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Geographic Position Updates Using Beaconing Strategy in Mobile Ad Hoc Networks

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Abstract

Geographic routing relies on geographic positions information of their immediate neighbors for making effective forwarding decisions. The existing scheme to maintain neighbor position involves the Periodic broadcasting of beacon packets with location coordinates of the nodes which is not attractive in terms of update cost and routing performance regardless of the node mobility and traffic patterns in the network. The Adaptive Position Update (APU) strategy for geographic routing has been proposed, which adopts to the frequency of position updates based on the mobility of nodes and the forwarding patterns in the network. APU works 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). The performance analysis, which is validated by NS2 simulations of a well-known geographic 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 the existing periodic beaconing and other recently proposed updating schemes.

Index terms - *Geographic routing, Periodic broadcasting, Adaptive Position Update, location coordinates*

I. INTRODUCTION

Mobile ad hoc networks are collections of wireless nodes (usually battery powered) that communicate with one and another using radio frequency without a fixed infrastructure or centralized control. They are widely reorganized to have great potentials in a wide range of applications in disaster relief conference, and battlefield environments In Mobile ad hoc networks, a message sent by a node is received by all nodes located within the node's transmission range. Because the limited transmission range, two communicating nodes that are far apart from each other have to rely on some intermediate nodes relaying their messages. Under this circumstance, routing is a primary challenge. Geographic routing employs non-flooding based route discovery [1] and offers scalability. It requires that nodes know their own positions. Location awareness may be achieved by attaching each sensor a GPS device or running some non-GPS based localization algorithm when GPS is not available. In addition to their own location, nodes also need to know the position of the destination in order to engage geographic routing. When the destination is fixed, the information can be preprogrammed in the nodes; when the network size is small, it may be dynamically obtained by a broadcast task. In the general case that the destination can be any node and the network size is large, a location service algorithm is needed. The geographic routing protocols works on the principle of selecting the next routing hop from among a node's neighbors, which is geographically closest to the destination. The forwarding decision is based entirely on local topology, as it avoids the need to create and maintain routes for each destination. By this feature, position-based routing protocols are highly scalable and particularly robust to frequent changes in the network topology and each node always selects the optimal next hop based on the most current topology.

In MANET, due to mobility the nodes often switch off and on, the local topology rarely remains static. Hence, it is essential that each node broadcasts its updated location information to all of its neighbors. These position update packets are usually referred to as beacons [2]. In most geographic routing protocols beacons are transmitted periodically to maintain an accurate neighbor list at each node. Position updates are costly as 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. The retransmission of packets causes end-to-end delay. Instead of a static periodic update policy [3] it makes sense to adapt the frequency of beacon updates based on the mobility of nodes and the traffic conditions within the network. However, for nodes that 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. This paper introduced a concept of novel beaconing strategy for geographic routing which eliminates the drawbacks of periodic beaconing by adapting to mobility by incorporating two rules for beacon update process, which are Mobility Prediction Rule and On-Demand Learning Rule to quantify the beacon overhead and local topology accuracy.

II. RELATED WORK

Greedy Perimeter Stateless Routing (GPSR) [2], 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 uses a planar subgraph of the wireless network's graph to route around holes, makes *greedy* forwarding decisions using only information about a router's immediate neighbors in the network topology. Traditional shortest-path (Distance Vector and Link State) algorithms require state proportional to the number of reachable destinations at each router. The geographic routing allows routers to be nearly stateless, and GPSR scales better in per-router state than shortest-path and ad-hoc routing protocols as the number of network destinations increases. Under mobility with frequent topology changes, GPSR can use local topology information to find correct new routes quickly, consistently delivers upwards of data packets successfully and increasingly more successful than DSR as the number of nodes increases.

An approach to decrease overhead of route discovery by utilizing location information for mobile hosts which may be obtained by using the global positioning system(GPS)[4,5].With the availability of GPS, a mobile host may know its physical location which includes some amount of error as the difference between GPS calculated coordinates and real coordinates. The author demonstrated two Location-Aided Routing (LAR) [8], protocols (LAR Scheme1 & LAR Scheme 2) for route discovery to reduce the search space for a desired route. They also showed how a route discovery protocol based on flooding can be improved. LAR algorithms are similar to flooding with a modification that the node which is not in the request zone does not forward the route request to its neighbors. In this scheme, any intermediate node is detected with routing failure due to broken link, it informs the source by sending a route error packet to find a new path to the destination.

An on demand algorithm, Ad hoc On Demand Distance Vector Routing(AODV)[6], which builds route between nodes only as desired by the source nodes and provides loop free routes. AODV uses symmetric link between the neighboring nodes. Since AODV is a pure on-demand route acquisition system, the inactive path neither maintains routing information nor exchanges routing table. It uses a broadcast route discovery mechanism with enhanced features of Dynamic Source Routing (DSR) [7], also dynamically establish route table entries at the

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intermediate node. AODV additionally uses the concept of Destination –Sequenced Distance Vector algorithm to maintain most recent routing information between nodes as the nodes maintains a monotonically increasing sequence number counter. With AODV, nodes in the network frequently suffer from the hidden terminal problem. By using this algorithm, intermediate nodes leads to inconsistent routes and also consumes unnecessary bandwidth due to periodic beaconing.

A new link metric called Normalized Advance (NADV) [8], for geographic routing in multihop wireless networks; it selects the neighbor with the best trade-off between link cost and proximity, instead of the neighbor closest to the destination. The author presented this technique for efficient and adaptive link cost estimation while some of existing work uses additional probe messages for link cost estimation which consumes scarce network resources. NADV denotes the amount of advance achieved per unit cost. The proposed link metric routing can be generalized to various cost types such as power consumption and link delay and it tries to minimize the hop count between source and destination. The goal of this work is to balance the trade-off, by selecting a neighbor with both large advance and good link quality for fast and efficient packet delivery. The use of NADV leads to 81% higher delivery ratio compared to centralized routing, geographic routing using NADV finds paths whose cost is close to the optimum. By NADV, each link cost type can be treated independently. However, while considering multiple interdependent costs simultaneously, choosing the next hop based on one cost type may not be always the best choice for other costs. The work may be outing to design a link cost model that balances multiple cost criteria.

Terminode routing [9], preferred as a means to achieve scalability and also to overcome the difficulties of location based routing when there are holes in the network topology, frequent disconnection of nodes. It uses a combination of location based routing (Terminode Remote Routing, TRR) for far destination and link state routing (Terminode Local Routing, TLR) for closer destination. Also it uses a special form of restricted search mode (Restricted Flooding, RLF) to solve the inaccuracy of location information for control packets. Christo Ananth et al. [10] proposed a secure hash message authentication code. A secure hash message authentication code to avoid certificate revocation list checking is proposed for vehicular ad hoc networks (VANETs). The group signature scheme is widely used in VANETs for secure communication, the existing systems based on group signature scheme provides verification delay in certificate revocation list checking. In order to overcome this delay this paper uses a Hash message authentication code (HMAC). It is used to avoid time consuming CRL checking and it also ensures the integrity of messages. The Hash message authentication code and digital signature algorithm are used to make it more secure . In this scheme the group private keys are distributed by the roadside units (RSUs) and it also manages the vehicles in a localized manner. Finally, cooperative message authentication is used among entities, in which each vehicle only needs to verify a small number of messages, thus greatly alleviating the authentication burden.

III. ADAPTIVE POSITION UPDATE SCHEME

The geographic routing with Adaptive Position Update strategy dynamically adjusts the beacon intervals based on the mobility dynamics and the forwarding patterns of the network in which the beacon transmitted by the nodes contain their current position and speed.

A) Mobility Prediction Rule

Mobility prediction rule adapts beacon generation rate to the frequency with which nodes change characteristics that govern their motion (velocity and heading). Motion characteristics are included in beacons broadcast to a node's neighbors. Nodes that frequently change their motion need to frequently update their neighbors. Upon receiving a beacon update from a node each of its neighbors records node's current position and velocity, periodically track node's location using simple prediction scheme based on linear

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kinematics. MP rule send next beacon update from a node when error between predicted location in neighbors and node's actual location is greater than an acceptable threshold. Use a simple location prediction scheme based on physics of motion to estimate a node's current location. MP rule maximize effective duration of each beacon by broadcasting a beacon only when predicted position information based on previous beacon becomes inaccurate. Extends effective duration of beacon for nodes with low mobility reduce number of beacons. In the proposed APU scheme using MP rule,

upon receiving a beacon update from a node i, each of its neighbors records node i's current position and velocity and periodically track node i's location using a simple prediction scheme based on linear kinematics. Based on this position estimate, the neighbors can check whether node i is still within their transmission range and update their neighbor list accordingly. The goal of the MP rule is to send the next beacon update from node i when the error between the predicted location in the neighbors of i and node i's actual location is greater than an acceptable threshold. A simple location prediction scheme has been used based on the physics of motion to estimate a node's current location. Also with an assumption that the nodes are located in a 2D coordinate system with the location indicated by the x and y coordinates. However, this scheme can be easily extended to a 3D coordinate system.

***B)* On Demand Learning Rule**

On Demand Learning Rule maintain a more accurate local topology in those regions of network where significant data forwarding activities are on-going node broadcasts beacons on-demand. Node waits for a small random time interval before responding with beacon to prevent collisions with other beacons. Data packet contains the location of the final destination any node that overhears a data packet checks its current location and determines if the destination is within its transmission range. Destination node is added to the list of neighboring nodes if it is not already present. ODL rule allows active nodes involved in data forwarding to enrich their local topology beyond this basic set. Rich neighbor list is maintained at the nodes located in regions of high traffic load. ODL ensures that nodes involved in data forwarding are highly mobile, alternate routes easily established without incurring additional delays.

***C)* Analysis of Adaptive Position Update**

Adaptive Position Update can be done by listing the assumptions that includes,

- All nodes are aware of their own position and velocity,
- All links are bidirectional,
- The beacon updates include the current location and velocity of the nodes, and
- 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.

The performance of the proposed beaconing strategy, APU focuses on two key performance measures: 1) Update cost 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:

- **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 node's radio range to the total number of neighbors.

IV. RESULTS AND DISCUSSIONS

The simulations are conducted in NS-2 with each experiment being run for 1,000 seconds. The results represented here are averaged over 30 runs. In each simulation, 150 nodes are randomly placed in a region of size 1500 m x 1500 m. The radio range for each node is assumed to be 250 meters (thus the average number of one-hop neighbors for each node is 12). The simulation uses Constant Bit

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Rate (CBR) traffic sources with each source generating four packets per second and simulates 15 traffic flows and randomly select nodes as source- destination pairs as the traffic flows. Also, assumed that the nodes move according to the RDM model, to be consistent with our analytical results.

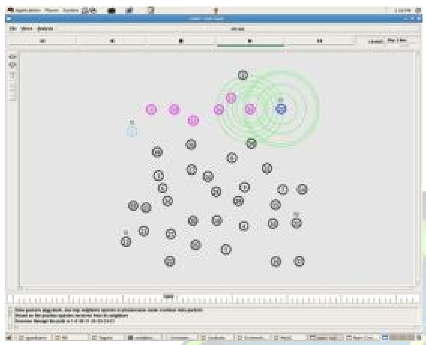

Figure 1 Formation of Bi-directional link

The Figures 1 and 2 mentioned that the bidirectional links are created between the data source and destination and the position updates of each neighbors was done by beaconing at each node to indicate the mobility of nodes.

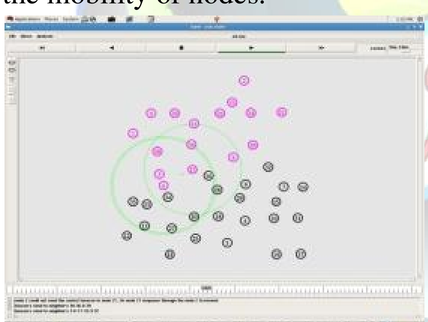

Figure 2 Location Updates from Neighbor Nodes

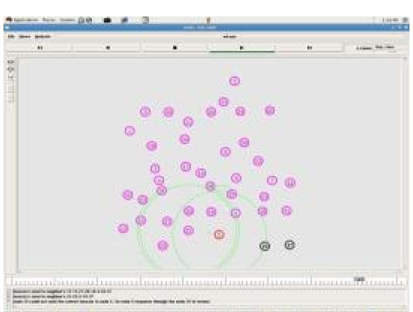

Figure 3 Identify False Neighbors

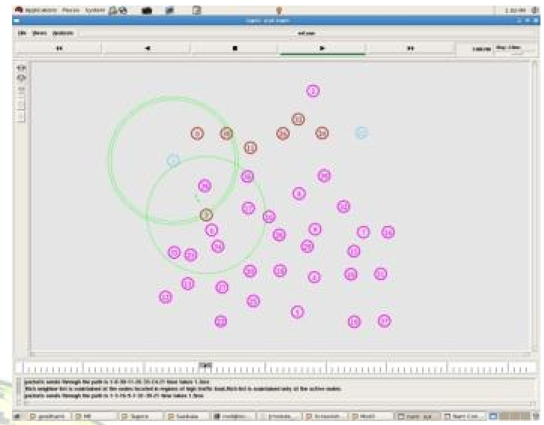

Figure 4 Performs Routing

Figure 3 identifies the false neighbor, thereby updating the neighbor table and Figure 4 performs geographic routing.

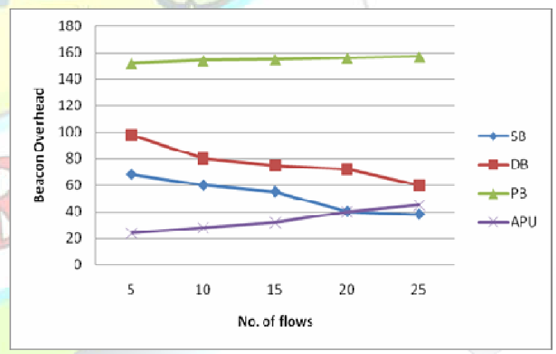

Figure 5 Beacon Overhead (packets)

The simulation has been conducted to evaluate the impact of varying the traffic load on the performance of APU and also compare APU with the three beaconing schemes under consideration by fixing the average node speed to 15 m/s and also the number of flows has been varied from 5 (low load) to 25 (high load). Figure 5 shows that the beacon overhead increases with the traffic load. As the number of traffic flows increases, more nodes in the network are involved in forwarding packets. Since, the ODL rule in APU aims at maintaining an accurate view of the local topology for nodes involved in forwarding packets.

V. CONCLUSION

In geographic routing, the forwarding decision at each node is based on the locations of the node's one-hop neighbors and location of the packet destination as well. If certain nodes are frequently changing their mobility characteristics, it makes sense to frequently broadcast their updated position. To overcome the traffic load due to periodic beaconing, it has been identified that there is a need to adapt the beacon update policy employed in geographic routing protocols to the node mobility dynamics and the traffic load. The Adaptive Position Update strategy has been proposed 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. The beacon overhead and local topology accuracy of APU has been analyzed and validated the analytical model with the simulation results. By embedding 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 simulation 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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