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Energy-Aware with Mobility-Assisted Geographic Routing Protocol for Mobile Ad Hoc Networks

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Abstract- Most of the existing on-demand geographic routing protocol provides energy efficiency but lack due to the continuous motion of nodes. The topology changes frequently which mean tracking down of particular node become difficult. The nodes can easily come out of or into the radio range of various other nodes and the battery power is limited in all the devices, which does not allow infinitive operational time for the nodes. We propose an energy-aware with mobility-assisted geographic routing protocol for mobile ad hoc networks (EAGRP) that increases accuracy and reduces energy consumption in transmission of packets by considering local position information and residual energy levels of nodes to make routing decisions. Simulation results shows that proposed approach has a good energy conservation performance and also performs better in context of average end-to-end delay without much affecting the throughput.

Keywords: on-demand geographic routing, energy-aware geographic routing, simulation.

I. INTRODUCTION

A MANET(Mobile Ad hoc Network) is a type of wireless network characterized by a collection of mobile nodes to form a temporary network without an aid of centralized administration. The network topology is dynamic, the nodes in this network act as both host and router. Nodes can communicate each other by multi hop route. Ad Hoc wireless network has applications in emergency search-and-rescue operations, decision making in the battlefield, data acquisition operations in hostile terrain, etc. It is featured by limited resources (bandwidth, CPU, battery, etc.). These characteristics put special challenges in routing protocol design. One of the most important objectives of MANET routing protocol is to maximize energy efficiency, since nodes in MANET depend on limited energy resources, and additionally to maximize network throughput, network lifetime and minimize delay. The network throughput is usually measured by packet delivery ratio while the most significant contribution to energy consumption is measured by routing overhead which is the number or size of routing control packets. A major challenge that a routing protocol designed for ad hoc wireless networks faces is resource constraints. Devices used in the ad hoc wireless networks in most cases require portability and hence they also have size and weight constraints along with the restrictions on the power source. Increasing the battery power may make the nodes bulky and less portable.

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The energy efficiency remains an important design consideration for these networks. Therefore ad hoc routing protocol must optimally balance these conflicting aspects. To achieve the desired behavior, some proposals make use of clustering or maintain multiple paths to destinations (in order to share the routing load among different nodes).

The majority of energy efficient routing protocols for MANET try to reduce energy consumption by means of an energy efficient routing metric, used in routing table computation instead of the minimum-hop metric. This way, a routing protocol can easily introduce energy efficiency in its packet forwarding. These protocols try either to route data through the path with maximum energy bottleneck, or to minimize the end-to-end transmission energy for packets, or a weighted combination of both. In recent years, geographic unicast [1] and multicast [2] routing have drawn a lot of attentions. They assume mobile nodes are aware of their own positions through GPS[3][4]or other localization schemes [5] and a source can obtain the destination's position through some kind of location service [6].

In geographic unicast protocols, an intermediate node makes packet forwarding decisions based on its knowledge of the neighbors' positions and the destination's position inserted in the packet header by the source. By default, the packets are transmitted greedily to the neighbor that allows the packet forwarding to make the greatest geographic progress toward the destination. When no such a neighbor exists, perimeter forwarding [7] is used to recover from the local void, in which packets traverse the face of the planarized local topology sub graph by applying the right-hand rule until greedy forwarding can be resumed. As the forwarding decisions are only based on the local topology, geographic routing is more scalable and robust in a dynamic environment.

II. MOBILITY-ASSISMENT IN ROUTING ALGORITHM

GPSR [8] is a location-based routing protocol using position data of the destination node and intermediate ones while forwarding all packets. When knowing the exact position of the destination node, GPSR selects the neighbor node which is closest to the destination (in this case, considered as the "best neighbor") as the next hop. This neighbor node, in turn, relays data to its best neighbor, and so on. GPSR defines a beacon message to update their neighbor position periodically. However, nodes in mobile ad hoc networks change their location quickly, there is a tradeoff between routing overhead and connection stability (the smaller the beacon message interval is, the more overhead is generated and the more stable the connection is).

To improve the accuracy of GPSR, We can consider the speed and direction of movement to routing decision. In a ad hoc network, as nodes usually move along a certain direction in a short updating interval (at millisecond level) and they do not significantly change the direction and speed, each node is able to predict a new position of its neighbors using the previous position data, the moving direction and speed. In addition, coordinates of the destination are contained in every transmitted packet once the connection is established. Another enhancement of is that it uses a routing metric that is a function of speed, distance to the destination, and movement direction to make the routing decision .

$$m(s,d,\theta) = \alpha_{speed}\ f(s) + \alpha_{distance}\ g(d) + \alpha_{movement}\ h(\theta) \quad (1)$$

where α is weight of f(s), g(d) and h(θ). These functions and α describe how the chosen route depends on speed (s), distance(d) and movement direction (θ).

At the first time point (t1), the source node stands at position t1(x1, y1), and the destination node is being at position t1(x3, y3). At the next time instance t2, the source and the destination move to the new position t2(x2, y2) and t2(x4,y4), at speed s1 and s2 respectively.

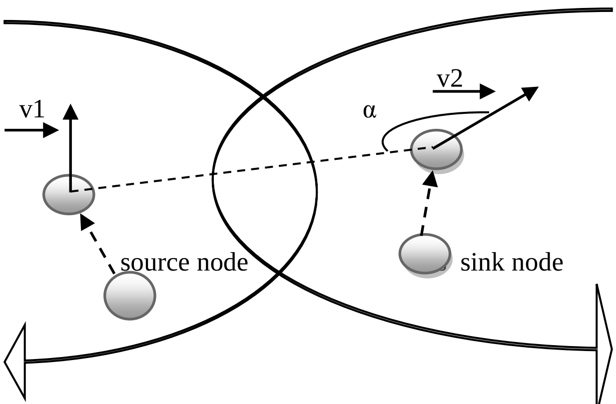

Figure 1. Illustrates how the position of a node is predicted.

Each moving node is characterized by two parameters, i.e. movement orientation and speed. In reality, the speed statistics can be collected by GPS receivers. Movement data of each node is calculated based on the position statistics obtained after each regular time interval. As indicated in Figure 1, movement angle of destination node compared to the source node is *α*. *α* angle and nodes speed are subsequently exploited to implement our proposed EAGRP protocol.

III. ENERGY-AWARE GEOGRAPHIC ROUTING PROTOCOL

A. Energy consumption model

A wireless network interface can be in one of the following four states: Transmit, Receive, Idle or Sleep. Each state represents a different level of energy consumption.

- Transmit: A node is transmitting a packet with transmission power P_{tx};
- Receive: A node is receiving a packet with reception power P_{rx}. That energy is consumed even if the frame is discarded by the node (because it was intended for another destination, or it was not correctly decoded);
- Idle(listening):Even when no messages are being transmitted over the medium, the nodes stay idle and keep listening the medium with P_{idle};
- Sleep: When the radio is turned off and the node is not capable of detecting signals. No communication is possible. The node uses P_{sleep} that is largely smaller than any other power.

The energy dissipated in transmitting (E_{tx}) or receiving (E_{rx}) one packet can be calculated as:

$$E_{tx} = P_{tx} * \text{Duration} \quad (2)$$

$$E_{rx} = P_{rx} * \text{Duration} \quad (3)$$

where *Duration* denote the transmission duration of the packet.

1. Greedy forwarding based on energy levels of nodes

The EAGRP routing protocol can be seen as an enhancement of the GPSR protocol. The main idea is to add a energy efficient feature to GPSR in order to increase the lifetime of the network. At each hop, a forwarder node decides through which neighbor it will send the packet. Forwarding policy at each node is based on these four rules: (1) the remaining energy at each neighbor, (2) the number of hops made by the packet before it arrives at this node (3) the actual distance between the node and its neighbors, and (4) the history of the packets forwarded belonging to the same stream unit. Furthermore, only a subset of available neighbors is chosen for greedy forwarding.

In EAGRP routing protocol, each node stores some information about its *one*-hop neighbors N_i. Information includes the estimated distance to its neighbors, the distance of the neighbor to the sink, the data-rate of the link, and the residual energy. This information is updated by the mean of beacon messages, scheduled at fixed intervals. Relaying on this information, a forwarder node F will give a score to each neighbor according to an objective function "f(x)".

Let us illustrate energy consumption of packet. We assume that the transmitted data packets in the network have the same size. When node A sends a packet of 'n' bits size to a node B, the energy of node A will decrease by $E_{tx}(n, AB)$ while the energy of the node B will decrease by $E_{rx(n)}$ Consequently, the cost of this routing decision is $E_{tx}(n,AB) + E_{rx}(n)$ considering the energy of the whole network.

Now let us consider a candidate set of neighbor nodes I, which is a subset of primary neighbor nodes N_i. Then for each node I,

$$\text{Residual energy (I)} = \frac{\text{Available energy(I)}}{\text{Initial energy(I)}} \quad (4)$$

$$\text{Routing Process (F,I)} = \frac{\text{Distance}_{F\text{-}S} - \text{Distance}_{I\text{-}S}}{\text{Distance}_{F\text{-}S}} \quad (5)$$

$$\text{Weight(I)} = \text{Residual energy(I)} + \text{Routing Process(F,I)} \quad (6)$$

The candidate neighbor nodes that has the maximum *Weight* value is chosen by *F* as the next hop node to forward the data packet.

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Lastly we propose an objective function to evaluate a neighbor N_i for packet forwarding. This objective function takes into account the packet energy consumption and also the initial energy of that neighbor. The proposed objective function can simply be:

$$f(N_i)=N_{i\ energy} - E_{tx}(N_{i\ distance}) - E_{rx} + weight(I) \qquad (7)$$

If the forwarding node *F* could not find a neighbor node that lies closer to the destination than itself, then switches to perimeter forwarding.

2. *EAGRP algorithm*

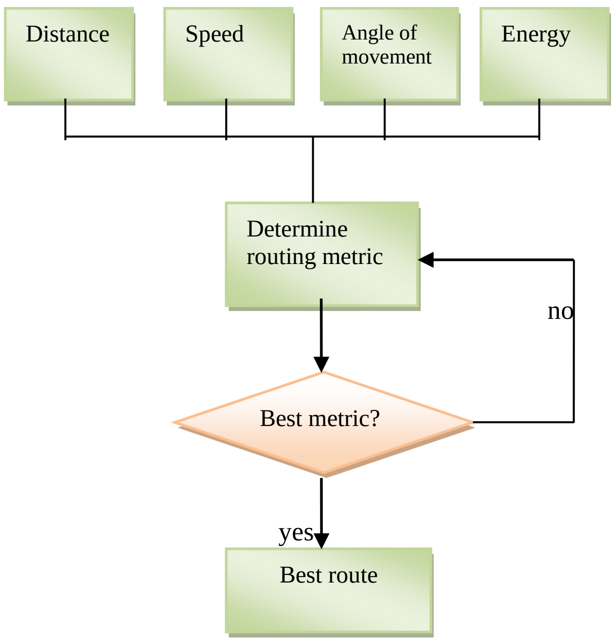

Figure 2: EAGRP algorithm

EAGRP basically inherits all the features of GPSR a promising routing protocol for mobile ad hoc network. GPSR is a reactive protocol in which it does not have a full view of the network topology. When one node needs to communicate with another that is not in its neighbors list, it has to get the position data of the desired destination. Once the destination coordinates are returned, the best next hop is able to be figured out. In EAGRP, each node records its energy, score, position, speed and direction of its neighbors, and advertises the data to other nodes nearby. All the intermediate nodes help to decide the best route by selecting the best next hop to be added into the connection path, taking into account the metric.

IV. SIMULATION AND RESULTS

In this paper we proposed energy-aware with mobility-assisted geographical routing protocol (EAGRP) to improve performance of protocols. It was successfully implemented using OPNET modeler 14.0, in which 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 time, overall performance ratio, and traffic sensitivity. The simulation parameters of our paper work as follows:

Table1: simulation parameters

Parameters	**Values**
Channel model	Wireless
Terrain Co-ordinates	(1000m,1000m)
Routing protocol	GPSR, EAGRP
Propagation range	250m
Bandwidth	2Mbps
Traffic	CBR
Item size	512 bytes
Interval time of item sending	1 sec

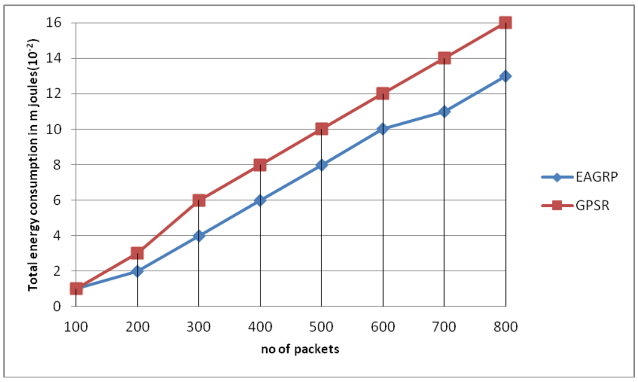

Figure 3:Total energy consumption vs. no. of packets

The graph for energy consumption vs. no. of packets is shown in Figure 3. It is observed from the graph that the energy consumption in our proposed scheme is lesser that of the existing (GPSR). This is because in proposed scheme the transmission of packets takes place by lesser number of nodes.

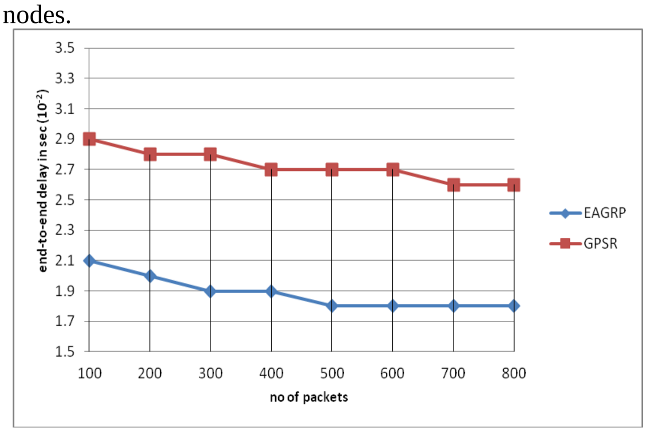

Figure 4: average end-to-end delay vs. No. of packets.

The comparison for end-to-end delay in between GPSR and EAGRP protocol is shown in Figure 4. It is observed from the figure that the end to end delay in our proposed scheme is lesser than that of existing approach. This is because in proposed scheme as less number of nodes are taking part in packet transmission, so the packet needs to travel less hops, resulting the average end-to-end delay is minimized.

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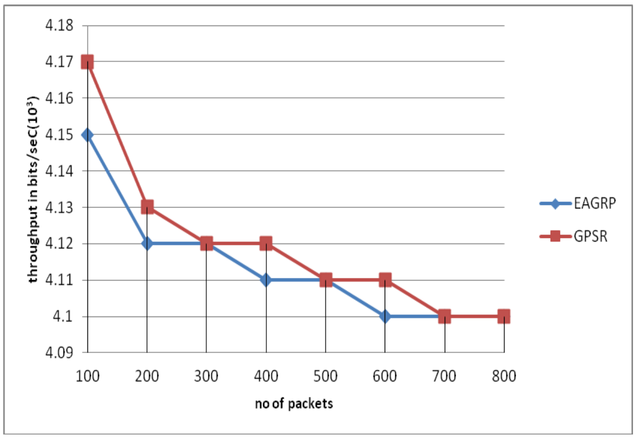

Figure 5: Throughput vs. No. of packets

The graph for throughput vs. no. of packets is plotted in Figure 5. It is observed from the figure that the throughput in our proposed scheme is lesser than that of the existing scheme for packet number 100 to 800.

V. CONCLUSION

We have proposed an energy-aware with mobility-assisted geographic routing protocol referred as EAGRP. The main idea is to add a energy efficient feature to GPSR in order to increase the lifetime of the network. EAGRP considers both the progress made towards the destination as well as the residual energy available at the neighboring nodes of a forwarding node before choosing the next hop towards the destination. Simulation results compared to GPSR show that EAGRP is well suited for mobile ad hoc networks since it ensures uniform energy consumption and meets the delay constraint.

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