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RESEARCH ARTICLE

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MOBILITY BASED FORWARDING NODE SELECTION USING ADAPTIVE POSITION UPDATE IN 'MANET'

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ABSTRACT

It is a challenge to develop routing scheme that can meet different application needs and optimize routing paths according to the topology change in mobile ad hoc networks. In geographic routing, nodes need to maintain up-to-date positions of their immediate neighbors for making effective forwarding decisions. Hence each node should update its location information through a message called beacon. Existing routing mechanisms invokes periodic beacon update scheme which is not attractive from both update cost and routing performance points of view. The Proposed Routing scheme Adaptive Position Update (APU) can be effectively used in geographic routing, based on two simple rules: (1) Mobility Prediction, and (2) On-Demand Learning, which dynamically adjusts the frequency of position updates based on the mobility dynamics of the nodes and the forwarding patterns in the network, attractive for update cost and routing performance. Our route optimization scheme adapts the routing path according to both topology changes and actual data traffic requirements by selecting the nodes with low mobility which means selection of stable node's as forwarder based on its mobility. Simulation studies have shown that the proposed routing scheme are more robust and outperform the existing geographic routing scheme by achieving higher packet delivery ratio and reducing the packet delivery latency.

Keywords—Mobile Ad Hoc Networks, geographic routing, algorithm design and analysis

INTRODUCTION

There are increasing interest and use of mobile ad hoc networks with the fast progress of computing techniques and wireless networking techniques. In a Mobile Ad-hoc Network (MANET), wireless devices could self-configure and form a network with an arbitrary topology. The network's topology may change rapidly and unpredictably. Such a network may operate in a stand-alone fashion, or may be connected to the larger Internet. Mobile ad-hoc networks became a popular subject for research in recent years, and various studies have been made to increase the performance of ad hoc networks and support more advanced mobile computing and applications.

The topology of a Mobile Ad Hoc Network (MANET) is very dynamic, which makes the design of routing protocols much more challenging than that of a wired network. Geographic routing protocols are generally more scalable and reliable [1], [2] based routing protocols with their forwarding decisions based on the local topology. With the growing popularity of positioning devices (e.g., GPS) and other localization schemes [3], geographic routing protocols are becoming an attractive choice for use in mobile ad hoc networks [1], [2]. The underlying principle used in these schemes involves selecting the next routing hop from among a node's neighbours, 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.

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 neighbours. The former can be obtained by querying a location service such as the Grid Location System (GLS) [4] or Quorum [5]. To obtain the latter, each node exchanges its own location information (obtained using GPS or the localization schemes discussed in [3]) with its neighbouring 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 broadcast its updated location information to all of its neighbours. These location update packets are usually referred to as beacons. In most geographic routing protocols (e.g., GPSR [1], [6]), beacons are broadcast periodically for maintaining an accurate neighbour list at each node. But Position updates are costly in many ways, it 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 propose system include a novel beaconing strategy for geographic routing called Adaptive Position Updates strategy [7].

1. RELATED WORK

At each node of geographic routing, forwarding decision is based on locations on node's one-hop neighbours and other packet's destination. The nodes need to maintain these two types of locations. Many works have been proposed to discover and maintain the location of destination. Some geographic routing schemes assume forwarding node knows the location of its neighbours. While others, e.g. [1], [8], use periodical beacon broadcasting to exchange neighbours locations. In periodic beaconing scheme, each node broadcast beacon with fixed interval. A node does not hear any beacon from a neighbour a certain time interval, called neighbour time-out interval, the node considers this neighbour has moved out of radio range and remove the outdated neighbour from its neighbour list. The neighbour time-out interval often is multiple times of beacon interval. Heissenbuttel et al. [9] have shown that periodic beaconing can cause the inaccurate local topologies in mobile ad-hoc networks, which leads to performance degradation, i.e. frequent packet loss and longer delay. The proposed several simple optimizations that adapt beacon interval to node mobility or traffic load, including distance-based beaconing (DB), speed-based beaconing and reactive beaconing.

The adaptive position update (APU) strategy proposed in this work which dynamically adjusts the beacon update intervals based on mobility dynamics of node's and forwarding patterns in the network. The beacons transmitted by nodes contain their current position and speed. Nodes estimate their positions periodically. If the predicted location is different from the actual location, new beacon is broadcast to inform the neighbours about changes in node's mobility characteristics. But an accurate representation of the local topology is particularly desired at those nodes that are responsible for forwarding packets. Therefore 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.

2. PROPOSED SYSTEM

A. Mobility Prediction Rule

This rule adapts the beacon generation rate to the frequency with which the nodes change the characteristics that govern their motion (velocity and heading). The beacons transmitted by the nodes contain their current position and speed. Nodes estimate their positions periodically by employing 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 following figure 1 illustrates the Mobility Prediction of node *i* given the position and its velocity along the x and y axes at time T_l, its neighbors can estimate the current position of *i*, by using the following equations:

$$\begin{aligned} X_p^i &= X_l^i + (T_c - T_l) * V_x^i, \\ Y_p^i &= Y_l^i + (T_c - T_l) * V_y^i. \end{aligned} \qquad (1)$$

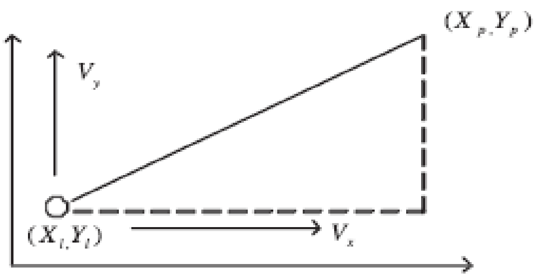

Figure1: An example of mobility prediction.

TABLE 1: Notations for Mobility Prediction

Variables	Definition
(X_l^i, Y_l^i)	The coordinate of node i at time T_l (included in the previous beacon)
(V_x^i, V_y^i)	The velocity of node i along the direction of the x and y axes at time T_l (included in the previous beacon)
T_l	The time of the last beacon broadcast
T_c	The current time
(X_p^i, Y_p^i)	The predicted position of node i at the current time

Note that, here $(X_l^i, Y_l^i)$and (V_x^i, V_y^i) refers to the location and velocity information that was broadcast in the previous beacon from node i. Node i uses the same prediction scheme to keep track of its predicted location among its neighbours. 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_{devi}^i as follows:

$$D_{devi}^i = \sqrt{(X_a^i - X_p^i)^2 + (Y_a^i - Y_p^i)^2}. \qquad (2)$$

If the deviation is greater than a certain threshold, know 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 neighbours are aware of the rapidly changing topology.

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.

B. On Demand Learning Rule

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. This ensures that nodes involved in forwarding data packet maintain more up-to date view of the local topology. On the contrary, nodes that are not in the vicinity of forwarding path are unaffected by this rule and do not broadcast beacons very frequently. The following figure 2 illustrates the ODL behavior

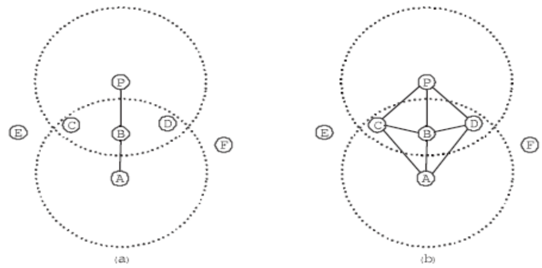

Figure 2: An example illustrating the ODL rule.

Figure (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 neighbour 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 neighbourhood. Similarly, when B forwards the data packet to P, the links BC and BD are discovered. Figure (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 respond back with a beacon. Since E and F do not lie in 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.

C. Mobility based forwarding node selection

In Mobile Ad-hoc Networks if forwarding nodes have high mobility, may chance to make local topology inaccuracy. If the node involved in the forwarding path moves frequently then there is the situation of frequent beacon update which leads to network traffic in turn packet collision. Hence it is required to select the nodes with low mobility which means selection of stable node's as forwarder based on its mobility.

Algorithm for selection of forwarder

Step1: Find distance [d(t)] of each neighbour from source at time T

Step2: Find distance [d(t+T)] of each neighbour from source at time (T+t)

Step3: If {[d(t+T)] ~[d(t)] < Threshold }→ Select the neighbour as high stable link

Step4: Find distance D_{des} between destination and the node having high stable link

Step5: Link having minimum D_{des} is selected as next hop

3. SIMULATION RESULTS

The simulations were run with 48 nodes randomly distributed in an area of 3000m×1500m. We chose a rectangular network area to obtain a longer path. The movement of node's follows the improved random waypoint mobility model. The moving pause time was set at 0 second, the minimum speed was 0m/s and the default maximum speed was 20 m/s except in the performance evaluation of the impact of mobility. A simulation result was gained by averaging over 20 runs with different seeds to increase the confidence of the results. We study the following metrics:

1) Beacon Overhead: The Number of messages involved in position update process. Figure 3 illustrates that the APU routing scheme generates less beacon overhead compared to Periodic routing scheme.

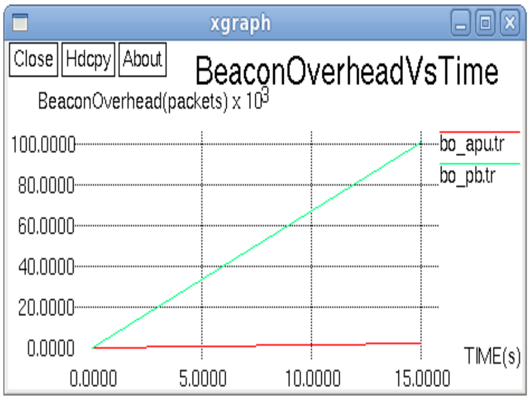

Figure3: Beacon Overhead (packets)

Beacon Overhead: The Number of messages involved in position update process. Figure 3 illustrates that the APU routing scheme generates less beacon overhead compared to Periodic routing scheme.

2) Packet Delivery Ratio: PDR is the proportion to the total amount of packets reached the receiver and amount of packet sent by source. The high mobility of nodes causes PDR to decrease. The following figure 4 shows the results obtained for PDR under varying mobility. It is obvious that the PDR ratio increases with time and outperform the existing approaches.

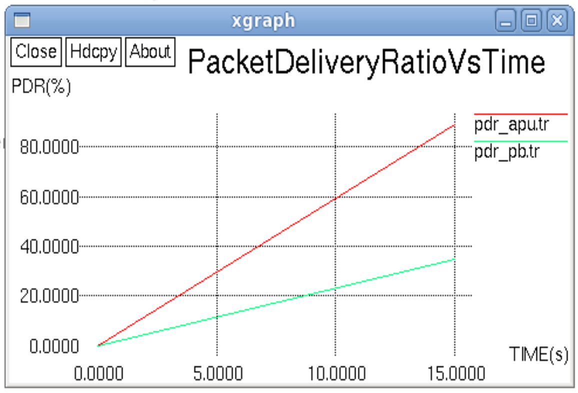

Figure4: Packet Delivery Ratio

3) Energy Consumption: The Energy Consumption depends on the amount of energy consumed by the sensors for the data transmission over the network. The following figure 5 shows that the energy consumed by each node is less compared to periodic approach routing.

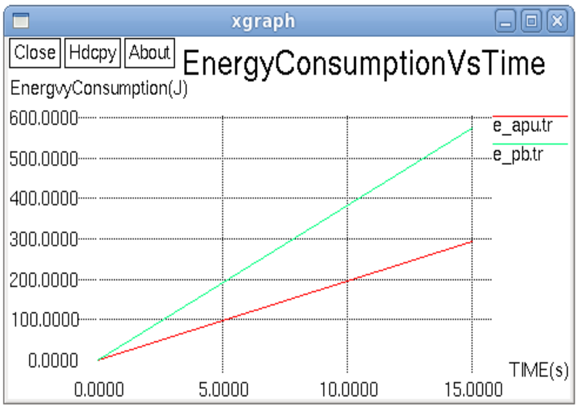

Figure5: Energy Consumption

CONCLUSION

In this paper, the need to adapt the beacon update is identified and the corresponding policy is employed in geographic routing scheme to the node mobility dynamics and the traffic load. The Adaptive Position Update (APU) routing scheme 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 packet that are overheard from new neighbours. The selection of highly stable node as forwarder based on its mobility outperform the existing geographic routing scheme by achieving higher packet delivery ratio and reducing the packet delivery latency. Performance of APU routing scheme is evaluated using extensive NS-2 simulations for varying node speeds and traffic load. Results indicate that the APU routing scheme generates less amount of beacon overhead as other beaconing schemes but achieve better packet delivery ratio, less overhead and energy consumption.

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