

Security for Geographic Routing In Mobile Adhoc Networks Using RC4 Algorithm

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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. Periodic broadcasting of beacon packets that contain the geographic location coordinates of the nodes is a popular method used by most geographic routing protocols to maintain neighbor positions. We contend and demonstrate that periodic beaconing regardless of the node mobility and traffic patterns in the network is not attractive from both update cost and routing performance points of view. We propose the 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 (and vice versa). Our theoretical analysis, which is validated by NS2 simulations of a 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 in comparison with periodic beaconing and other recently proposed updating schemes. The benefits of APU are further confirmed by undertaking evaluations in realistic network scenarios, which account for localization error, realistic radio propagation, and sparse network. Also for security purpose we are also encrypting the data packets during transmission. So that the intermediate nodes are not able to view the data during transmission. For Encryption process, we are using RC4 Algorithm.

Keywords: Geographic routing, positions, Manets, Nodes.

I. INTRODUCTION

We propose here Geographic Random Forwarding (GeRaF, pronounced as “giraffe”), a novel transmission scheme based on geographical routing where packets are relayed on a besteffort basis, i.e., the actual node which acts as a relay is not known a priori by the sender, but rather is decided after the transmission has taken place. This idea leverages on the fact that in the wireless environment broadcast is free (from the sender’s point of view) and that in the presence of randomly changing topologies a node may not be aware of which of its current neighbors is in the best position to act as a relay. In a sense, this is like doing contention at the receiver’s end, which is untraditional because in classic schemes it is the transmitter which contends for the channel. Here, since the intended recipient is not specified, multiple nodes may be able to receive the packet, and a receiver contention scheme is therefore needed to guarantee that a single relay is chosen, thereby avoiding packet duplication.

An ad hoc network is a set of wireless mobile nodes (MNs) that cooperatively form a network without specific user administration or configuration. Each node in an ad hoc network is in charge of routing information between its neighbors, thus contributing to and maintaining connectivity of the network. Since ad hoc networks have proven benefits, they are the subject of much current research. Many unicast routing protocols have been proposed for ad hoc networks; a performance comparison for a few of the protocols are in [1] and [2]. Some of the unicast routing protocols for an ad hoc network use location information in the routing protocol in an effort to improve the performance of unicast communication. A few of the proposed algorithms include the Location-Aided Routing (LAR) algorithm [3], the Distance Routing Effect Algorithm for Mobility (DREAM) [4], the Greedy Perimeter Stateless Routing (GPSR) algorithm [5], and the Geographical Routing Algorithm (GRA) [6]. 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). We

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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). We 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.

II. LITERATURE REVIEW

GPSR: GREEDY PERIMETER STATELESS ROUTING FOR WIRELESS NETWORKS

We present 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. We describe the GPSR protocol, and use extensive simulation of mobile wireless networks to compare its performance with that of Dynamic Source Routing. Our simulations demonstrate GPSR's scalability on densely deployed wireless networks.

In networks comprised entirely of wireless stations, communication between source and destination nodes may require traversal of multiple hops, as radio ranges are finite. A community of adhoc network researchers has proposed, implemented, and measured a variety of routing algorithms for such networks. The observation that topology changes more rapidly on a mobile, wireless network than on wired networks, where the use of Distance Vector (DV), Link State (LS), and Path Vector routing algorithms is well-established, motivates this body of work.

DV and LS algorithms require continual distribution of a current map of the entire network's topology to all routers. DV's Bellman-Ford approach constructs this global picture transitively; each router includes its distance from all network destinations in each of its periodic beacons. LS's Dijkstra approach directly floods announcements of the change in any link's status to every router in the network. Small inaccuracies in the state at a router under both DV and LS can cause routing loops or disconnection. When the topology is in constant flux, as under mobility, LS generates torrents of link status change messages, and DV either suffers from out-of-date state, or generates torrents of triggered updates.

The two dominant factors in the scaling of a routing algorithm are:

- _ The rate of change of the topology.
- _ The number of routers in the routing domain.

Both factors affect the message complexity of DV and LS routing algorithms: intuitively, pushing current state globally costs packets proportional to the product of the rate of state change and number of destinations for the updated state. *Hierarchy* is the most widely deployed approach to scale routing as the number of network destinations increases. Without hierarchy, Internet routing could not scale to support today's number of Internet leaf networks. An Autonomous System runs an intra-domain routing protocol inside its borders, and appears as a single entity in the backbone inter-domain routing protocol, BGP. This hierarchy is based on well-defined and rarely changing administrative and topological boundaries. It is therefore not easily applicable to freely moving ad-hoc wireless networks, where topology has no well-defined AS boundaries, and routers may have no common administrative authority.

Caching has come to prominence as a strategy for scaling ad-hoc routing protocols. Dynamic Source Routing (DSR), Ad-Hoc On-Demand Distance Vector Routing (AODV), and the Zone Routing Protocol (ZRP) all eschew constantly pushing current topology information network-wide. Instead, routers running these protocols request topological information in an *on-demand* fashion as required by their packet forwarding load, and cache it aggressively.

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When their cached topological information becomes out-of-date, these routers must obtain more current topological information to continue routing successfully. Caching reduces the routing protocols' message load in two ways: it avoids pushing topological information where the forwarding load does not require it (*e.g.*, at idle routers), and it often reduces the number of hops between the router that has the needed topological information and the router that requires it (*i.e.*, a node closer than a changed link may already have cached the new status of that link).

BLR: BEACON-LESS ROUTING ALGORITHM FOR MOBILE AD-HOC NETWORKS

Routing of packets in mobile ad-hoc networks with a large number of nodes or with high mobility is a very difficult task and current routing protocols do not really scale well with these scenarios. The Beacon-Less Routing Algorithm (BLR) presented in this paper is a routing protocol that makes use of location information to reduce routing overhead. However, unlike other position-based routing protocols, BLR does not require nodes to periodically broadcast Hello-messages (called beaconing), and thus avoids drawbacks such as extensive use of scarce battery-power, interferences with regular data transmission, and performance degradation. BLR selects a forwarding node in a distributed manner among all its neighboring nodes with having information neither about their positions nor even about their existence. Data packets are broadcasted and the protocol takes care that just one of the receiving nodes forwards the packet. Optimized forwarding is achieved by applying a concept of Dynamic Forwarding Delay (DFD). Consequently, the node which computes the shortest forwarding delay relays the packet first. This forwarding is detected by the other nodes and suppresses them to relay the same packet any further. Analytical results and simulation experiments indicate that BLR provides efficient and robust routing in highly dynamic mobile ad-hoc networks.

A wireless mobile ad-hoc network operates without any centralized administration and does not rely on any fixed infrastructure. Instead the network is completely self-organizing and the communication is maintained on a peer-to-peer basis between the mobile hosts. If two hosts that wish to communicate are not within range, other intermediate nodes act as relay stations.

Due to the mobility of the nodes, changes to the network topology may be frequent and unpredictable. Furthermore, nodes may suddenly be switched on/off, causing new links to appear and established links to vanish. Routing in such a dynamic environment is a difficult task and has been subject of extensive research over the past years. Several routing protocols have been defined within MANET working group of IETF such as AODV, DSR, TORA, DSDV, TBRPF, OLSR, ZRP, FSR, LANDMAR. These protocols either use a kind of flooding to detect routes on-demand or proactively maintain routing information at each node. Generally, they are considered not to scale in networks with more than several hundred nodes. Unlike these topology-based routing protocols which do not make use of location information, position-based (also called geometric or directional routing) protocols try to optimize routing by making use of geographical information available at each node (GFG, GPSR, LAR, TRR, AFR, EASE, DREAM). Every node is aware of its own position and is notified of its neighbors' positions through the exchange of beacons (small packets broadcasted by the neighbors to announce their position). Additionally, a node is able to determine the location of the destination through a location management scheme.

This additional position-information allows improving routing significantly and, thus, increases the network scalability in terms of network size, mobility, and traffic. Position-based routing is likely one of the enablers for large-scale mobile ad-hoc networks, where the number of nodes can potentially reach several thousands as considered in the Terminodes project. (Even though, it was shown in that the per node capacity tends to zero as the number of nodes goes to infinity for certain network and traffic models.)

The Beacon-Less Routing algorithm (BLR) described in this paper performs routing in a distributed manner without information about neighboring nodes. If a node has a packet to send, it broadcasts the packet and every neighboring node receives it. The protocol takes care that just one of these nodes relays the packet. This is accomplished by computing a Dynamic Forwarding Delay (DFD) at each node depending on its position relative to the previous and the destination node. The node located at the "optimal" position introduces the shortest delay and thus transmits the packet first. Other nodes recognize the occurrence of the relaying and cancel their scheduled transmission of the same packet. Avoiding periodical transmission of beacons provides many advantages, such as conserving scarce battery power and avoiding interferences with regular data transmission. To ensure that all nodes detect the forwarding, only nodes within a certain area apply DFD and take part in the contention to forward the packet.

PERFORMANCE COMPARISON OF TWO LOCATION BASED ROUTING PROTOCOLS FOR AD HOC NETWORKS

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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). We 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). We 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.

An ad hoc network is a set of wireless mobile nodes (MNs) that cooperatively form a network without specific user administration or configuration. Each node in an ad hoc network is in charge of routing information between its neighbors, thus contributing to and maintaining connectivity of the network. Since ad hoc networks have proven benefits, they are the subject of much current research. Many unicast routing protocols have been proposed for ad hoc networks; a performance comparison for a few of the protocols are in. Some of the unicast routing protocols for an ad hoc network use location information in the routing protocol in an effort to improve the performance of unicast communication. A few of the proposed algorithms include the Location-Aided Routing (LAR) algorithm, the Distance Routing Effect Algorithm for Mobility (DREAM), the Greedy Perimeter Stateless Routing (GPSR) algorithm, and the Geographical Routing Algorithm (GRA).

This paper is the first to provide a detailed, quantitative evaluation comparing the performance of two location based ad hoc network routing protocols: LAR and DREAM. Simulation results on LAR, DREAM, and other location based protocols exist on the individual protocols; however, since these simulation results are based on different simulation environments, different simulation parameters and even different network simulators, the performances are not comparable. We compare the simulation results for LAR and DREAM with the Dynamic Source Routing (DSR) protocol, a unicast routing protocol that does not use location information. We chose DSR since it performs well in many of the performance evaluations of unicast routing protocols).

The NS-2 code used in our simulations of DSR was obtained from [8]; we wrote the NS-2 code used in our simulations of LAR and DREAM. During implementation, we followed the protocol descriptions provided for LAR in and DREAM in. When implementation questions occurred, we contacted the protocol authors for guidance. We discuss the implementation decisions made and protocol parameters chosen in the description of each protocol. Some of the simulation results we present are different from previously reported results; we discuss the reasons for the differences in this paper. Lastly, at the end of this paper, we list five conclusions which summarize our findings.

LOCATION-AIDED ROUTING (LAR) IN MOBILE AD HOC NETWORKS

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. We present two algorithms to determine the *request zone*, and also suggest potential optimizations to our algorithms.

Mobile ad hoc networks consist of wireless mobile hosts that communicate with each other, in the absence of a fixed infrastructure. 1 Routes between two hosts in a Mobile Ad hoc Network (MANET) may consist of hops through other hosts in the network. Host mobility can cause frequent unpredictable topology changes. Therefore, the task of finding and maintaining routes in MANET is nontrivial. Many protocols have been proposed for mobile ad hoc networks, with the goal of achieving efficient routing. These algorithms differ in the approach used for searching a new route and/or modifying a known route, when hosts move.

In this paper, we suggest an approach to decrease overhead of route discovery by utilizing location information for mobile hosts. Such location information may be obtained using the global positioning system (GPS). We demonstrate how location information may be used by means of two *Location-Aided Routing* (LAR) protocols [19,20,22] for route discovery. The LAR protocols use location information (which may be out of date, by the time it is

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used) to reduce the search space for a desired route. Limiting the search space results in fewer route discovery messages.

EFFICIENT GEOGRAPHIC ROUTING IN MULTIHOP WIRELESS NETWORKS

We propose a new link metric called normalized advance (NADV) for geographic routing in multi hop wireless networks. NADV selects neighbors with the optimal trade-off between proximity and link cost. Coupled with the local next hop decision in geographic routing, NADV enables an adaptive and efficient cost-aware routing strategy. Depending on the objective or message priority, applications can use the NADV framework to minimize various types of link cost. We present efficient methods for link cost estimation and perform detailed simulations in diverse scenarios. Our results show that NADV outperforms current schemes in many aspects: for example, in high noise environments with frequent packet losses, the use of NADV leads to 81% higher delivery ratio. When compared to centralized routing under certain settings, geographic routing using NADV_nds paths whose cost is close to the optimum.

Geographic routing (or position-based routing) uses location information for packet delivery in multihop wireless networks. Neighbors locally exchange location information obtained through GPS (Global Positioning System) or other location determination techniques. Since nodes locally select next hop nodes based on this neighborhood information and the destination location, neither route establishment nor per-destination state is required in geographic routing. As large-scale sensor networks become more feasible, properties such as stateless nature and low maintenance overhead make geographic routing increasingly more attractive. Also, location-based services such as geocasting can be best realized using geographic routing.

The most popular strategy for geographic routing is simply forwarding data packets to the neighbor geographically closest to the destination. Although this *greedy* method is effective in many cases, packets may get routed to where no neighbor is closer to the destination than the current node. Many *recovery* schemes have been proposed to route around such *voids* for guaranteed packet delivery as long as a path exists. These techniques typically exploit planar subgraphs (i.e., Gabriel graph, Relative Neighborhood graph), and packets traverse faces on such graphs using the well-known *right-hand* rule. Most geographic routing protocols use one-hop information, but generalization to two-hop neighborhood is also possible.

III. RELATED WORK

Dynamic Source Routing (DSR)

DSR is a source routing protocol which determines routes on demand [7]. In a source routing protocol, each packet carries the full route (a sequenced list of nodes) that the packet should be able to traverse in its header. In an on demand routing protocol (or reactive protocol), a route to a destination is requested only when there is data to send to that destination and a route to that destination is unknown or expired. In the evaluation of DSR, both [1] and [2] only locate routes that consist of bi-directional links. (Although DSR does not require bi-directional links in the protocol, IEEE 802.11 requires bi-directional links in the delivery of all non-broadcast packets.) The version of DSR in our study also only locates bi-directional links. In other words, a route reply packet containing the complete route from S to D is sent along the reverse route to S. MNs using DSR may operate in promiscuous mode. In promiscuous mode, an MN can learn potentially useful routes by listening to packets not addressed to it. Simulation results on DSR presented in [1] use promiscuous mode operation, while simulation results on DSR presented in [2] do not use promiscuous mode operation. Contrary to comments in [2], we discovered that including promiscuous mode operation in DSR significantly reduced control overhead and significantly increased delivery ratio at higher speeds. However, as noted in [2], promiscuous mode operation is power consuming. Thus, we chose to present both promiscuous mode operation and non-promiscuous mode operation in our simulation results for DSR.

Location Aided Routing (LAR)

1) Protocol Overview: Like DSR, LAR [3] is an on-demand source routing protocol. The main difference between LAR and DSR is that LAR sends location information in all packets to (hopefully) decrease the overhead of a future route discovery. In DSR [7], if the neighbors of S do not have a route to D, S floods the entire ad hoc network with a route request packet for D. LAR uses location information for MNs to flood a route request packet for D in a forwarding zone instead of in the entire ad hoc network. (The term forwarding zone in this paper is defined the same as

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the term request zone in [3].) This forwarding zone is defined by location information on D. The authors of [3] propose two methods used by intermediate nodes between S and D to determine the forwarding zone of a route request packet. In method 1, which we call LAR Box, a neighbor of S determines if it is within the forwarding zone by using the location of S and the expected zone for D. The expected zone is a circular area determined by the most recent location information on D, (XD, YD), the time of this location information, (t0), the average velocity of D, (Vavg), and the current time, (t1). This information creates a circle with radius $R = V_{avg} \times (t_1 - t_0)$ centered at (XD, YD). The forwarding zone is a rectangle with S in one corner, (XS, YS), and the circle containing D in the other corner.

A number of recent papers also propose specific energy efficient routing schemes for sensor networks. The authors of [17] [18] propose LEACH, which is a cluster-based routing protocol in which the role of clusterhead is rotated among the sensor nodes to avoid stressing only some of them. An improvement of LEACH, called PEGASIS, which is chain-based and provides near optimum energy and delay performance is proposed in [19]. Similarly, energy aware routing [20] avoids using consistently the lowest-energy routing paths, as this may lead to energy depletion of nodes in key locations; instead, it allows the use of suboptimal paths. Routing is coupled with a thresholding mechanism in [21] [22], where transmissions are inhibited when the sensed attribute is not significant or not significantly different from what sensed/transmitted in the past, thereby reducing the transmission/relaying activity of nodes. A routing scheme which minimizes the control traffic in the network is proposed in [23]. Traffic shaping to make the network load more uniform, thereby improving the energy utilization of the nodes in the network, is proposed in [24]. An algorithm based on constrained shortest paths, which tries to minimize energy consumption while retaining good end to end performance, introduces the maximum flow-life curve as the routing objective and proposes a new routing scheme based on this concept. Techniques to improve packet forwarding in sensor networks are proposed. The authors of [20] propose to modify the sensor node layering architecture so that forwarding decisions can be made by the hardware, thereby greatly improving the energy (and latency) performance of the overall system.

Routing protocols based on geographic information have been considered in the past. GPSR is a scalable greedy algorithm with the ability to go around low-density network regions. GEAR also uses geographic information to deliver packets to a certain service region (rather than to a specific node). Other protocols which make use of geographic information to improve efficiency include LAR and DREAM.

IV. OUR WORK

We propose a novel beaconing strategy for geographic routing protocols called Adaptive Position Updates strategy (APU). 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.

We 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. Our analytical results are validated by extensive simulations.

Also for security purpose we are also encrypting the data packets during transmission. So that the intermediate nodes are not able to view the data during transmission. For Encryption process, we are using RC4 Algorithm. We 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. Our analytical results are validated by extensive simulations.

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V. ALGORITHM

ADAPTIVE POSITION UPDATES STRATEGY

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.

Upon initialization, each node broadcasts a beacon informing its neighbors about its presence and its current location and velocity. Following this, in most geographic routing protocols such as GPSR, each node periodically broadcasts its current location information. The position information received from neighboring beacons is stored at each node. Based on the position updates received from its neighbors, each node continuously updates its local topology, which is represented as a neighbor list. Only those nodes from the neighbor list are considered as possible candidates for data forwarding. Thus, the beacons play an important part in maintaining an accurate representation of the local topology.

RC4 Algorithm

RC4 generates a [pseudorandom stream of bits](#) (a [keystream](#)). As with any stream cipher, these can be used for encryption by combining it with the plaintext using bit-wise [exclusive-or](#); decryption is performed the same way (since exclusive-or with given data is an [involution](#)). (This is similar to the [Vernam cipher](#) except that generated *pseudorandom bits*, rather than a prepared stream, are used.) To generate the keystream, the cipher makes use of a secret internal state which consists of two parts:

- A [PERMUTATION](#) OF ALL 256 POSSIBLE [BYTES](#) (DENOTED "S" BELOW).
- TWO 8-BIT INDEX-POINTERS (DENOTED "I" AND "J").

VI. CONCLUSION

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. We have identified the need to adapt the beacon update policy employed in geographic routing protocols to the node mobility dynamics and the traffic load. We proposed the Adaptive Position Update 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. We mathematically analyzed the beacon overhead and local topology accuracy of APU and validated the analytical model with the simulation results. We 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. 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. In addition, we have simulated the performance of the proposed scheme under more realistic network scenarios, including the considerations of localization errors and a realistic physical layer radio propagation model. 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.

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VII. FUTURE ENHANCEMENT

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.

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