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Adaptive Quadrant-Based Geographic Routing For MANET

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ABSTRACT
Coping with mobility and dynamism is one of the biggest challenges 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. Periodic broadcasting of beacon packets that contain the geographic location coordinates of the nodes is a popular method used by most geographic routing protocols to maintain neighbor positions. We contend and demonstrate that periodic beaconing regardless of the node mobility and traffic patterns in the network is not attractive from both update cost and routing performance points of view. This paper propose an adaptive on-demand geographic routing scheme in which topology information is updated in a timely manner according to network dynamics and traffic demands to provide efficient and reliable routing. It uses a limited flooding routing protocol that restricts the broadcast region to all nodes in the same quadrant as the source and destination and does not require maintenance of a separate neighbor table at each node. As a result the number of broadcast messages decreases, reducing data flooding, providing improved channel efficiency and improves bandwidth utilization and lifetime of intermediate nodes which provides improved route stability. It proposes a route optimization scheme that adapts the routing path according to both topology changes and actual data traffic requirements.
Keywords:- ad hoc networks, geographic routing, quadrant-based forwarding, reactive, dynamic

I. INTRODUCTION

As technology advances, people are gaining more interest towards mobile devices, which makes it an attractive source for many new enhancements. The applications running on mobile devices most probably are not related to each other, and do not communicate. Nevertheless, there are scenarios where few devices move closer to each other forming a temporary network with an arbitrary topology allowing transfer of different kinds of data and information. Such networks are known as mobile ad hoc networks (MANET). Routing in MANET is a challenging task as the topology changes as node moves. To cope with the self- organizing, dynamic, volatile, peer-to-peer communication environment in a MANET, most of the main functionalities of the Networking protocols (i.e., network and transport protocols in the Internet architecture) need to be re-designed. Over the past several years, more than 50 MANET routing protocols have been proposed and can be categorized into topology-based and position-based protocols. In recent years, geographic unicast [2], [3], [4], [5] and multicast [6], [7] routing have drawn a lot of attentions. They assume mobile nodes are aware of their own positions through GPS or other localization schemes and a source can obtain the destinations position through some kind of location service [8].In geographic unicast protocols, an intermediate node makes packet forwarding decisions based on its knowledge of the neighbors positions and the destinations position inserted in the packet header by the source. The use of geolocation information avoids network-wide searches, as both control and data packets are sent towards the known geographical coordinates of the destination node. These features make location- aware routing protocols quickly adaptive to route changes, and more scalable than unicast protocols. In most geographic routing protocols [9],[10],[11] beacons are broadcast periodically for maintaining an accurate neighbor list at each mode. Such a proactive mechanism not only creates a lot of control overhead when there is no traffic, but also results in outdated topology knowledge under high dynamics. On the other hand beaconless schemes have been proposed [12],[13], [14], [15] to find the next-hop forwarders in the absence of beacons before each packet transmission. Although this avoids the overhead of sending periodic beacons when there is no traffic, the search of next- hop forwarder before each packet sending introduces a high overhead and end- to-end delay during packet transmissions [30]. MANET devices may be battery operated and therefore for mobile battery operated devices power efficiency is one of the key criteria for efficient and effective MANET routing. Power inefficient nodes tend to drop packets which reduce network .It is required to extend the longevity of nodes by utilizing effective and energy-saving algorithm.

The goal of our work is to develop a geographic routing scheme that can adapt to various scenarios to provide efficient and robust routing paths. First, to reduce control overhead. It adopts a reactive beaconing mechanism which is adaptive to the traffic need .The next-hop of a forwarding node is determined reactively with the combination of geographic-based and topology-based mechanisms. By incorporating topology based path searching, an important benefit of the proposed scheme is to obtain the topology information at a larger range when necessary to build more efficient routing path, while general geographic routing protocols are usually constrained by their local topology view. It uses a limited flooding routing protocol that concentrates on a specified zone relative to source and destination nodes. It restricts the broadcast region to all nodes in the same quadrant as the source and destination which will significantly reduce not only energy but also reduce the probability of packet collisions of messages rebroadcast by neighbors using the same transmission channel. This will result in reduced routing overhead especially in a dense network. Routing path is optimized with the cooperation of the forwarding node and its neighbors to avoid non-optimal routing due to the inaccuracy in topology knowledge.

The rest of this paper is organized as follows: In Section 2, we discuss some related work. Section 3 provides detailed descriptions of the protocol. Section 4 provide the proposed algorithm, performance analysis is explained in Section 5. Finally, Section 6 concludes the paper.

II. RELATED WORK

A wide variety of routing protocols have been proposed, all with their own strengths and weaknesses, and all with varying degrees of success. We will discuss literature work related to geographic routing protocols and on-demand routing protocols for MANET. The conventional on-demand routing protocols [17], [18] often involve flooding in route discovery phase, which limits their scalability. LAR [5] and DREAM [4] make use of the nodes position information to reduce the flooding range. In LAR, the flooding of route searching messages is restricted to a request zone which covers the expected zone of the destination. In DREAM, intermediate nodes forward packets to all the neighbors in the direction of the estimated region within which the destination may be located.

The position information has the following three sources which all impact routing performance, with the first two assumed to be known and the third one contained in geographic routing protocols: 1) positioning system (e.g. ,GPS): each node can be aware of its own position through a positioning system, which may have measurement inaccuracy. 2) Location service: every node reports its position periodically to location servers located on one or a set of nodes. The destination positions obtained through these servers are based on node position reports from the previous cycle and may be outdated. 3) Local position distribution mechanism: every node periodically distributes its position to its neighbors so that node can get knowledge of the local topology. Recently, the impact of the position inaccuracy from the first source has been studied in [20] and the second one is discussed in [19]. Being an important self-contained part of geographic routing protocols, the design of position distribution mechanism will affect local topology knowledge and hence geographic forwarding.

Paper [22] proposed a new protocol that consider in both areas of routing and energy. It proposes a more efficient routing method which minimizes the spread of unnecessary control messages. Secondly, an energy aware method is proposed to select proper transmission power by the distance between nodes. This technique is made to provide efficient routing by minimizing the flooding of unnecessary control message, considering limited energy of mobile node and using appropriate transfer power to communication.

Q-DIR [21] is a restricted flooding algorithm which uses location information of the source, destination and the intermediate node to determine the broadcasting decision. Nodes that are in the restricted broadcast region will broadcast while other nodes which are out of this region will ignore the RREQ packet. The simple mathematical comparison is implemented in the kernel environment which does not incur processing delay due the crossing from user to kernel space and vice versa. The restricted flooding and directional routing reduces the number of participating nodes as the RREQ traverses in the network towards the destination node and hence reduced routing overhead and power consumption are achieved in Q-DIR. The decision to participate at each node is made immediately as the node receives the RREQ packet and a neighbors table is not required to make the decision.

Paper [1] proposed two geographic routing protocols SOGRHR and SOGR-GR that are adaptive to the demand of traffic transmissions Specifically, it propose two self-adaptive on demand geographic routing protocols that can provide transmission paths based on the need of applications. The two protocols share the following features. First, to reduce control overhead, the routing path is built and the position information is distributed on the traffic demand. Second, through a more flexible position distribution mechanism, the forwarding nodes are notified of the topology change in a timely manner and thus more efficient routing is achieved. Lastly, each node can set and adapt the protocol parameters independently based on the environment change and its own condition. In Both the scheme the cost of beaconing and route searching through greedy forwarding is energy consuming .To overcome the drawbacks of both scheme we propose an energy efficient algorithm (AQGR) which also reduces the control overhead in a network.

III. AQGR: ADAPTIVE QUADRANT-BASED GEOGRAPHIC ROUTING FOR MANET

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 bi-directional, (3) the route request packets 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.

In AQGR, the next-hop of a forwarding node is determined reactively with the combination of geographic-based and topology-based mechanisms. By incorporating topology based path searching, an important benefit of the proposed scheme is to obtain the topology information at a larger range when necessary to build more efficient routing path, while general geographic routing protocols are usually constrained by their local topology view.

If a node wants to send a packet to destination, first it creates a packet with source node position, destination node position, and speed and forwards the packet to the neighbor nodes. Then the packet is flooded through the network till the packet reaches the destination node. On receiving the REQ each neighboring node cache the position and speed for a particular time period. Setting the caching time too low may lead to more frequent path discovery and increase the delivery delay and control overhead, while setting it too high will result in outdated information and routing failure. To take into account node mobility, in our simulation, a receiving node j adapts the

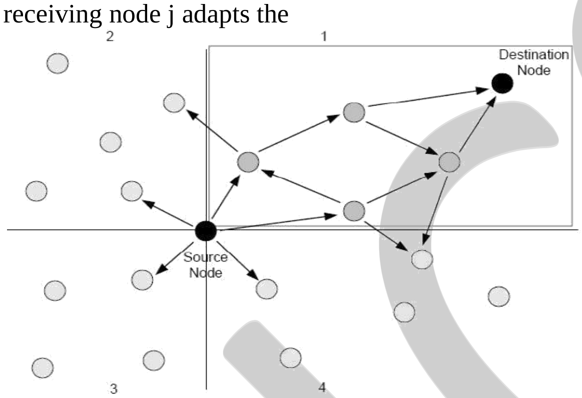

Fig. 1. Quadrant-based Greedy Forwarding

caching time of the position and speed of the sending node i based on the relative velocity between i and j, vij, as

$$Time_{cache} = Dist/V_{ij} \quad (1)$$

where Dist is a moving distance threshold for time- out. This ensures a node to keep a more updated position of a neighbour for which it has a higher relative moving speed. Node j can estimate vi,j according to the speed field in the REQ message of i. To avoid transmission failure of data packets on bad channel, a node will reply only if the received signal to noise plus interference ratio of its received REQ is above a conservative threshold set higher than the target decoding need. Further, to avoid collisions, a neighbor N waits for a back off period before sending back the REPLY and the pending REPLY will be cancelled if it overhears either a REPLY from another neighbor closer to D than itself or the packet sending by F with the next-hop closer to D than N, indicating that F has already received a REPLY without being overheard by N. To make sure the neighbor closer to D responds sooner and suppresses others REPLYs, the back off period TbfN should be proportional to dis(N,D).The back off period for a node N is calculated as

$$T_{bf}^{N} = 1 - [\frac{dis(F,D) - dis(N,D)}{h * R}] \quad (2)$$

IV. PROPOSED ALGORITHM

AQGR algorithm employs a Quadrant-based Greedy forwarding that is illustrated in fig 1.For the convenience of presentation, in the remainder of the paper F represents the current forwarding node,D is the destination, N denotes one of Fs neighbors, posA is the position coordinates of A, and dis(A,B) is the geographical distance between node A and B.

A. Route Discovery

1) Forwarding node F broadcast a RREQ packet with hopcount=1
2) On receiving RREQ packet each one-hop neighbour N of F do
   a) if quadrant(N)=quadrant(F) then
   b) if quadrant(Dest)=quadrant(F) then

TABLE I. POSITION ESTIMATION PARAMETERS

Variables	Meanings
X^N_{last}, Y^N_{last}	The coordinates of Node N at time tlast
V^N_X, V^N_Y	The velocity of Node N along x and yaxis at time tlast
t_{last}	Time of last RREP message
t_{curr}	Current Time
X^N_{curr}, Y^N_{curr}	Estimated position of Node N

      i) send a RREP packet to F. Otherwise drop the packet
3) For RREP packet received from each N, if dis(N,D)<cacheentry(F,D)
   a) Update next hop to D from F as N.
   b) Forward the data packet to N
4) If F does not receive any RREP within a backoff period perform a recovery forwarding by incrementing hopcount until Maxhops .

B. Route Maintenance

In MANET the mobility of the node will be high; with the movement of nodes, the cached topology information gets outdated and the routing path may become inefficient. The validity of the cached topology information is evaluated before the packet is forwarded to avoid forwarding failure due to outdated neighbor information. In our scheme, upon receiving a beacon update from a node i, each of its neighbor's records node is current position and velocity and periodically track node is 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. Given the position of node N and its velocity along the x and y axes at time Tlast , its neighbors can estimate the current position of N, by using the following equations:

$$X_{cur}^{N} = X_{last}^{N} + (t_{curr} - t_{last}) * V_{X}^{N} \quad (3)$$

$$Y_{cur}^{N} = Y_{last}^{N} + (t_{curr} - t_{last}) * V_{Y}^{N} \quad (4)$$

The position estimation parameters are explained in table 1.If estimated position of N is out of the transmission range of F, or is no longer closer to D, a route discovery process will be triggered to find a valid next hop.

C. Route Optimization

In geographic forwarding due to the local topology change, the cached next hop N may no longer be the best one toward D. To achieve more optimal routing, Fs neighbors monitor whether F makes correct forwarding decisions and help to improve transmission path opportunistically. F forwards a packet to N which continues the forwarding toward D, a neighbor Ni overhears both transmissions and gets posF, posN , and posD. If Ni determines that it is a more optimal next hop than N, it sends to F a message CORRECT (posNi, D) asking it to change its next hop to Ni. Our route optimization algorithm optimizes the route in the following cases:

- Ni is the destination of the packet. When Ni moves into transmission range of F, F forward the packet directly to i.
- When another node N is currently closer to D than C is, i.e., dis(Ni;D) < dis(N;D), node Ni will inform F which will set its new next hop to N.

V. PERFORMANCE ANALYSIS

Various performance metrics are considered for evaluating the performance of the proposed scheme and it is also compared with AODV [22], SOGR-HR[1] and presented in Table2.

- Packet delivery ratio: The ratio of the packets delivered to those originated by CBR sources.
- Control overhead: The total number of control message transmissions (the forwarding of a control message at each hop is counted as one control transmission) divided by the total number of data packets received.
- Number of data packet forwarding per delivered packet: The total number of data packet forwarding accumulated from each hop (including rerouting and retransmissions due to collisions) over the total number of data packets received.
- Average end to end delay. The average time interval for the data packets to traverse from the CBR sources to the destinations.
- Effective energy consumption per data packet received: The total energy consumption in the network for every data packet successfully received by the destination.

TABLE II. PERFORMANCE ANALYSIS

Metrics/Parameters		Moving speed	Node Density	Traffic Load
Packet delivery ratio	AODV	low	medium	medium
	SOGR-HR	high	high	high
	AQGR	high	high	high
Control Overhead	AODV	high	high	medium
	SOGR-HR	medium	medium	medium
	AQGR	low	low	low
Average Packet Forwarding	AODV	medium	medium	medium
	SOGR-HR	high	high	medium
	AQGR	low	low	low
Average end to end delay	AODV	medium	low	high
	SOGR-HR	high	low	medium
	AQGR	low	low	medium
Energy Consumption	AODV	high	high	high
	SOGR-HR	high	medium	medium
	AQGR	low	low	low

VI. CONCLUSION

In this work, we have designed efficient and robust geographic routing scheme that can be applied for applications with different traffic patterns and adapt to various scenarios to provide efficient routing paths and improve routing performance in a dynamic resource-constrained wireless ad hoc network. Specifically, we propose an adaptive on-demand geographic routing protocol AQGR. The protocol adopts different schemes to obtain and maintain local topology information where it combines both geographic and topology based mechanisms for more efficient path building.

Also, this paper has utilized Quadrant forwarding which is a restricted flooding algorithm which uses location information of the source, destination and the intermediate node to determine the broadcasting decision. Nodes that are in the restricted broadcast region will broadcast while other nodes which are out of this region will ignore the RREQ packet. The simple mathematical comparison is implemental in the kernel environment which does not incur processing delay. The restricted flooding and greedy forwarding reduces the number of participating nodes as the RREQ traverses in the network towards the destination node and hence reduced routing overhead and power consumption are achieved.

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