

Localized Energy-Aware Restricted Neighbourhood Routing (LEARN) in Mesh Network

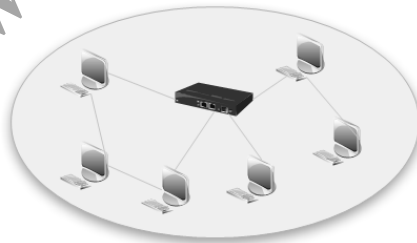
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Abstract - Since sensor networks can be composed of a very large number of nodes, the developed protocols for these networks must be scalable. Moreover, these protocols must be designed to prolong the battery lifetime of the nodes. Typical existing routing techniques for ad hoc networks are known not to scale well. In multihop wireless networks the nodes generally wireless devices are usually powered by batteries only and have limited computing capability while the number of such devices could be large. Energy conservation and Scalability are probably two most critical issues in designing protocols for multihop wireless networks. The nodes have limited initial amounts of energy that is consumed in different rates depending on the power level and the intended receiver. On the other hand, the so-called geographical routing algorithms are known to be scalable but their energy efficiency has never been extensively and comparatively studied. For this reason, an algorithm named Localized Energy-Aware Restricted Neighborhood routing (LEARN), which can guarantee the energy efficiency of its route if it can find the route successfully. We then theoretically study its critical transmission radius in random networks which can guarantee that LEARN routing finds a route for any source and destination pairs asymptotically almost surely is introduced. In a geographical routing algorithm, the packets are forwarded by a node to its neighbour based on their respective energy based technique. Also extend the further routing protocol into 3D three-Dimensional networks.

1. INTRODUCTION

Energy conservation and scalability are probably two mostcritical issues in designing protocols for multihopwireless networks, because wireless devices are usuallypowered by batteries only and have limited computing capability while the number of such devices could be large. In my paper focus on designing routing protocols formultihop wireless networks which can achieve both energy efficiency by carefully selecting the forwarding neighbors and high scalability by using only local information to makerouting decisions.



Mesh networking (topology) is a type of networking where each node must not only capture and disseminate its own data, but also serve as a relay for other nodes, that is, it must collaborate to propagate the data in the network.

2. OVERVIEW

Energy conservation refers to efforts made to reduce energy consumption. Energy conservation can be achieved through increased efficient energy use, in conjunction with decreased energy consumption and/or reduced consumption from conventional energy sources. The use of telecommuting by major corporations is a significant opportunity to conserve energy, as many peoples now work in service jobs that enable them to work from home instead of commuting to work each day.

LEARN routing is the first localized routing which can theoretically guarantee the energy efficiency of its routes. Learning is a branch of artificial intelligence, is a scientific discipline concerned with the design and development of algorithms that allow computers to evolve behaviours based on empirical data, such as from sensor data or databases. Machine Learning is concerned with the development of algorithms allowing the machine to learn via inductive inference based on observing data that represents incomplete information about statistical phenomenon.

Main contributions are: New Localized Routing Protocol, Power Efficiency of LEARN, Critical Transmission Range for LEARN, Simulation for LEARN.

3. NETWORK MODEL AND ROUTING PROBLEM

Network Model:

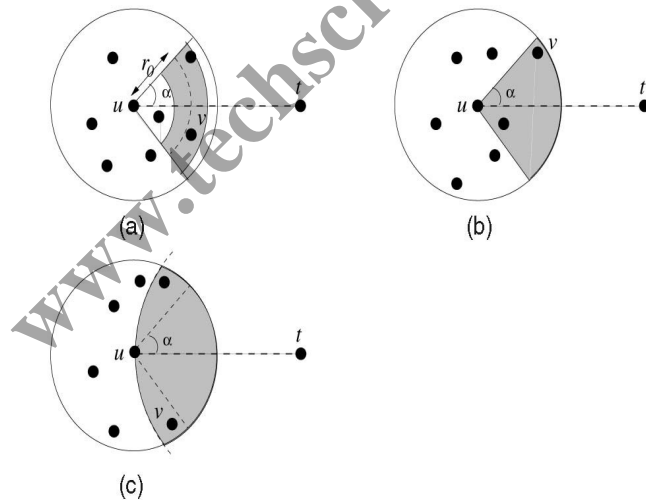
Here consider a set V of n wireless devices (called nodes hereafter) distributed in a compact and convex region Ω . Typically, the region Ω is a unit-area square or a unit-area disk. We assume that each node knows its position information either through a low-power GPS receiver or some other ways such as localization algorithms or location services.

4. PROBLEM SPECIFICATION

Localized versus Energy Efficient

Here focus on designing a new localized and energy efficient routing method. It gives the formal definitions of localized routing and energy efficient routing. A routing protocol A is said to be a localized protocol if, given the information of the source node s and the target node t and the k -hop neighborhood information, the current node u can decide which neighboring node v to forward the message. Here k is a constant, usually 1 or 2.

A routing method A is called energy efficient if for every pair of nodes s and t , the energy consumption of path $P_A(s,t)$ is within a constant factor of the least energy consumption path connecting s and t in the network.



(a) Energy efficient forwarding in a restricted forwarding region
 (b) Greedy forwarding in the 2α sector region
 (c) Classic greedy forwarding when the sector region is empty.

5. ENERGY EFFICIENT LOCALIZED ROUTING

In this section, describe in detail our energy-efficient localized routing method, called LEARN, which is a variation of classical greedy routing. In greedy routing, current node u selects its next hop neighbor based purely on its distance to the destination, i.e., it sends the packet to its neighbor who is closest to the destination. However, such choice might not be the most energy-efficient link locally, and the overall route might not be globally energy efficient too. The definition of energy mileage provides us the insight in designing energy efficient routing. Whenever possible, the forwarding link

that has larger energy mileage should be used. In addition, to save the energy consumption, the total distance traveled should be as small as possible. Thus, we introduce a restricted region to restricting the forwarding direction.

Our routing protocol will work as follows:

The current intermediate node u with a message first finds the "best" neighbor v among all neighbors w inside a restricted area. If there is no neighbor inside the restricted area current node u finds the node v inside the 2α sector region with minimum distance. When there is no neighbor in the 2α sector region, classical greedy routing or face routing can be applied. In our protocol, there are various input parameters:

- 1) $\alpha < \pi/3$ is an adjustable parameter to define the 2α sector restricted forwarding region;
- 2) η_1 and η_2 are two constant parameters to control the restricted forwarding region around r_0 if $r_0 < r$, usually $\eta_1 < 1$ and $\eta_2 > 1$;
- 3) r_0 is the link length with maximum energy mileage which can be derived from energy model $c(x)$.

To make the later analysis easier, we call the routing algorithm LEARN if no Greedy routing and no Face routing is used when no node v satisfying that $\langle uvt \rangle \leq \alpha$. If greedy routing is applied afterward, then the routing protocol is called LEARN-G. Furthermore, if the Face routing is used at the end to get out of the local minimum, the routing protocol is called LEARN-GF.

6. CRITICAL TRANSMISSION RADIUS OF LEARN

This section is devoted to study the critical transmission radius for LEARN routing method in random networks. In any greedy routing method (including LEARN), the packet may be dropped by some intermediate node u before it reaches the destination 't' when node 'u' could not find any of its neighbors that is "better" than itself.

Thus, to ensure that the routing is successful for every pair of possible source and destination nodes, each node in the network should have a sufficiently large transmission radius such that each intermediate node u will always find a better neighbor.

General Results on Critical Transmission Radius:

So far, we mainly concentrated on the routing LEARN. Notice that the critical transmission radius of our LEARN-G routing protocol will be exactly same as the traditional greedy routing method since at last we use the greedy routing to find the forwarding node if LEARN fails. There are a number of other localized routing methods developed already and many to be developed in the future. We thus would like to know the general critical transmission radius for successful routing by any localized routing method.

7. RELATED WORK

A. Localized Routing:

The geometric nature of the multihop wireless networks allows the promising idea: localized routing protocols. The most popular localized routing is greedy routing where the current node always finds the next relay node who is the nearest to the destination. Though greedy routing (or its variation) was widely used, it is easy to construct an example where greedy routing will not succeed to reach the destination but fall into a local minimum.

Although face routing or greedy face routing can guarantee the packet delivery on planar networks and some localized routing protocols can guarantee the delivery if certain geometry structures are used as the routing topology, none of them guarantees the ratio of the distance traveled by the packets over the minimum possible.

B. Energy Efficient Routing:

Since energy is a scarce resource which limits the life of wireless networks, a number of energy efficient routing protocols have been proposed recently using a variety of techniques. Classical routing algorithm may be adapted to take into account energy-related criteria rather than classical metrics such as delay or hop distance. Most of the proposed energy-aware metrics are defined as a function of the energy required to communicate on a link or a function of the nodes remaining

lifetime. However, to minimize the global consumed energy of selected route, most of minimum energy routing algorithms are centralized algorithms. In my paper, we focus on stateless localized routing. Thus, we only review the following related work about energy efficient techniques for localized routing which address how to save energy when making local routing decision.

A partial topology knowledge forwarding for sensor network, where each node selects the shortest energy-weighted path based on local knowledge of topology. They assumed that the neighborhood discovery protocol provides each node the local knowledge of topology within certain range. They gave a linear programming formulation to select the range which minimizes the energy expenditure of the network.

8. CONCLUSION

We proposed the localized energy aware restricted neighborhood routing protocol for wireless networks. We theoretically proved that our LEARN routing protocol is energy efficient if it can find a path. We also studied its critical transmission radius for the successful packet delivery. We also extended the proposed routing method into 3D networks. Our mathematical formulation also extends to any routing protocol in which the region to find the next hop node by an intermediate node is compact and convex. We conducted extensive simulations to study the performance of our LEARN routing.

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