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Localized Energy-Aware Restricted Neighbourhood Routing in Multihop Wireless Sensor Networks

A. Latha[1,]*, G. Srinivasan[2]

[1]Department of Electronics & Communication Engineering, Adhiparasakthi Engineering College, Melmaruvathur, India
[2]Department of Computer Science and Engineering Adhiparasakthi Engineering College, Melmaruvathur, India

*Corresponding author email: latha.arthanari@gmail.com

ABSTRACT

In the recent years, research has been increased towards wireless sensor network in various fields. It consists of thousands of small and low cost sensors with limited power, computation, storage and communication capabilities. The nodes have limited initial amounts of energy that is consumed in different rates depending on the power level and the intended receiver. Energy conservation and Scalability are probably two most critical issues in designing protocols for multihop wireless networks. The protocols developed for these networks should be energy efficient and also scalable. Geographical routing algorithms are known to be scalable but their energy efficiency has never been comparatively studied. In geographical routing algorithm, the packets are forwarded by a node to its neighbour based on their respective energy. We propose an algorithm named Localized Energy-Aware Restricted Neighbourhood routing (LEARN) which finds route for any source and destination pairs asymptotically and guarantee the energy efficiency of its route if it finds the route successfully.

Keywords – Wireless network sensors, neighbourhood routing.

1. INTRODUCTION

Energy conservation and scalability [1] are probably two most critical issues in designing protocols for multihop wireless networks, because wireless devices are usually powered by batteries and have limited computing capability while the number of such devices could be large.

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, it 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. In this paper we focus on designing routing protocols for multihop wireless networks which can achieve both energy efficiency and scalability by carefully selecting the forwarding neighbors and high scalability by using only local information to make routing decisions.

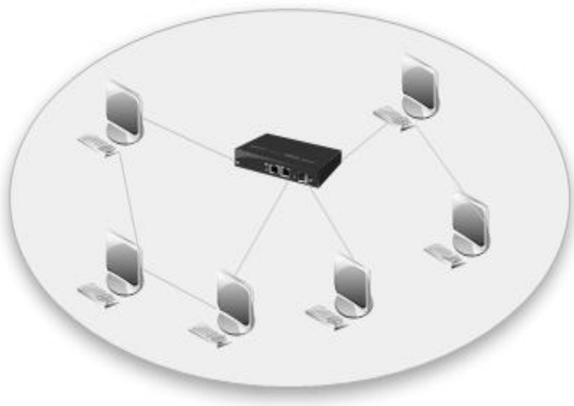

Fig.1 Network Topology

Figure 1 show the type of networking topology used in this work. Each node in the network captures and disseminates its own data and also serve as a relay for other nodes.

2. RELATED WORK

The geometric nature of the multihop wireless networks as author [2] 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 [4] 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.

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 [3] 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 this paper, we focus on stateless localized routing.

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.

3. NETWORK MODEL AND ROUTING PROBLEM

Here consider a set V of n wireless devices (called nodes hereafter) distributed in a compact and convex regionΩ. Typically, the regionΩ 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.

A routing protocol A is said to be a localized protocol if the information of the source node s and the target node t and the k-hop neighborhood information is known. The current node u can decide which neighboring node v to forward the message. Here k is a constant, usually 1 or 2.

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 as shown in the Figure 2 then the routing method A is called energy efficient

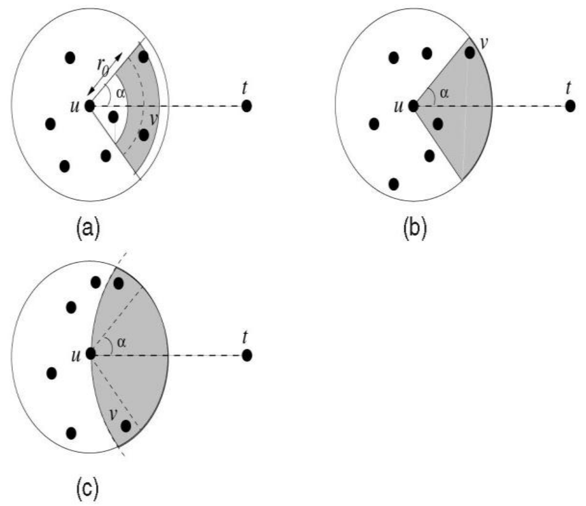

Fig. 2 Node Forwarding

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

3.1 Energy Efficient Localized Routing

In this section, energy-efficient localized routing method called LEARN is described in detail. 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.

3.2 Learn Routing Protocol

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 2 α sector region with minimum distance. When there is no neighbor in the 2 α sector region, classical greedy routing or face routing can be applied.

In LEARN protocol, there are various input parameters:

1) $\alpha < \pi/3$ is an adjustable parameter to define the 2 α sector restricted forwarding region;

2) Ƞ1 and Ƞ 2 are two constant parameters to control the restricted forwarding region around r0 if r0 < r, usually Ƞ1< 1 and Ƞ2> 1;

3) r0 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 < uvt ≤ α. 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.

3.3 Critical Transmission Radius Of Learn

This section is about 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.

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 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.

4. 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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