Location Systems for Ubiquitous Computing", in IEEE Computer, vol. 34, no. 8, pp. 57-66, August 2001, To serve us well, emerging mobile computing applications will need to know the physical location of things so that they can record them and report them to us: What lab bench was I standing by when I prepared these tissue samples? How should our search-and-rescue team move to quickly locate all the avalanche victims? Can I automatically display this stock evaluation chart on the large screen I am standing next to? Researchers are working to meet these and similar needs by developing systems and technologies that automatically locate people, equipment, and other tangibles. Indeed, many systems over the years have

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addressed the problem of automatic location sensing. Because each approach solves a slightly different problem or supports different applications, they vary in many parameters, such as the physical phenomena used for location determination, the form factor of the sensing apparatus, power requirements, infrastructure versus portable elements, and resolution in time and space. To make sense of this domain, I have developed taxonomy to help developers of location-aware applications better evaluate their options when choosing a location-sensing system. The taxonomy may also aid researchers in identifying opportunities for new location-sensing techniques.

B. Karp and H. T. Kung. "GPSR: Greedy Perimeter Stateless Routing for Wireless Networks", in Proceedings of ACM Mobicom 2000, pp. 243- 254, Boston, MA, USA, August 2000, It has been a big challenge to develop routing protocol that can meet different application needs and optimize routing paths according to the topology change in mobile ad hoc networks. Basing their forwarding decisions only on the local topology, geographic routing protocols have drawn a lot of attentions in recent years. However, inaccurate local topology knowledge and the outdated destination position information can lead to inefficient geographic forwarding and even routing failure. Proactive local position distribution can hardly adapt to the traffic demand. It is also difficult to pre-set protocol parameters correctly to fit in different environments. I have developed two self-adaptive on-demand geographic routing schemes. The local topology is updated in a timely manner according to network dynamics and traffic demands. Our route optimization scheme adapts the routing path according to both topology changes and actual data traffic requirements. Each node can determine and adjust the protocol parameter values independently according to different network environments, data traffic conditions and node's own requirements. Our simulation studies have shown that the proposed routing protocols are more robust and outperform the existing geographic routing protocol. Specifically, the packet delivery latency is reduced almost four times as compared to GPSR at high mobility

L. Blazevic, S. Giordano, J-Y. LeBoudec. "A Location Based Routing Method for Mobile Ad Hoc Networks", in IEEE Transaction on Mobile Computing, Vol. 3 No. 4, December 2004, A mobile ad hoc network consists of wireless hosts that may move often. Movement of hosts results in a change in routes, requiring some mechanism for determining new routes. Several routing protocols have already been proposed for ad hoc networks. This paper suggests an approach to utilize location information (for instance, obtained using the global positioning system) to improve performance of routing protocols for ad hoc networks. By using location information, the proposed Location-Aided Routing (LAR) protocols limit the search for a new route to a smaller "request zone" of the ad hoc network. This results in a significant reduction in the number of routing messages. I present two algorithms to determine the request zone, and also suggest potential optimizations to our algorithms.

T. Camp, J. Boleng, B. Williams, L. Wilcox and W. Navidi. "Performance Comparison of Two Locations Based Routing Protocols for Ad Hoc Networks". In Proceedings of IEEE Infocom, pp. 1678- 1687, NY, USAL, June 2002, In recent years, many location based routing protocols have been developed for ad hoc networks. This paper presents the results of a detailed performance evaluation on two of these protocols: Location-Aided Routing (LAR) and Distance Routing Effect Algorithm for Mobility (DREAM). I compare the performance of these two protocols with the Dynamic Source Routing (DSR) protocol and a minimum standard (i.e., a protocol that floods all data packets). I used NS-2 to simulate 50 nodes moving according to the random waypoint model. Our main goal for the performance investigation was to stress the protocols evaluated with high data load during both low and high speeds. Our performance investigation produced the following conclusions. First, the added protocol complexity of DREAM does not appear to provide benefits over a flooding protocol. Second, promiscuous mode operation improves the performance of DSR significantly. Third, adding location information to DSR (i.e., similar to LAR) increases both the network load and the data packet delivery ratio; our results conclude that the increase in performance is worth the increase in cost. Lastly, our implementation of DREAM provides a simple location service that could be used with other ad hoc network routing protocols.

D. Johnson, Y. Hu and D. Maltz, "The Dynamic Source Routing Protocol (DSR) for Mobile Ad Hoc Networks for IPv4", RFC4728, February 2007, The Dynamic Source Routing protocol (DSR) is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. DSR allows the network to be completely self-organizing and self-configuring, without the need for any existing network infrastructure or administration. The protocol is composed of the two mechanisms of Route Discovery and Route Maintenance, which work together to allow nodes to discover and maintain source routes to arbitrary destinations in the ad hoc network. The use of source routing allows packet routing to be trivially loop-free, avoids the need for up-to-date routing information in the intermediate nodes through which packets are forwarded, and allows nodes forwarding or overhearing packets to cache the routing information in them for their own future use. All aspects of the protocol operate entirely on-demand, allowing the routing packet overhead of DSR to scale automatically to only that needed to react to changes in the routes currently in use. Ihave evaluated the operation of DSR through detailed simulation on a variety of movement and communication patterns, and through implementation and significant experimentation in a physical outdoor ad hoc networking test bed I have constructed in Pittsburgh, and have demonstrated the excellent performance of the protocol. In this chapter, I describe the design of DSR and provide a summary of some of our simulation and test bed implementation results for the protocol.

III. METHODOLOGY AND IMPLEMENTATION

I propose a novel beaconing strategy for geographic routing protocols called Adaptive Position Update strategy (APU) [12]. Our scheme eliminates the drawbacks of periodic beaconing by adapting to the system variations. APU incorporates two rules for triggering the beacon update process. The first rule, referred as Mobility Prediction (MP), uses a simple mobility prediction scheme to estimate when the location information broadcast in the previous beacon becomes inaccurate. The next beacon is broadcast only if the predicted error in the location estimate is greater than a certain threshold, thus tuning the update frequency to the dynamism inherent in the node's motion. The second rule, referred as On-Demand Learning (ODL), aims at improving the accuracy of the topology along the routing paths between the communicating nodes. ODL uses an on-demand learning strategy, whereby a node broadcasts beacons when it overhears the transmission of a data packet from a new neighbor in its vicinity. This ensures that nodes involved in forwarding data packets maintain a more up-to-date view of the local topology. On the contrary, nodes that are not in the vicinity of the forwarding path are unaffected by this rule and do not broadcast beacons very frequently. I model APU to quantify the beacon overhead and the local topology accuracy. The local topology accuracy is measured by two metrics, unknown neighbor ratio and false neighbor ratio. The former measures the percentage of new neighbors a forwarding node is unaware of but that are actually within the radio range of the forwarding node. On the contrary, the latter represents the percentage of obsolete neighbors that are in the neighbor list of a node, but have already moved out of the node's radio range.

A. Greedy Algorithm

A greedy algorithm is a mathematical process that recursively constructs a set of objects from the smallest possible constituent parts. Recursion is an approach to problem solving in which the solution to a particular problem depends on solutions to smaller instances of the same problem.

Greedy algorithms look for simple, easy-to-implement solutions to complex, multi-step problems by deciding which next step will provide the most obvious benefit. Such algorithms are called greedy because while the optimal solution to each smaller instance will provide an immediate output, the algorithm doesn't consider the larger problem as a whole. Once a decision has been made, it is never reconsidered.

The advantage to using a greedy algorithm is that solutions to smaller instances of the problem can be straightforward and easy to understand. The disadvantage is that it is entirely possible that the most optimal short-term solutions may lead to the worst long-term outcome.

Greedy algorithms are often used in ad hoc mobile networking to efficiently route packets with the fewest number of hops and the shortest delay possible. They are also used in machine learning, business intelligence (BI), artificial intelligence (AI) and programming.

B. Greedy Perimeter Stateless Routing Protocol

In wireless networks comprised of numerous mobile stations, the routing problem of finding paths from a traffic source to a traffic destination through a series of intermediate forwarding nodes is particularly challenging. When nodes move, the topology of the network can change rapidly. Such networks require a responsive routing algorithm that finds valid routes quickly as the topology changes and old routes break. Yet the limited capacity of the network channel demands efficient routing algorithms and protocols that do not drive the network into a congested state as they learn new routes. The tension between these two goals, responsiveness and bandwidth efficiency, is the essence of the mobile routing problem.

Greedy Perimeter Stateless Routing, GPSR, is a responsive and efficient routing protocol for mobile, wireless networks. Unlike established routing algorithms before it, which use graph-theoretic notions of shortest paths and transitive reach ability to find routes, GPSR exploits the correspondence between geographic position and connectivity in a wireless network, by using the positions of nodes to make packet forwarding decisions. GPSR uses greedy forwarding to forward packets to nodes that are always progressively closer to the destination. In regions of the network where such a greedy path does not exist (i.e., the only path requires that one move temporarily farther away from the destination), GPSR recovers by forwarding in perimeter mode, in which a packet traverses successively closer faces of a planar sub graph of the full radio network connectivity graph, until reaching a node closer to the destination, where greedy forwarding resumes.
GPSR will allow the building of networks that cannot scale using prior routing algorithms for wired and wireless networks. Such classes of networks include:

- Sensor networks: potentially mobile, potentially great density, vast numbers of nodes, impoverished per-node resources Rooftop networks: fixed, dense deployment of vast numbers of nodes
- Vehicular networks: mobile, non-power-constrained, widely varying density
- Ad-hoc networks: mobile, varying density, no fixed infrastructure

Extending GPSR:

Obstacles and localization errors**:** I have investigated GPSR's behavior in the presence of obstacles to radio propagation and node localization errors, which introduce the risk that the planar sub graph used by GPSR's perimeter mode may not be connected. I initially investigated the "mutual witness" proposal, a heuristic for preserving the connectivity of the planar sub graph, mentioned in the thesis and DIMACS talk below. More recently (2004), we've developed the Crossing Link Detection Protocol (CLDP), which allows provably correct geographic routing on any connected network, i.e., even on networks where obstacles, irregularly shaped radio ranges, and localization errors occur. CLDP is described in the NSDI 2005 paper below.

Geographic provisioning**:** I use geographic forwarding via a waypoint not on the path found by naive GPSR to distribute load on the network. This approach is promising because on a wireless network, position and capacity are correlated; distributing load geographically leverages spatial reuse, and cuts the average load in regions where traffic is concentrated.

C. Adaptive Position Update (APU)

I begin by listing the assumptions made in our work: (1) all nodes are aware of their own position and velocity, (2) all links are bi-directional, (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 adapts the beacon update intervals to the mobility dynamics of the nodes and the amount of data being forwarded in the neighborhood of the nodes.

D. Mobility prediction

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. The neighbors can then track the node's motion using simple linear motion Equations. Nodes that frequently change their motion need to frequently update their neighbors, since their locations are changing dynamically. On the contrary, nodes which move slowly do not need to send frequent updates.

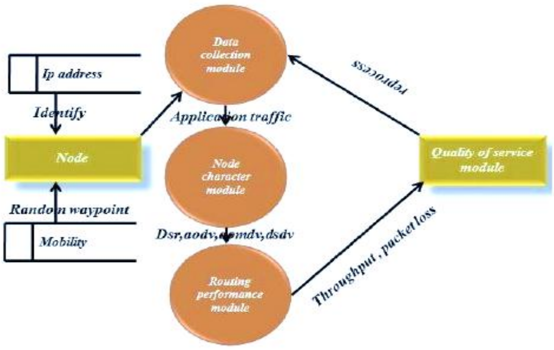

Fig 1. Architecture Diagram

In this section, I analyze the performance of the proposed beaconing strategy, APU. I focus on two key performance measures: (i) update cost and (ii) 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:

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.

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 nodes radio range to the total number of neighbors.

IV. CONCLUSION

In this paper, I have identified the need to adapt the beacon update policy employed in geographic routing protocols to the node mobility dynamics and the traffic load. I proposed the Adaptive Position Update (APU) strategy to address these problems. The APU scheme employs two mutually exclusive rules. The MP rule uses mobility prediction to estimate the accuracy of the location estimate and adapts the beacon update interval accordingly, instead of using periodic beaconing. The ODL rule allows nodes along the data forwarding path to maintain an accurate view of the local topology by exchanging beacons in response to data packets that are overheard from new neighbors. I mathematically analyzed the beacon overhead and local topology accuracy of APU and validated the analytical model with the simulation results. I have embedded APU within GPSR and have compared it with other related beaconing strategies using extensive NS-2 simulations for varying node speeds and traffic load. The 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.

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