Effective Wireless Ad-hoc routing communication using APU

Kavitha.S [1], ***K.Loheswaran*** [2]
[1]PG Scholar, [2]Assistant Professor
[1, 2] Department of Computer Science and Engineering
[1, 2] Sasurie College of Engineering
Vijayamangalam, India
[1]kavithasavithiri124@gmail.com
[2] loheswaran.k@gmail.com

Abstract – Abstract: Geographic routing protocols are best choice for managing positioning devices and other localization schemes in mobile ad hoc network. Most geographic routing protocols uses Periodic broadcasting of beacon packets that contain the geographic location coordinates of the nodes to maintain neighbour positions. Adaptive Position Update strategy for geographic routing, which dynamically adjusts the frequency of position is proposed. Adaptive Position Update strategy is based on two simple principles, first principle states that the nodes whose movements are harder to predict update their positions more frequently(and vice versa).second principle states that the nodes closer to forwarding paths update their positions more frequently(and vice versa). 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 schemes.

Index Terms—Wireless communication, algorithm/protocol design and analysis, routing protocols

I. INTRODUCTION

With the growing popularity of positioning devices (e.g., GPS) and other localization schemes , 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 neighbors, which is geographically closest to the destination. Since the forwarding decision is based entirely on local knowledge, it obviates the need to create and maintain routes for each destination. By virtue of these characteristics, position-based routing protocols are highly scalable and particularly robust to frequent changes in the network topology. Furthermore, since the forwarding decision is made on the fly, each node always selects the optimal next hop based on the most current topology. Several studies have shown that these routing protocols offer significant performance improvements over topology-based routing protocols such as DSR and AODV. 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 former can be obtained by querying a location service such as the Grid Location System (GLS) or Quorum. 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. In most geographic routing protocols, beacons are broadcast periodically for maintaining an accurate neighbor list at each node.

Position updates are costly in many ways. Each update consumes node energy, wireless bandwidth, and increases the risk of packet collision at the medium access control layer. Packet collisions cause packet loss which in turn affects the routing performance due to decreased accuracy in determining the correct local topology. A lost data packet does get retransmitted, but at the expense of increased end-to-end delay. Clearly, given the cost associated with transmitting beacons, it makes sense to adapt the frequency of beacon updates to the node mobility and the traffic conditions within the network, rather than employing a static periodic update policy. For example, if certain nodes are frequently changing their mobility characteristics, it makes sense to frequently broadcast their updated position. However, for nodes that do not exhibit significant dynamism, periodic broadcasting of beacons is wasteful. Further, if only a small percentage of the nodes are involved in forwarding packets, it is unnecessary for nodes which are located far away from the forwarding path to employ periodic beaconing because these updates are not useful for forwarding the current traffic. In this paper, we propose a novel beaconing strategy for geographic routing protocols called Adaptive Position Updates strategy .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, uses a simple mobility prediction scheme to estimate when the location information broadcast in the previous beacon becomes inaccurate. The next beacon is broadcast only if the predicted error in the location estimate is greater than a certain threshold, thus tuning the update frequency to the dynamism inherent in the node's motion. The second rule, referred as On-Demand Learning, 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. 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. In the first set of simulations, we evaluate the impact of varying the mobility dynamics and traffic load on the performance of APU and also compare it with periodic beaconing and two recently proposed updating schemes: distance-based and speed-based beaconing. The simulation results show that APU can adapt to mobility and traffic load well. For each dynamic case, APU generates less or similar amount of beacon overhead as other beaconing schemes but achieve better performance in terms of packet delivery ratio, average end-to-end delay and energy consumption. In the second set of simulations, we evaluate the performance of APU under the consideration of several real-world effects such as a realistic radio propagation model and localization errors. The extensive simulation results confirm the superiority of our proposed scheme over other schemes. The main reason for all these improvements in APU is that beacons generated in APU are more concentrated along the routing paths, while the beacons in all other are scattered in the whole network. As a result, in APU, the nodes located in the hotspots, are responsible for forwarding most of the data traffic in the network have an up-to-date view of their local topology, thus resulting in improved performance. The rest of paper is organized as follows: In Section 2, we briefly discuss related work. A detailed description of the APU scheme is provided in Section 3, followed by a comprehensive theoretical analysis in Section 4. Section 5 presents a simulation-based evaluation highlighting the performance improvements achieved by APU in comparison with other schemes.

2 RELATED WORK

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 approach therefore is adaptive to the node mobility, e.g., a faster moving node sends beacons more frequently and vice versa. However, this approach has two problems. First, a slow node may have many outdated neighbors in its neighbor list since the neighbor time-out interval at the slow node is longer. Second, when a fast moved node passes by a slow node, the fast node may not detect the slow node due the infrequent beaconing of the slow node, which reduces the perceived network connectivity.

In the speed-based beaconing, the beacon interval is dependent on the node speed. A node determines its beacon interval from a predefined range ½a; 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.

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. This process is initiated prior to each data transmission, which can lead to excessive beacon broadcasts, particularly when the traffic load in the network is high.

The APU strategy proposed in this work dynamically adjusts the beacon update intervals based on the mobility dynamics of the nodes and the forwarding patterns in the network. The beacons transmitted by the nodes contain their current position and speed. Nodes estimate their positions periodically by employing linear kinematic equations based on the parameters announced in the last announced beacon. If the predicted location is different from the actual location, a new beacon is broadcast to inform the neighbors about changes in the node’s mobility characteristics. Note that, an accurate representation of the local topology is particularly desired at those nodes that are responsible for forwarding packets. Hence, APU seeks to increase the frequency of beacon updates at those nodes that overhear data packet transmissions. As a result, nodes involved in forwarding packets can build an enriched view of the local topology.

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3 ADAPTIVE POSITION UPDATE

We begin by listing the assumptions made in our work:

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. 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 employs two mutually exclusive beacon triggering rules, which are discussed in the following.

4 MOBILITY PREDICTION

Mobile Ad hoc networks (MANETs) are composed of mobile nodes connected by wireless links. All nodes can freely and dynamically self-organize into arbitrary and temporary “Ad Hoc” network topologies. MANETs are self-organizing networks because they do not use any infrastructure such as base station or router. This implies that every node performs as a host as well as a router since it is in charge of routing information between its neighbors, contributing to and maintaining connectivity of the network. Thus, in a MANET, the routing protocol used is of primary importance because it determines how a data packet is transmitted over multiple hops from a source node to a destination node.

By exploiting non-random behaviors for the mobility patterns that mobile user's exhibit, we can predict the future state of network topology and perform route reconstruction proactively in a timely manner. Moreover, by using the predicted information on the network topology, we can eliminate transmissions of control packets otherwise needed to reconstruct the route and thus reduce overhead. In this paper, we propose various schemes to improve routing protocol performances by using mobility prediction. We then evaluate the effectiveness of using mobility prediction via simulation

Mobility characteristics includes the following speed, predictability, direction of movement pattern of movement uniformity (or lack thereof) of mobility characteristics among different nodes.

Uses of mobility prediction involves prediction the future state of network topology, proactive route reconstruction, eliminate transmission of control packets, reduce overheads, minimize disruptions and find routes in a timely manner, improve routing protocol performance.

For an example Sender S trying to reach D will broadcasts data packet P to all its neighbors, Each node receiving P forwards P to its neighbors, Sequence numbers used to avoid the possibility of forwarding the same packet more than once, Packet P reaches destination D provided that D is reachable from sender S, Node D does not forward the packet.

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.

In mobility prediction, 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 neighbour 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.

6 ON DEMAND LEARNING

The MP rule solely may not be sufficient for maintaining an accurate local topology. Node A move in a direction. Node B also dynamic, when they are at certain distance they cannot communicate. When node A moves a certain distance towards B unknowingly, then it begins communication. 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. In the worst case, assuming no other nodes were in the vicinity, the data packets would not be transmitted at all. Hence, 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, 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. As assumed early 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. Node refers 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 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.

7 CONCLUSION

Detailed analysis using adaptive position updating, identified the need to adapt the beacon update policy employed in geographic routing protocols to the node mobility dynamics and the traffic load. Adaptive Position Update strategy to address these problems is studied. 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. Mathematically analyzed the beacon over- head and local topology accuracy of APU and validated the analytical model with the simulation results. The results indicate that the APU strategy generates less or similar amount of beacon overhead as other beaconing schemes but achieve better packet delivery ratio, average end-to-end delay and energy consumption. In addition, 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 is studied. 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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