An Efficient Adaptive Position Update for Geographic Routing in MANET

Aqeela S. Ummer
Student, Computer Science Dept.
MES College of Engineering
Kuttippuram, India

Sreekanth E. S.
Asst.Prof., Computer Science Dept.
MES College of Engineering
Kuttippuram, India

***Abstract*—Routing of packets in mobile ad hoc networks with a large number of nodes or with high mobility is a very difficult task. In geographic routing, nodes need to maintain up-to-date positions of their immediate neighbors for making effective forwarding decisions. To achieve the requirement of up-to-date location information, many location update schemes have been proposed. Periodic broadcasting of beacon packets that contain the geographic location co-ordinates of the nodes is a popular method used by most geographic routing protocols to maintain neighbor positions. Some routing protocols do not require the proactive transmission of control messages which saves network resources. An Adaptive Position Update (APU) strategy is implemented which dynamically adjusts the frequency of position updates based on the mobility dynamics of the nodes and the forwarding patterns in the network. Setting the periodicity of checking location according to the mobility, can make the existing scheme more efficient. Mobility prediction is used differently for finding a node's own location and that of its neighbors.**

Keywords—Geographic routing; Periodic broadcasting; Adaptive Position Update; Mobility Prediction

I. INTRODUCTION

Mobile Ad Hoc NETworks (MANET) are a set of wireless mobile nodes that do not require a pre-established infrastructure. Due to frequent change in topologies, routing in MANET becomes a challenging task to deal with. Position information available at each node is the key enabler for position-based routing protocols to enhance routing. Forwarding decisions are based on absolute or relative position of the current node, the positions of neighboring nodes and the destination. In position-based routing protocols, nodes periodically broadcast beacons to announce their presence and location to their neighbors. Each node stores all neighbors and their current positions in a neighbor table. This table contains all nodes within the transmission range from which it receives beacons. If a node does not receive any beacon from one of its neighbors within a certain time interval, called neighbor time-out interval, the corresponding node is considered to have left the transmission range or is unreachable and is deleted from the neighbor table. Routing of packets is done based on the positions of nodes in the neighbor table. Inaccurate or outdated neighborhood information may severely affect position-based routing protocols because the data packets may not be delivered to the next hop or may be delivered to sub-optimally located neighbors. So mechanisms that improve the accuracy of neighborhood information is very essential.

II. LITERATURE SURVEY

Several location update schemes are there for mobile ad hoc networks. Some of the approaches are described here.

A. Quorum based location update

Quorum-based approaches for information dissemination are based on replicating location information at multiple nodes acting as location servers along north and south directions of a node updating its location server ie, column of current location of updating node. In quorum systems [1], information updates are sent to a group (quorum) of available nodes and information queries to another quorum. Updated information is found only at nodes available at the intersection of these quorums. Location update is triggered whenever a link or edge is broken or created.

B. Home agent based location update

Another method is home agent based location update scheme [3], where each node selects a circular area as its home agent and informs other nodes about it. When a node moves away to a new location update messages are sent only to nodes located within its home agent. The update may fail if home agent is disconnected from the current node location. Such failure may be reported back to the node, which will then choose a new home.

C. Periodic beaconing

Periodic broadcasting of beacon packets, that contain the geographic location coordinates of the nodes, is a popular method used by most geographic routing protocols (GPSR) [5]. This helps to maintain up to date positions of neighbor nodes. Periodic beaconing is done regardless of the node mobility and traffic patterns in the network.

D. Beaconless routing

Beacon-less Routing protocol (BLR) does not require nodes to periodically broadcast hello messages and thus avoids drawbacks such as extensive use of scarce batterypower, interferences with regular data transmission, and outdated position information in case of high mobility[7].

E. Distance based beaconing

M.Heissenbuttel, T.Braun and T.Bernoulli[8] have discussed the limitations, alternatives in beaconing and proposed some optimizations. In distance based beaconing, a node transmits a beacon when it has moved a certain 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 timeout.

F. Speed based beaconing

The beacon interval is dependent on the node speed in speed based beaconing. A node determines its beacon interval from a predefined range with 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.

G. Reactive beaconing

In reactive beaconing, the beacon generation is triggered by data packet transmissions. When 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, the node can build an accurate local topology before the data transmission.

III. ADAPTIVE POSITION UPDATE

Adaptive Position Updates (APU) is a modified beaconing strategy for geographic routing protocols. It eliminates the drawbacks of periodic beaconing by adapting to the system variations [9]. 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. APU incorporates two rules for triggering the beacon update process –Mobility Prediction (MP) rule and On Demand Learning (ODL) rule.

A. Mobility Prediction (MP) rule

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

In APU, 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 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. It is assumed that the nodes are located in a 2D coordinate system with the location indicated by the x and y coordinates. Given the position of node i and its velocity along the x and y axes at time T_l, its neighbors can estimate the current position of i, ie, predicted position, by using the following equations:

$$X^i{}_p = X^i{}_l + (T_c - T_l) * V^i{}_x \quad (1)$$

$$Y^i{}_p = Y^i{}_l + (T_c - T_l) * V^i{}_y \quad (2)$$

Here, $X^i{}_l$, $Y^i{}_l$ and $V^i{}_x$, $V^i{}_y$ refers to the location and velocity information that was broadcast in the previous beacon from node i. T_c gives the current time. Node i uses the same prediction scheme to keep track of its predicted location among its neighbors. Let (X_a, Y_a), denote the actual location of node i, obtained via GPS or other localization techniques. Node i then computes the deviation $D^i{}_{devi}$ as follows:

$$D^i{}_{devi} = \sqrt{(X^i{}_a - X^i{}_p)^2 + (Y^i{}_a - Y^i{}_p)^2} \quad (3)$$

If the deviation is greater than a certain threshold, known as the Acceptable Error Range (AER), it acts as a trigger for node i to broadcast its current location and velocity as a new beacon. The MP rule, thus, tries to maximize the effective duration of each beacon, by broadcasting a beacon only when the predicted position information based on the previous beacon becomes inaccurate. This extends the effective duration of the beacon for nodes with low mobility, thus reducing the number of beacons. Further, highly mobile nodes can broadcast frequent beacons to ensure that their neighbors are aware of the rapidly changing topology.

B. On Demand Learning (ODL) rule

The MP rule alone may not be sufficient for maintaining an accurate local topology. It has disadvantages also. Consider the example in the fig.1, where node A moves from P1 to P2 at a constant velocity. Assume that node A has just sent a beacon while at P1. Since node B did not receive this packet, it is unaware of the existence of node A. If AER is sufficiently large, when node A moves from P1 to P2, the MP rule is never triggered. However, node A is within the communication range of B for a significant portion of its motion. Even then, neither A nor B will be aware of each other. In situations where neither of these nodes are transmitting data packets, this is perfectly fine since they are not within communicating range once A reaches P2. But, if either A or B was transmitting data packets, then their local topology will not be updated and they will exclude each other while selecting the next hop node. Assuming no other nodes were in the vicinity, the data packets would not be transmitted at all. Hence, there should be a mechanism, which will maintain a more accurate local topology in those regions of the network where significant data forwarding activities are on-going.

On Demand Learning (ODL) rule aims to achieve this need. With this rule, a node broadcasts beacons on-demand, i.e., in response to data forwarding activities that occur in the vicinity of that node. According to this rule, whenever a node overhears a data transmission from a new neighbor, it broadcasts a beacon as a response. New neighbor, is a neighbor who is not contained in the neighbor list of this node. It is 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. 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.

The neighbor list is referred to, as the list developed at a node by virtue of the initialization phase. And that list developed by MP rule, is 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. Thus, a rich neighbor list is maintained at the nodes located in the regions of high traffic load. The rich list is maintained only at the active 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 ensures that in situations where the nodes involved in data forwarding are highly mobile, alternate routes can be easily established without incurring additional delays.

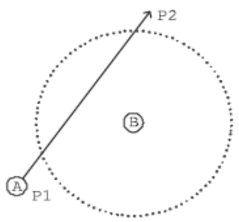

Fig. 1. Drawback of MP rule

IV. PROBLEM DEFINITION

The APU strategy can reduce update cost to some extent. It generates less or similar amount of beacon overhead as other beaconing schemes, but the beacon overhead is still a disadvantage which affects the performance of geographic routing.

Upon receiving a beacon update from a node *i*, each of its neighbors records node i's current position and velocity and track node i's location using MP rule. It estimates the position of the neighbors periodically, to check whether a node is its neighbor or not. This periodicity, ie, how often the location tracking is done, is not well defined in the method. If the period is larger, then the node will have more stale entries in the base list. If the period is less, then the node will have to invoke the calculation more often which is a burden to the node.

While the beaconing frequency can be adapted to the degree of mobility, a fundamental problem of inaccurate (outdated) position information is always present. There is a possibility that a node updated by ODL rule may no longer be in the transmission range. If the node is close to the boundary of the transmission range, it increases the probability that the node will soon become unreachable. This leads to a significant decrease in the packet delivery rate with increasing node mobility.

V. PROPOSED WORK

The existing Adaptive Position Update strategy has many advantages that is required in a mobile ad hoc network. But, it has drawbacks too. There are possible solutions also for some of them, which can improve the existing method. This section deals with such modifications made to the existing system.

A. Variation in MP rule

The Mobility Prediction (MP) rule and On Demand Learning (ODL) rule are the main two components in APU method. The issue in the MP rule is that the periodicity of location tracking is not well defined. Each node executes two types of location tracking – one is checking its own location among others, for deciding the beacon transmission, and the other is tracking the location of its neighbors. To improve the existing approach, a variation of MP rule could be considered, both applied from the point of view of the self and from the view of neighbors. When applying MP rule for self, the periodicity may be set based on the following constraint- If a node i is moving at a greater speed, set the period to be a smaller value, otherwise set a larger value. Thus, adapting the prediction to the node mobility, wrong entries in the base list can be avoided.

Another issue in MP rule is that tracking of all the neighbors periodically incurs computational overhead. This can be rectified by modifying the MP rule for checking location of neighbors, ie, by defining when to track the location. When applying MP rule for the neighbors, mobility prediction for the neighbors (of i) may be done only when node i has some data to transmit. Thus the base list is updated only when we have data to transmit. Since, the neighborhood information is essential only at the time of data transmission, this change will not seriously affect the routing performance. Thus we could reduce the computational load at the nodes, but still maintaining accurate topology, by predicting the location of self with respect to others.

B. Variation in ODL rule

The issue in ODL rule is that, the updated node which is close to the boundary region has a chance to move out the next moment. This problem can be solved by combining MP rule and ODL rule, ie, ODL rule may be followed along with MP rule. When packet transmission is overheard, according to ODL rule, the nodes in the forwarding path send beacons in response. This beacon updation need not be done every time they overhear the transmission. Instead, calculate the validity of the previous beacon using MP rule or check the velocity of the node, and then decide whether to send the beacon or not. If the node is moving so fast there is no point in updation. So, beacon updation may be ignored for fast moving nodes, comparing with certain threshold. Thus, it can maintain accurate local topology. The modifications discussed here can thus overcome both communication overhead and computational overhead.

VI. Results and Discussion

The proposed method is implemented using ns2. Nodes are mobile and has random movement. The proposed work has been compared with Adaptive Position Update method based on various parameters such as packet overhead, computation overhead, energy consumption and packet delivery ratio.

By setting the period of prediction according to the node mobility, the beacon overhead can be reduced to some extent. The packet overhead of APU method and the proposed method are shown in Fig. 2.

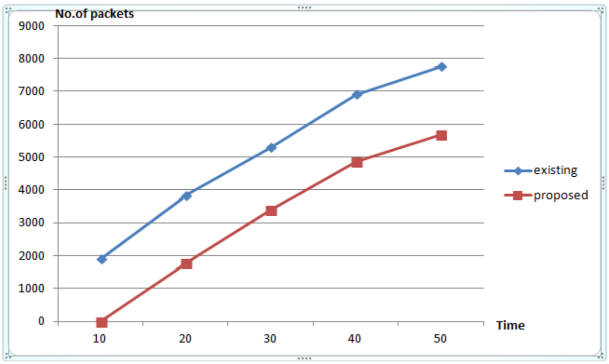

Fig. 2. Packet overhead

In the proposed method, prediction of the location of the neighbors is done only during the data transmission, instead of periodic prediction. Hence, there is a significant change in the number of predictions required for the location update, reducing the computational overhead. Fig. 3 shows the change in existing and proposed system.

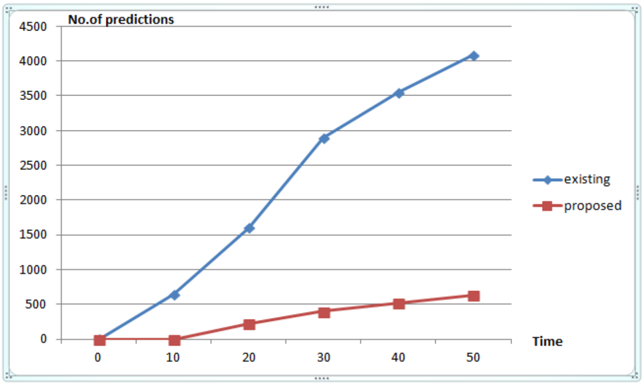

Fig. 3. Computational overhead

Fig. 4 shows the energy consumption of existing and proposed system. The energy consumed is low for proposed method when compared to the APU method, since there is a decrease in beacon overhead.

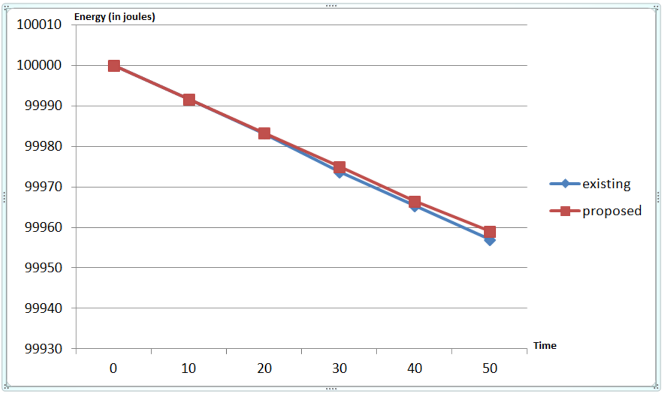

Fig. 4. Energy consumption

Even though the modifications made decrease the overhead and energy consumption, it does not affect the packet delivery ratio. The changes in ODL rule helps in maintaining the accurate local topology and thus the packet delivery ratio. From fig. 5, it is clear that the new method maintains the stable packet delivery ratio.

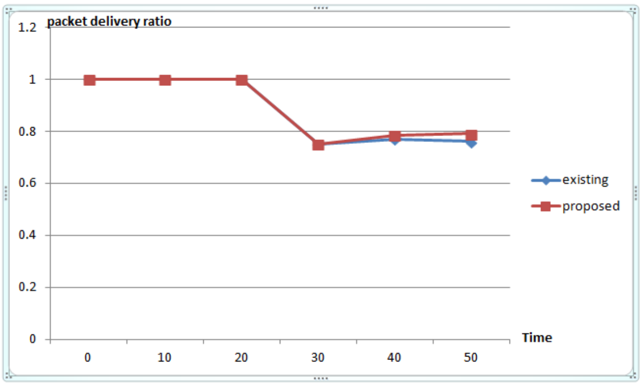

Fig. 5. Packet delivery ratio

VII. Conclusion and Future work

Routing of packets in mobile ad hoc networks is done based on the positions of nodes in the neighbor table. Inaccurate or outdated neighborhood information severely affects the routing performance of position based routing protocols. Various location update schemes and their drawbacks were studied. Among them, Adaptive Position Update method finds better results. Mobility Prediction Rule helps to adapt the beacon generation rate to the frequency with which the nodes change the characteristics that govern their motion. On-Demand Learning (ODL) rule, aims at improving the accuracy of the topology along the routing paths between the communicating nodes. By using the variation of MP rule, communication overhead and computational overhead can be reduced. Thus better results are obtained. It helps to reduce the overhead, maintaining the accurate topology and the routing performance.

For efficient routing in wireless network, research on location update mechanisms is necessary. Effective mechanisms have to be explored that can maintain accurate local topology and adapt with highly dynamic networks. No single update scheme under study provides the best results for the entire performance metrics. Therefore, possibility of either a new location update scheme or modifications to some of existing ones needs to be investigated.

Acknowledgment

I warmly thank all my friends for their cooperation, positive criticism, consistent support and consideration during the preparation of this work.

References

[1] Stojmenovic I., Pena P.E.V., “A Scalable Quorum Based Location Update Scheme for Routing in Ad Hoc Wireless Networks ", Computer Science, SITE, Sept 1999.

[2] Ivan Stojmenovic, “Location Updates for Efficient Routing in Ad Hoc Networks ", Handbook of Wireless Networks and Mobile Computing, 2002.

[3] Ivan Stojmenovic, “Home agent based location update and destination search schemes in ad hoc wireless networks", Advances in Information Science and Soft Computing, WSEAS, 2002.

[4] Khaled Omer, Daya Lobiyal, “Performance Evaluation of Location Update Schemes in Mobile Ad Hoc Networks", The International Arab Journal of Information Technology, July 2005.

[5] Brad Karp, H.T. Kung, “GPSR: Greedy Perimeter Stateless Routing for Wireless Networks", ACM/IEEE International Conference on Mobile Computing and Networking, July 2006.

[6] Torsten Braun, Marc Heissenbuttel, Tobias Roth, “Performance of the beacon-less routing protocol in realistic scenarios", Elsevier- Ad hoc networks, 2010.

[7] Juan A. Sanchez, Rafael Marin-Perez, Pedro M. Ruiz, “Beacon-Less Geographic Routing in Real Wireless Sensor Networks", Journal of Computer science and technology, May 2008.

[8] M. Heissenbuttel, Torsten Braun, Markus Walchli, Thomas Bernoulli, “Evaluating the limitations of and alternatives in beaconing", Elsevier- Ad hoc networks, 2007.

[9] Quanjun Chen, Salil S. Kanhere, Mahbub Hassan, “Adaptive Position Update for Geographic Routing in Mobile Ad Hoc Networks", IEEE Transactions on Mobile computing, March 2013.