Enhanced APU for Geographic Routing in MANETS

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Abstract

A mobile ad hoc network (MANET) is a self-configuring infrastructure less network of mobile devices connected by wireless. Each device in a mobile adhoc network is free to move independently in any direction, and will therefore change its connections to other devices very frequently. In geographic routing to forward a packet we need router's position and destination of packet. Location information is updated based on the beacon messages. Periodic broadcasting of beacon packets which contain the geographic location coordinates of the nodes is a most widely used method by most geographic routing protocols to maintain neighbor positions. Here the proposed 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. 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, average end-to-end delay, Routing Overhead and Throughput, in comparison with distance based beaconing, speed based beaconing and other recently proposed updating schemes.

Keywords: *Greedy Perimeter Stateless Routing Protocol (GPSR), Adaptive Position Update (APU), Beacon.*

1. INTRODUCTION

An ad hoc network is a set of wireless mobile nodes 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.

Position updates are the key factors of geographic routing protocols, 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 neighbours, which is geographically closest to the destination.

The forwarding decision is based entirely on local knowledge, it obviates the need to create and maintain routes for each destination. The forwarding strategy employed in the aforementioned geographic routing protocols requires the following information: 1) The position of the final destination of the packet and 2) The position of a node's neighbors. The first one can be obtained by querying a location service such as the Grid Location System (GLS) [10]. To obtain the latter, each node exchanges its own location information with its neighboring 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. Position updates are costly in many ways. Each update consumes node energy, wireless bandwidth and increases the risk of packet collision at MAC (medium access control) layer. Packet

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collisions cause packet loss which in turn affects the routing performance. A lost packet does get retransmitted, but at the cost of increased end-end delay.

In this paper, here a novel beaconing strategy for geographic routing protocols called Adaptive Position Updates strategy is proposed (APU) [14]. This 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) [1], uses a simple mobility prediction scheme. The second rule referred as on demand learning (ODL) [1], aims at improving the accuracy of the topology along the routing paths between the communication nodes.

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2. LITERATURE REVIEW

1. Distance-based beaconing (DB)

In the distance-based beaconing, a node transmits a beacon when it has moved a given distance d. The node removes an outdated neighbor if the node does not hear any beacons from the neighbor while the node has moved more than k-times the distance d, or after a maximum time out of 5 s.

This method is adaptive to the node mobility, there for a faster moving node sends beacons more frequently and vice versa.

Problems arise if neighbor list of a slow node possess many outdated neighbors in it since the neighbor time out interval at the slow node is longer. Also when a fast moved node passes by a slow node, and then corresponding slow node may not be detected by fast node due the infrequent beaconing of the slow node, thus reduces the perceived network connectivity.

2. Speed based beaconing

In the speed-based beaconing, the beacon interval is dependent on the node speed. A node determines its beacon interval from a predefined range [a,b] with the exact value chosen being inversely proportional to its speed. The neighbor time-out interval of a node is a multiple k of its beacon interval. Nodes piggyback their neighbor time-out interval in the beacons. A receiving node compares the piggybacked time-out interval with its own time-out interval, and selects the smaller one as the time-out interval for this neighbor. In this way, a slow node can have short time-out interval for its fast neighbor and therefore eliminate the first problem presented in the distance-based beaconing. However, the speed-based beaconing still suffers the problem that a fast node may not detect the slow nodes.

3. Reactive beaconing

In reactive beaconing, beacon generation is triggered by data packet transmissions. If a node has a packet to transmit, the node first broadcasts a beacon request packet. The neighbors overhearing the request packet respond with beacons. Thus, by using these beacons node can build an accurate local topology before the data transmission.

4. GPRS.

Greedy Perimeter Stateless Routing Protocol is a wireless datagram's novel routing protocol that makes use of position of routers and a packet's destination to create forwarding decisions**.** Another impressing feature is Small Routing message complexity .Creates less number of routing messages as mobility increases is another attracting feature. In most geographic routing protocol beacons are broadcast periodically for maintaining an accurate neighbor list at each node.

Major advantages of GPSR is that it generates routing protocol traffic in a quantity independent of the length of the routes through the network, and therefore creates a constant as well as low volume of routing protocol messages as mobility increases, so doesn't suffer from decreased robustness in finding routes. GPSR represents another powerful lever for scaling routing.

Main problems with GPRS are position update usually is a cost consuming process. Each update consumes Node energy and wireless bandwidth. Also increases the risk of packet collision at the medium access control (MAC) layer. Packet loss may happen due to packet collision which in turn affects the routing performance due to decreased accuracy in determining the correct local topology. A lost data packet does get transmitted again (i.e. retransmission), but at the expense of increased end-to-end delay.

5. LAR

Location Aided Routing is a Reactive category of protocol. It uses shortest path metric. Allow multiple paths. This protocol makes effective use of nodes position information to reduce the flooding range. Here flooding of routing messages restricted to a request zone which covers the expected zone

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of the destination. Location Aided Routing (LAR) Protocols limit the search for a new route to a smaller "request zone" of the ad hoc network using location information. Location information can be used to reduce overhead here. This limits the search for a route to the so-called requested zone. Fewer route discovery messages are another important advantage due to limiting search space. Medium communication overhead is another advantage as well as disadvantage. No need of hello message is important feature .Reduces traffic overhead. Main disadvantage of this protocol is that it experiences variable delay with variable node density. Uses only prediction scheme to compute the current position of neighbours and still employed periodic update of beacons. And so further optimizations are needed on basic LAR scheme to improve performance.

6. DREAM

Distance Routing Effect Algorithm For Mobility. This is one of the first protocols that incorporated position information within a routing protocol. Each node maintains a position database that stores information about all other nodes in the network. Here it involves a distance effect that uses the fact that the greater the distance between two nodes, the slower they appear to be moving with respect to each other. Accordingly, location information in routing table can be updated as a function of the distances separating nodes without compromising the routing accuracy.

Main advantage of this approach is that the algorithm is fully distributed, provides loop-free paths, and is robust, since it supplies multiple routes. It minimizes the amount of bandwidth and transmission power needed to maintain routing tables without penalizing the accuracy of the routing tables. Lower the end-to-end delay, also robust in providing multiple routes to a given destination.

Limitation of this approach is that it is not scalable and requires large number of beacon updates.

3. PROPOSED SYSTEM

3.1 Adaptive Position Update

The proposed system is based on update the location of mobile node. Based on the mobility dynamics of the nodes and the forwarding patterns in the network the APU strategy dynamically adjusts the beacon update intervals.

Initially, 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 location updates received from its neighbors, each node continuously updates its local topology, which is represented as a neighbor list. Instead of periodic beaconing, 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. Adaptive Position Updates [APU] strategy eliminates the drawbacks of periodic beaconing. APU employs two mutually exclusive beacon triggering rules,

1] Mobility Prediction rule
2] On-Demand Learning rule

Adaptive Position Updates uses two principles 1) nodes that are frequently changing its position are updated frequently 2) nodes which are in forwarding path are updated. 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. (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.

3.1.1 Mobility Prediction Rule

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. A periodic beacon update policy cannot satisfy both these requirements simultaneously, since a small update interval will be wasteful for slow nodes, whereas a larger update

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interval will lead to inaccurate position information for the highly mobile nodes.

This section shows the importance of mobility prediction in routing Ad Hoc networks, by giving a simple mobility scenario. Fig.1 represents an Ad Hoc networks containing four nodes which are A, B, C and D. A is stable, C moves slowly towards A and B moves rapidly away from A and D. A has data packets to send to D. It finds that to reach D, packets can pass either through B, or through C. If A chooses B as intermediate node, then the communication will not last long time since the link (A,B) will be rapidly broken, due to the mobility of B. But if A, takes into account the mobility of B and C, it will choose C as intermediate node because the expiration time of the link (A,C) is superior to that of (A, B), since C have chance to remain in A transmission range, more than B. The fact that A chooses C as next hop to reach D contributes to the selection of the path which has the greatest expiration time or the most stable path.

The MP rule thus, tries to maximize the effective duration of each beacon, by broadcasting a beacon only when the position information in the previous beacon becomes inaccurate. Further, highly mobile nodes can broadcast frequent beacons to ensure that their neighbors are aware of the rapidly changing topology.

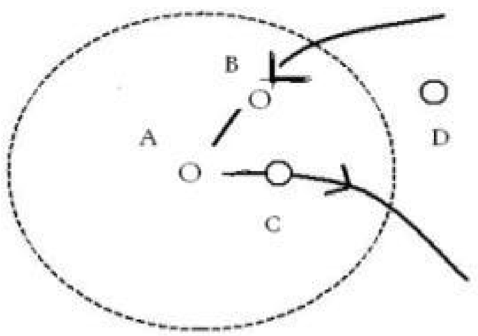
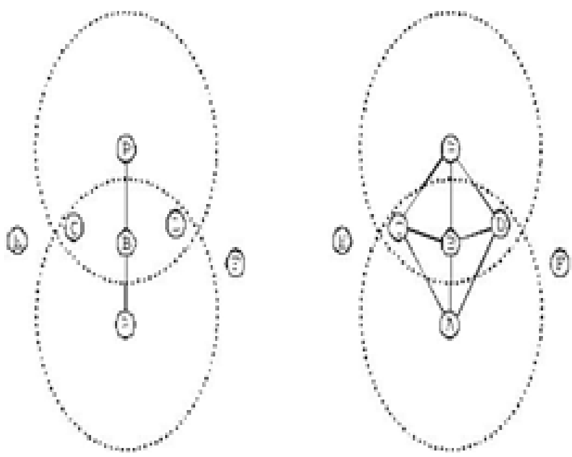


Figure.1: Simple mobility scenario in an Ad Hoc network.

3.1.2 on-Demand Learning Rule

It is necessary to devise a mechanism, which will maintain a more accurate local topology in those regions of the network where significant data forwarding activities are on-going. This is precisely what the On-Demand Learning rule aims to achieve. As the name suggests, 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. By a new neighbor, we imply a neighbor who is not contained in the neighbor list of this node. In reality, a node waits for a small random time interval before responding with the beacon to prevent collisions with other beacons. Recall that, we have assumed that the location updates are piggybacked on the data packets and that all nodes operate in the promiscuous mode, which allows them to overhear all data packets transmitted in their vicinity. In addition, since the data packet contains the location of the final destination, any node that overhears a data packet also checks its current location and determines if the destination is within its transmission range. If so, the destination node is added to the list of neighboring nodes, if it is not already present. Note that, this particular check incurs zero cost, i.e., no beacons need to be transmitted. We refer to the neighbor list developed at a node by virtue of the initialization phase and the MP rule as the basic list. This list is mainly updated in response to the mobility of the node and its neighbors. The ODL rule allows active nodes that are involved in data forwarding to enrich their local topology beyond this basic set. In other words, a rich neighbor list is maintained at the nodes located in the regions of high traffic load. Thus, the rich list is maintained only at the active



(a) (b)

Figure2. An example illustrating the ODL rules.

Nodes and is built reactively in response to the network traffic. All inactive nodes simply maintain the basic neighbor list. By maintaining a rich neighbor list along the forwarding path, ODL

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ensures that in situations where the nodes involved in data forwarding are highly mobile, alternate routes can be easily established without incurring additional delays.

Fig. 2a illustrates the network topology before node A starts sending data to node P. The solid lines in the figure denote that both ends of the link are aware of each other. The initial possible routing path from A to P is A-B-P. Now, when source A sends a data packet to B, both C and D receive the data packet from A. As A is a new neighbor of C and D, according to the ODL rule, both C and D will send back beacons to A. As a result, the links AC and AD will be discovered. Further, based on the location of the destination and their current locations, C and D discover that the destination P is within their one-hop neighborhood. Similarly, when B forwards the data packet to P, the links BC and BD are discovered. Fig. 2b reflects the enriched topology along the routing path from A to P.

Note that, though E and F receive the beacons from C and D, respectively, neither of them responds back with a beacon. Since E and F do not lie on the forwarding path, it is futile for them to send beacon updates in response to the broadcasts from C and D. In essence, ODL aims at improving the accuracy of topology along the routing path from the source to the destination, for each traffic flow within the network.

4. SIMULATION RESULTS

In this section, we present a comprehensive simulation based evaluation of APU using the popular NS-2 simulator. We compare the performance of APU with other beaconing schemes. These include two recently proposed adaptive beaconing schemes in [13]: (i) Distance-based Beaconing and (ii) Speed-based Beaconing.

This APU scheme is compatible with any geographic routing protocol. In this study, we have incorporated the APU strategy in the popular GPSR protocol, which we refer to as GPSR-APU. In this section, we present a simulation-based comparison of GPSR-APU with the Distance based and Speed based beaconing schemes. We initially use a random topology which allows us to study the effect of varying the node mobility on the performance of GPSR-APU. In addition, we have also studied the effect of the traffic load on APU using a realistic vehicular network. The percentage of data packets that were routed over the shortest-hop path to the destination. Since in geographic routing protocols, each node is unaware of the entire network topology, the forwarding path chosen may be longer than the optimal shortest-hop path.

APU gives better performance as compared to Distance based and Speed based beaconing schemes in terms of packet delivery ratio, Routing overhead and Throughput, end-to end delay. Distance based and speed based beaconing schemes are implemented by using an AODV protocol and APU is implemented using an GPSR protocol so the comparison of Distance based and Speed based beaconing with APU is also a comparison between AODV and GPSR.

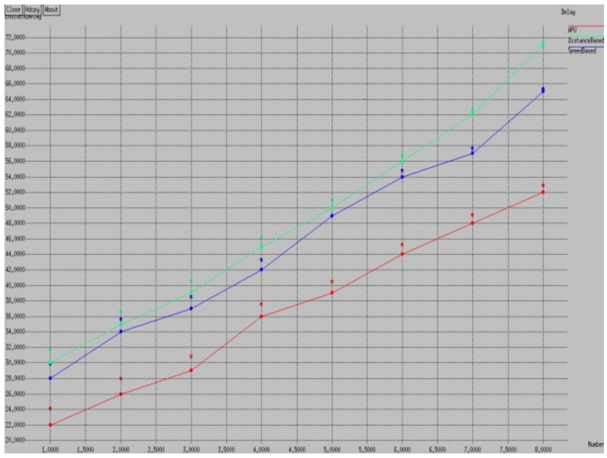

Figure 3.End to End Delay

In the above Figure 3 the end to end delay of APU is less then both the Distance based and Speed based beaconing scheme which implies that the proposed APU achieves better performance in terms end to end delay as compare to other beaconing schemes.

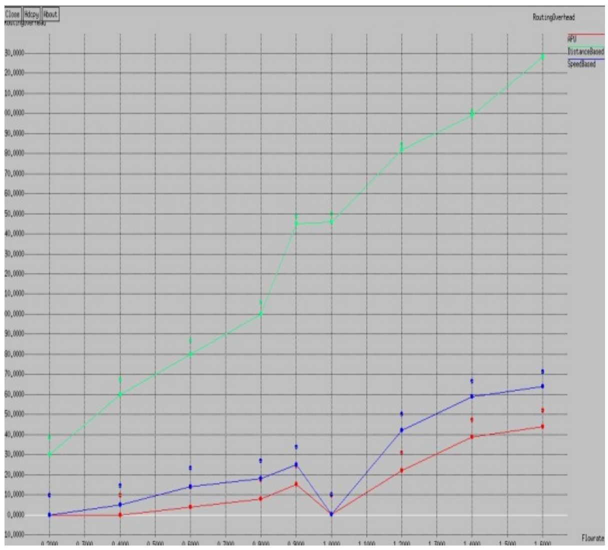

Figure4. Routing Overhead graph

The above graph given in Figure 4 is of Routing overhead in which the proposed APU gives based

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better performance in terms of Routing overhead because the Routing overhead generated in this scheme is Less compare to Distance based and Speed based beaconing schemes.

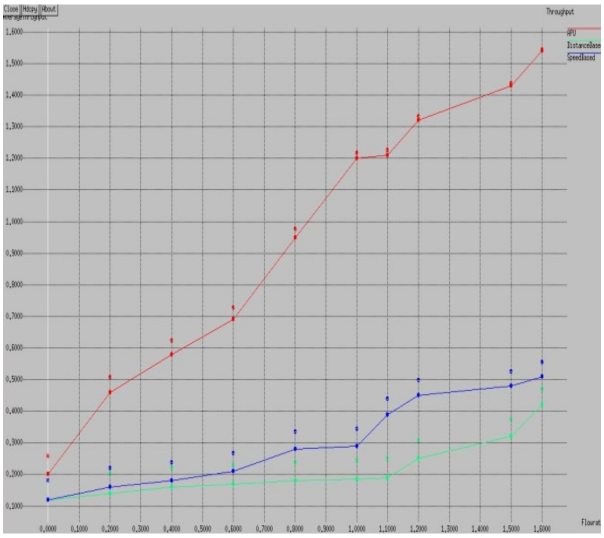

Figure5. Throughput graph

In the above Figure 5 the Throughput of APU is high then both the Distance based and Speed based beaconing scheme which implies that the proposed APU achieves better performance in terms Throughput as compare to other beaconing schemes.

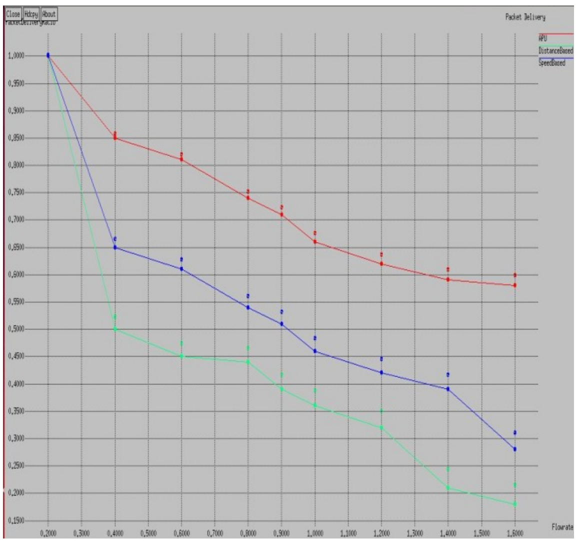

Figure6.Packet delivery ratio graph

In the above Figure6 the Packet delivery ratio of APU is high then both the Distance based and Speed based beaconing scheme which implies that the proposed APU achieves better performance in terms Packet delivery ratio as compare to other beaconing schemes.

5. CONCLUSION

This paper helps in identifying the need to adapt the beacon update policy employed in geographic routing protocols to the node mobility dynamics and the traffic load. And the Adaptive Position Update strategy is 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.

By mathematically analyzing the beacon overhead and local topology accuracy of APU and validating the analytical model with the simulation results. We have embedded APU within GPSR and have compared it with similar amount of beacon overhead as other beaconing schemes but achieve better packet delivery ratio, average end-to-end delay, Routing overhead and Throughput. 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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