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Energy Efficient on-Demand Georouting for *Mobile Ad Hoc Networks*

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Abstract— Even though geographic routing has many advantages and has shown a great potential, the inaccurate knowledge of local geographic topology can greatly affect routing performance. This not only leads to a larger packet delivery latency, more collisions and energy consumption but can also result in a routing failure. They perform effective forwarding decisions, based on the positions of their immediate neighbors. To maintain neighbor position, periodic broadcasting of beacon packets that contain the geographic location of the nodes is a popular method used. In our work called on-demand georouting reduces control overhead compared to the proactive schemes which provides reliable routing at the same time with less energy consumption. It consists of three mechanism, they adopt different schemes to obtain topology information. Firstly, SOGR-GR purely relies on one hop topology information. Secondly, SOGR-HR a hybrid scheme which combines geographic and topology-based mechanisms. Thirdly, SOGR-EE split a whole network into regions and combines greedy and SOGR-HR routing to provide energy efficient and reliable routing.

Key words: Georouting, beacon, SOGR-GR, SOGR-HR, SOGR-EE, network lifetime.

I. Introduction

In a mobile ad-hoc network (MANET), wireless devices could self-configure and form a network with an arbitrary topology. Such a network may operate in a stand-alone fashion, or may be connected to the larger Internet. The nodes themselves act as routers as well. Due to the limited transmission range of wireless nodes, intermediate nodes may be required to collaborate in forwarding a packet from source to destination. Therefore, nodes beyond direct wireless transmission range of each other will be able to communicate via multihop routing. Based on forwarding decisions i.e. On local topology it is a big challenge to develop a routing protocol that can meet different application needs and optimize routing paths according to the topology changes in mobile ad hoc networks. Geographic routing protocols have drawn a lot of attentions in recent years. On-demand routing mechanism reduces control overhead compared to the proactive schemes which are normally adopted in current geographic routing protocols. Additionally, route optimization scheme adapts the routing path according to both topology changes and actual data traffic requirements. On-demand geographic routing protocols that can provide transmission paths based on the need of applications. Self adaptive on-demand geographic routing for mobile ad hoc networks [1] reduces control overhead, the routing path is built and the position information is distributed on the traffic demand. A more flexible position distribution mechanism helps to notify the topology change in a timely manner and thus more efficient routing is achieved. An optimization schemes are designed to make routing paths adaptive to the change of topology and traffic, and robust to the position inaccuracy. The routing schemes naturally handle the destination position inaccuracy. Each node can set and adapt the protocol parameters independently based on the environment change and its own condition. 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 via GPS[2][3] each node can be aware of its own position through a positioning system, which may have measurement inaccuracy. 2) Location service [4] 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 a node can get knowledge of the local topology. An algorithmic approach to geographic routing in ad hoc and sensor networks [5] is a type of routing that currently appears to be most amenable to algorithmic analysis is geographic routing. An introduction to the problem field of geographic routing, presents a specific routing algorithm based on a synthesis of the greedy forwarding and faces routing approaches, and provides an algorithmic analysis of the presented algorithm from both a worst-case and an average-case perspective

II. Related Work

Greedy perimeter stateless routing for wireless networks (GPSR) [6], a novel routing protocol for wireless datagram networks that uses the positions of nodes and a packet's destination to make packet forwarding decisions. GPSR makes greedy forwarding decisions using only information about a node' immediate neighbors in the network topology. When a packet reaches a region where greedy forwarding is impossible, the algorithm recovers by routing around the perimeter of the region. By keeping state only about the local topology, GPSR scales better in per-router state than shortest-path and ad-hoc routing protocols as the number of network destinations increases.

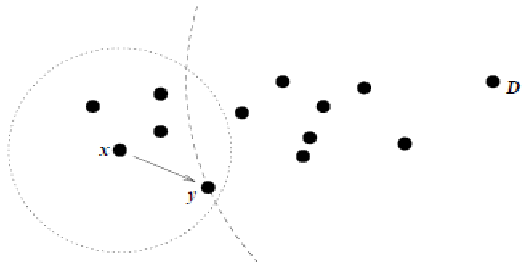

Fig 1: Greedy forwarding. *y* is *x's* closest neighbor to D

In Fig 1. Here, *x* receives a packet destined for *D*. *x*'s radio range is denoted by the dotted circle about *x*, and the arc with radius equal to the distance between *y* and *D* is shown as the dashed arc about *D*. *x* forwards the packet to *y*, as the distance between *y* and *D* is less than that between *D* and any of *x*'s other neighbors. This greedy forwarding process repeats until the packet reaches *D*.

III. Proposed Methodology

On Demand Georouting for Mobile Ad Hoc Networks consist of three mechanisms SOGR-GR, SOGR-HR and SOGR-EE. They adopt different schemes to obtain topology information. SOGR-GR purely relies on one hop topology information as other geographic routing schemes. SOGR-HR assumes a hybrid scheme which combines geographic and topology-based mechanisms. SOGR-EE split a whole network into regions and combines greedy and SOGR-HR routing to provide energy efficient and reliable routing.

A. SOGR with Hybrid Mechanism (SOGR-HR)

Without proactive beaconing to distribute local topology, a scheme needs to be designed for a forwarding node to find the path to the destination. In SOGR-HR, 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.

- Geography-Based Greedy Forwarding

Normally a forwarding node F will attempt to forward a packet greedily to a neighbor closest to the destination D and closer to D than itself. When there is no next-hop information cached, F buffers the packet first and broadcasts a request message REQ(D,posD,posF,h) with the hop number h =1 to restrict the searching range to its one-hop neighbors. If a neighbor node N closer to D than F sends back a REPLY, F will record N as the next-hop to D with the transmission mode set as greedy and unicast the data packet to N. If another REPLY from a node N' arrives later, F updates its next-hop to N' if N' is closer to D than N, and ignore the reply otherwise.

- Topology-Based Recovery Forwarding

There may be two reasons for F to fail in getting any reply message: 1) The reply messages from all its neighbors are lost; 2) F may not have neighbors closer to D, resulting in a local "void." In a recovery process, F increases its searching range to two hops. Since the absence of a REPLY on the first try may be caused by the loss of REQ or REPLY message due to collisions, whenever a REQ reaches a one-hop neighbor that is closer to D than F, the neighbor sends back a REPLY after a back off period with h= 1. Otherwise, the one-hop neighbor of F continues broadcasting the REQ to its own one-hop neighbors. When a second-hop neighbor of F gets this REQ and is closer to D, it sends a REPLY following the reverse path of the REQ message.

B. SOGR with Geographic-based Mechanism (SOGR-GR)

SOGR-GR depends only on one-hop neighbors' positions to make greedy and perimeter forwarding. However, it adopts a reactive beaconing mechanism which is adaptive to the traffic need. The periodic beaconing is triggered only when a node overhears data traffic from its neighbors the first time. The beaconing is stopped if no traffic is heard for a pre-defined period.

- Adaptive Position Distribution

To make the beacon sending on demand, every node keeps three time values treq, treqHeard, and tbc, in which treq records the time when the latest REQ or data packet was sent out, treqHeard is the time when the latest REQ or data transmission was heard, and tbc saves the last beaconing time. A REQ message or a data packet also serves as a beacon since it contains the forwarder's position.

C. SOGR with Energy Efficient Mechanism (SOGR-EE)

The whole network is divided into equal number of regions. Each region elects region-head. In order to elect region-heads, each node periodically broadcasts a discovery message that contains its node ID, its region ID, and its estimated lifetime. A node's estimated lifetime can be conservatively set by assuming the node will constantly consume energy at a maximum rate until it runs out of energy. A node selects itself as a region-head if it has the longest lifetime of all its neighbor nodes, breaking ties by node ID. Each node can independently make this decision based on exchanged discovery messages. Each node sets its region ID to be the node ID of its region-head. According to our scheme nodes with higher value decide they are the region-heads because they have the highest ID of all of their neighbors.
The source and destination is in same region source can directly send message. If it is in another region the region-head communicate with the region-heads and nodes from other region. Region-head transmits data to source node that is about the information of destination node, specifically location, speed and time. Source node calculates expected zone which indicate area where destination node will be located by considering movement. The path from source to destination node is established by multi-hop. The intermediate node is selected by considering the neighbor locations energy remains and transmitting power. When the packet arrives at expected region, the region-head in that region will participate in routing thus flooding in the expected region. When RREQ packet is reached at destination node, RREP packet is sent to source node.

Combination of Greedy and SOGR-HR routing.

The procedure of route discovery in SOGR-EE.

a. The source puts the location information of itself and the destination in the RREQ packet

b. The RREQ packet is broadcast within the source region using SOGR-HR. In other words, the nodes within the request region forward the message, others discard the message.

c. Once region-head holds a RREQ packet it looks for shortest path to destination region by considering greedy forwarding to reach destination region-head.

d. On receipt of the RREQ packet to destination region-head, it floods packet to intended destination using SOGR-HR.

e. The destination sends back a RREP packet which contains its current location.

By optimizing the route from source node to target node region, we have reduced the energy consumption in searching for the destination node. In our proposed work, the number of messages on network (beacons and search messages) is less compared to other messages, so there is less congestion in the network. By avoiding beacons (energy reduces due to transmission of beacon packets, receiving of beacon packet), energy consumption is also reduced.

D. Architecture of the System

The architecture of a system is shown in figure. The components of system are

Viewer: It is the front end of the system. User configures the system as well as the view the output results using the viewer. User can configure the node movement, location to be presented for the Node. It also configures the location service with the expiry timer for the cached entries.

Statistics: Energy consumed by each node is calculated using statistics module based on packet delivery history provided and other parameter are also calculated such as end to end delay, network lifetime.

Routing Engines: Four routing methodologies are present in the system. They are greedy forwarding, SOGR-HR, SOGR-GR, SOGR-EE. These are used to find routes and handles RREQ and RREP messages.

Wireless channel simulator: Nodes communicate with each other using wireless channel simulator module. Statistics module collects energy consumed reports from the nodes and delivery reports from the wireless channel simulator and provides to the viewer in turn it presents for user.

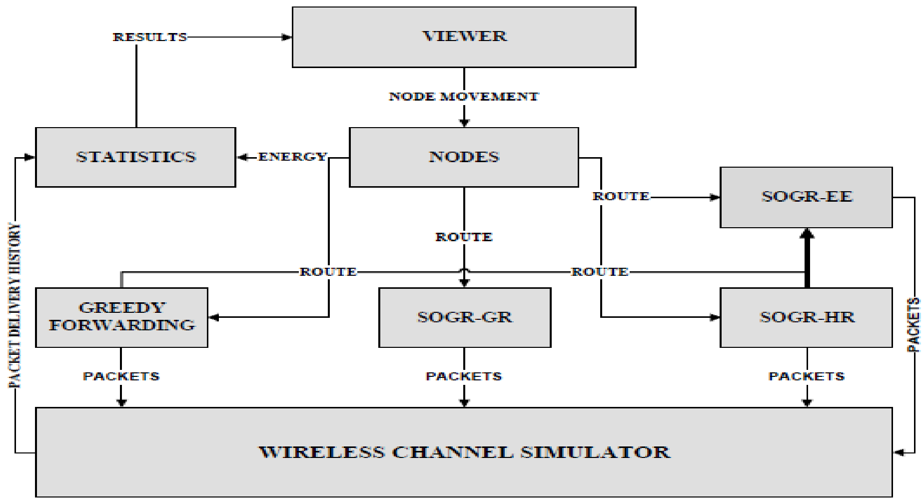

Fig 2: Architecture of the system

IV. Experimental Results

In our work, we have proposed energy efficient on-demand Georouting for mobile ad hoc networks improve performance. We have implemented the algorithm in existing techniques by making necessary changes in the existing system. The following choices are made for simulation considering accuracy of result and available resources then, we carry out quantitative and comprehensive evaluation of performance in terms of packet delay, throughput and finally network lifetime.

Table1: Simulation parameters

Parameters	**Values**
Channel model	Wireless
Terrain Co-ordinates	(800m,800m)
Routing protocol	SOGR-GR, SOGR-HR, SOGR-EE.
Propagation range	250m
Bandwidth	2Mbps
Traffic	CBR
Item size	512 bytes
Interval time of item sending	1sec

The analysis of routing protocols for parameters like throughput, packet delay. The parameters are defined in the following section.

- Throughput: It is the average rate of successful packet delivered over a communication channel.
- Packet Delay: The delay of packets can be due to buffering during route discovery latency, queuing at interface queue, retransmission delays at the MAC and transfer times may cause this delay. Once the time difference between every CBR packets sent and received was recorded, dividing the total time difference over the total number of CBR packets received gives the average delay for the received packets. Lower the delay better is the performance of the protocol.
  Packet Delay= Total end to end delay/number of packets received.
- Network lifetime: The Network Lifetime is defined as the duration from the beginning of the simulation to the first time a node runs out of energy. Network lifetime increase the performance due to less energy consumption of nodes in the network.

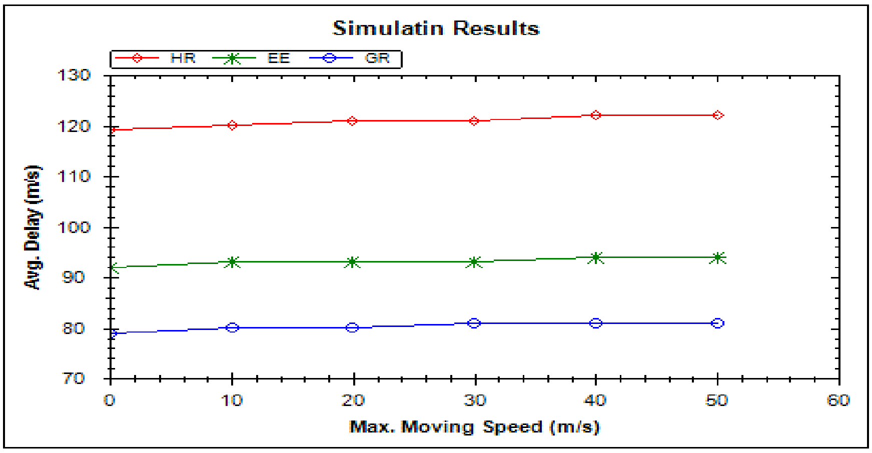

Fig 3: End-to-End delay of SOGR-HR, SOGR-GR, SOGR-EE.

The graph for packet end-to-end delay vs. moving speed is shown in Figure 3. We vary the moving speed of nodes and measure the packet delay. The packet delay is less in SOGR-GR then SOGR-EE and SOGR-HR.

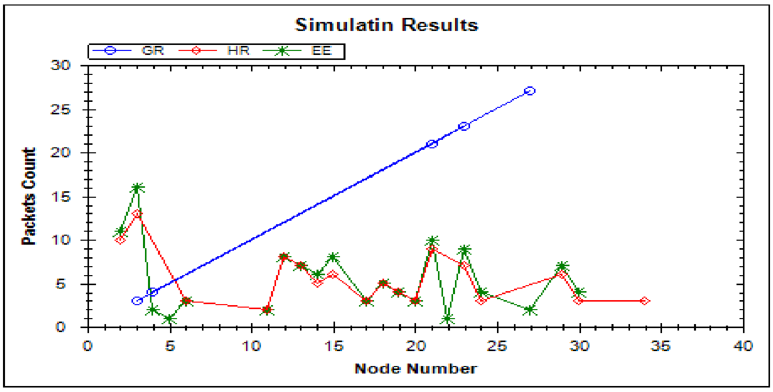

Fig 4: Throughput of SOGR-HR, SOGR-GR, SOGR-EE.

The graph for throughput packet count vs. no of nodes is plotted in Figure 4. It is observed from the figure that the throughput in SOGR-GR increases with number of nodes. Whereas in SOGR-HR and SOGR-EE are same.

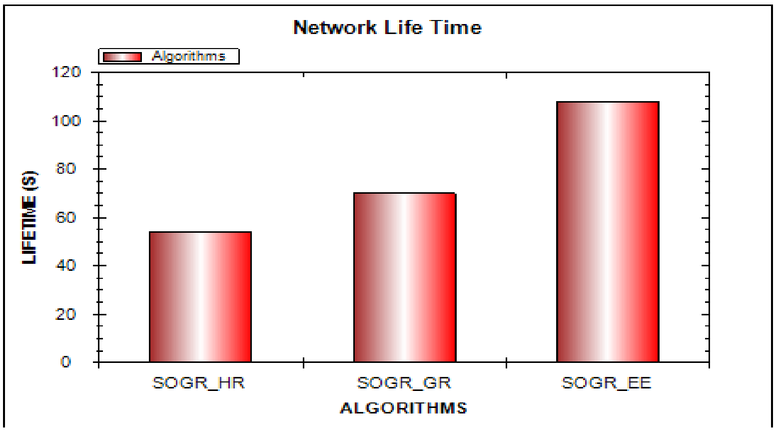

Fig 5: Network lifetime

Network lifetime graph is shown in figure 5. Under the max speeds, SOGR-EE gives much longer lifetime than SOGR-GR and SOGR-HR mechanism.

V. Conclusion

We have proposed an energy efficient on-demand georouting for mobile ad hoc networks. The main idea is to add to provide reliable and energy efficient feature to existing schemes in order to increase the lifetime of the network. Our proposed approach considers both the progress made towards the destination by providing reliable routing and at the same time with less energy consumption. It can efficiently adapt to different scenarios and perform better than existing geographic routing protocols and conventional on-demand protocols. Simulation results show that our proposed is well suited for mobile ad hoc networks since it ensures throughput, network lifetime and meets the delay constraint with

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