ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2015

Survey on Energy Efficient Geographic Routing Protocols in Wireless Sensor Networks

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ABSTRACT: Wireless Sensor Networks (WSNs), which is a system of nodes connected by wireless links, is a very popular area for exploration. The nodes are free to move around and organize themselves into a network. The network topology is often changing, and for relatively smaller networks, the flat routing schemes are sufficient. However in larger networks, either geographical or hierarchical routing protocols are required. Geographical routing uses location information to formulate an efficient route search toward the destination. In this paper, some of the major geographic routing protocols for WSNs are presented.

KEYWORDS: Geographic Routing, Wireless Sensor Networks.

I.INTRODUCTION

Geographic routing (also known as position-based routing or geometric routing) is a technique to deliver a message to a node in a network over multiple hops by means of position information. Routing decisions are not based on network addresses and routing tables; instead, messages are routed towards a destination location. With knowledge of the neighbors' location, each node can select the next hop neighbor that is closer to the destination, and thus advance towards the destination in each step. The fact that neither routing tables nor route discovery activities are necessary makes geographic routing attractive for dynamic networks such as wireless ad hoc and sensor networks. In such networks, acquiring and maintaining routing information is costly as it involves additional message transmissions that require energy and bandwidth and frequent updates in mobile and dynamic scenarios. In contrast, there are geographic routing algorithms that work nearly stateless and can provide high message delivery rates under mobility. All this applies under the following assumptions:

1. A node can determine its own position.
2. A node is aware of its neighbors' positions.
3. The position of the destination is known.

With GPS or other satellite based navigation systems, position information can be made available to even small mobile devices. Further location systems for indoor applications are described in [1]. The second assumption requires broadcasting the position information locally to other participants in the network. With this information a node is able to determine the next hop that is closer to the destination. The third assumption can be met by means of a location service that maps network addresses to geographic locations. In some cases, the destination is inherently known to the nodes, e.g. in some sensor network applications where a single sink node collects all the data measurement information. The disadvantage of such program is to take other nodes into consideration unless the energy of the nearest neighbor nodes is used up and it is easy to form energy hole. The current multipath route protocols use different parameters to build paths. For those parameters, the quantity of parameters whose paths do not cross is the main standard from source to sink multipath protocol.

The main prerequisite to meet the three assumptions is a positioning system. If this is available, geographic routing provides an efficient and scalable solution for routing in wireless and mobile networks. However, a simple greedy

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forwarding by minimizing the distance to the destination location in each step cannot guarantee message delivery. Nodes usually have a limited transmission range and thus there are situations where no neighbor is closer to the destination than the node currently holding the message. Greedy algorithms cannot resolve such dead-end or local minimum situation. Therefore, recovery methods have been developed, the most prominent of which are based on planar graph routing, where the message is guided around the local minimum by traversing the edges of a planar sub graph of the network communication graph. Planar graph routing techniques can provide delivery guarantees under certain assumptions, which are explained in Section 3, and complement the efficient greedy forwarding. Altogether, greedy forwarding in combination with a recovery can be considered as state-of-the-art technique in geographic routing.

There are many applications of the WSNs. The military applications include monitoring of enemy forces, monitoring of friendly forces and equipment, military –theatre and battlefield surveillance, battle damage assessment, targeting, nuclear and chemical attack detection and many more. The environmental applications include microclimates, forest fire detection, flood detection and precision agriculture. Among the health applications are monitoring doctors and patients within a hospital, remote monitoring of psychological data, drug administration, elderly assistance and many more. The home applications inculcate home automation and instrument environment. The commercial applications include environmental control in industrial and office buildings, inventory control, vehicle tracking and detection, and traffic flow surveillance.

This paper organizes as follows. Section 2 explains the geographical routing with its advantages and section 3 reviews geographic routing protocols. Finally, the conclusions are presented in Section 4.

II.GEOGRAPHIC ROUTING

Geographical routing [3, 4] uses location information to formulate an efficient route search toward the destination. Geographical routing is very suitable to sensor networks, where data aggregation is a useful technique to minimize the number of transmissions toward the base station by eliminating redundancy among packets from the different sources. [2]It is much attractive for large multi-hop wireless networks in which the nodes are not reliable and their network topology is frequently changing.

Geographical routing only requires the propagation of single hop topology information, like the best neighbor, to make correct forwarding decisions. Its localized approach reduces the need of maintaining routing tables, and hence reduces the control overhead. It does not require flooding. Only nodes that lie within the designated forwarding zone are allowed to forward the data packet. The forwarding region can be defined by the source node or by the intermediate nodes to exclude nodes that may cause a detour while forwarding the data packet. The second property of geographical routing is its position based routing. Here a node requires knowing only the location information of its direct neighbor.

The mechanism used is greedy mechanism where each node forwards a packet to the neighboring node that is closest to the destination. The Euclidean distance to the destination is generally used as metric. Position based routing protocols have the potential to reduce control overhead and reduce energy, as flooding for node discovery and state propagation are localized to within a single hop [2]. The network density, the accurate localization of nodes and the forwarding rule decides the efficiency of the scheme.

2.1. Advantages of Geographic Routing

a. The mobility support can be facilitated. Since each node sends its coordinates periodically, all its neighbors update their routing tables accordingly. Thus, all nodes aware of its alive neighbor nodes.
b. It is scalable. The size of routing table depends on network density not on network population. Hence wider networks consisting of thousands of nodes can be realized without cluster formation.
c. Minimum overheads are introduced. The only information needed is the location of neighbors. Only localized interactions take place. Hence bandwidth is economized. The processing and transmission energy is saved and the dimensions of routing table are decreased.

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III. REVIEW OF GEOGRAPHIC ROUTING PROTOCOLS

M. Chen et al [5] presented a reliable energy-efficient routing (REER) protocol to achieve the above goals for dense wireless sensor networks (WSNs). Based on the geographical information, REER's design harnesses the advantage of high node density and relies on the collective efforts of multiple cooperative nodes to deliver data, without depending on any individual ones. At first select reference nodes (RNs) between source and sink. Then, multiple cooperative nodes (CNs) are selected for each RN. The reliability is attained by cooperative routing: each hop keeps multiple CNs among which any one may receive the broadcast data packet from the upstream hop to forward the data successfully. The distance between two adjacent RNs provides a control knob to trade off robustness, total energy cost and end-to-end data latency. The main difference between REER and the traditional geographical routing protocols are as following: (1) REER is stateless and does not need to store any neighbor information; (2) In unreliable communication environments, traditional routing protocols may fail to deliver data timely since link/node failures can be found out only after trying multiple transmissions. In REER, each data is only broadcast once at each hop. If there is at least one of the CNs is in good status, the data packet is delivered successfully; (3) In REER, the number of cooperative nodes are adaptively selected before data delivery, such that the number is minimized while achieving required reliability according to the link failure rate. The unselected nodes will enter sleeping mode to save energy during data dissemination. Extensive simulation experiments are carried out to show that REER achieves an efficient trade-off among reliability, energy consumption, and end-to-end delivery latency. The REER protocol is evaluated through both analysis and extensive simulation.

A. B. Bagula et al [6] addresses the issue of Quality of Service (QoS) Routing to improve energy consumption in wireless sensor networks (WSNs). Building upon a previously proposed QoS provisioning benchmark model, the problem of routing sensed information is formulated in a WSN as a path-based energy minimization problem subject to QoS routing constraints expressed in terms of reliability, delay and geo-spatial energy consumption. Using probabilistic approximations, the path-based model is transformed into a link-based model and applies methods borrowed from the zero-one optimization framework to solve this problem. By comparing the performance achieved by its solution to the benchmark model, simulation results reveal that the model outperforms the benchmark model in terms of energy consumption and quality of paths used to route the sensed information.

B. Deb et al [7] investigate the use of directional geographical routing for multipath construction for multimedia data dissemination, and identify the challenging issue of achieving multipath balancing in proximity to the source/sink. While the previous work addresses the multipath expanding problem efficiently, this work presents a novel scheme to achieve the paths balancing distribution to alleviate the contention between the paths when close to the sink. The path construction is divided into expanding phase, parallel phase and converging phase in the proposed scheme, which includes two key algorithms, i.e., the detection algorithm for path construction phase and the deviation angle adjustment algorithm. Simulation results that verify the effectiveness of the proposed scheme are presented.

M. Chen et al [8] address the problem of real-time video streaming over a bandwidth and energy constrained wireless sensor network (WSN) from a small number of dispersed video-sensor nodes (VNs) to a sink by combining forward error correction (FEC) coding with a novel multipath routing scheme called directional geographical routing (DGR). DGR constructs an application-specific number of multiple disjointed paths for a VN to transmit parallel FEC-protected H.26L real-time video streams over a bandwidth-limited, unreliable networking environment. The multiple paths in DGR facilitate load balancing, bandwidth aggregation, and fast packet delivery. Extensive simulation experiments over randomly generated WSNs show that DGR has the following advantages: (i) lower delay, (ii) substantially longer network lifetime, and (iii) a better received video quality. In particular, DGR improves the average video peak signal-tonoise ratio (PSNR) by up to 3dB, compared to a traditional geographic routing scheme.

P. R. Morin et al [9] consider online routing algorithms for finding paths between the vertices of plane graphs. There exists a simple online O(1)-memory c-competitive routing strategy that approximates the shortest path in triangulations possessing the diamond property, i.e. the path found is at most a constant c times the total distance travelled by the algorithm. The results imply a competitive routing strategy for certain classical triangulations such as the Delaunay, greedy, or minimum-weight triangulation, since they all possess the diamond property.

Z. Wang et al [10] proposed an energy efficient and collision aware (EECA) node-disjoint multipath routing algorithm for wireless sensor networks. With the aid of node position information, the EECA algorithm attempts to find two collision-free routes using constrained and power adjusted flooding and then transmits the data with minimum power needed through power control component of the protocol. The preliminary simulation results show that ECCA algorithm results in good overall performance, saving energy and transferring data efficiently.

M. K. Marina and S. R. Das [11] presented AOMDV, an on-demand multipath distance vector protocol, in the framework of a well-known single path protocol (AODV) of similar nature. AOMDV computes multiple loop-free link disjoint paths during route discovery. The notion of an advertised hop-count to establish loop free multiple paths are introduced. Comparison is made on the performance of AOMDV with AODV using extensive simulation experiments based on ns- 2. Simulation results show that AOMDV is able to reduce the frequency of route discoveries by as much as 30% and also achieve a remarkable reduction in the end-to-end delay.

P. Hurni and T. Braun [12] investigate the usefulness of multi-path routing to achieve lifetime improvements by load balancing and exploiting cross-layer information in wireless sensor networks. Performance gains in the order of 10-15 % could be achieved by altering path update rules of existing on-demand routing schemes. Problems encountered with concurrent traffic along interfering paths have been identified as a direct consequence of special MAC protocol properties.

M. Radi et al [13] propose a Low-Interference Energy-efficient Multipath ROuting protocol (LIEMRO) for WSNs. This protocol is mainly designed to improve packet delivery ratio, lifetime, and latency, through discovering multiple interference-minimized node-disjoint paths between source node and sink node. In addition, LIEMRO includes a load balancing algorithm to distribute source node's traffic over multiple paths based on the relative quality of each path. Simulation results show that using LIEMRO in high traffic load conditions can increase data reception rate and network lifetime even more than 1.5x compared with single path routing approach, while end-to-end latency reduces significantly. Accordingly, LIEMRO is a multipath solution for event-driven applications in which lifetime, reliability, and latency are of great importance.

Pramod Kumar et al [14] attempt to analyze geographical location based hierarchical routing algorithms. The entire network life time depends on energy of individual nodes. The routing algorithm is modified in such a way that it highly depends on location information. This is to utilize the scare resource of energy. A Binary Location Index is formulated based on the binary encoded spatial frames for all participating nodes. This is to impart location aspects in an algorithm in much simpler way and avoids the situation of „hot spot‟. In the proposed method the entire service area is divided in to four zones and indexed as (I, II, III and IV). These zones are subdivided into subzones and into regions, sub regions and lastly into grids. The grids are further decomposed into infinitesimal area called cells. After a long duration these Location Areas and simple nodes reach their specified lowest energy. And it leads to a phenomenon called hot spot. This hot spot effect should be prolonged till the occurrence of maximum expected time (Horizon time). The selection of LAs and sensor nodes should be done likewise, for lifetime maximization of entire network.

Young-Gwan and Kang [15] propose the routing protocols that define the direction of data which is routed based on the position information of individual and sink nodes. The objective of this paper is to extend the service life of networks by reducing the energy consumed in networks through reducing the frequency of communication in each node using the routing protocol that employs position coordinates in each node. The paper defines a direction defining algorithm and evaluates its operation, to perform this goal. The proposed algorithm by authors, the position coordinate is not applied to actual longitudes and latitudes but simple abstractized x and y coordinates because it evaluates the performance of the protocol in a simulation level. In their work they conclude that the nodes that received messages identify whether their own position corresponds to the direction for the target area. If the results of the identification are true, the message will be forwarded, otherwise destroyed.

Tarek R. Sheltami et al [16] use energy aware neighbor selection to route a packet towards the target region and geographic forwarding or flooding approaches to disseminate the packet inside the destination region. The Protocol‟s object is to fairly balance the energy among neighbor nodes. The paper evaluates the performance of GEAR protocol and investigates the possibility to optimize its operation to achieve greatest performance. The simulator used is java. Static centralized strategy, dynamic and adaptive decentralized strategies are included for distance and energy balancing. The authors describe the importance of energy efficient communication and routing techniques to increase the network life time. They analyzed

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ISSN (Print): 2320-9798

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many protocols proposed by different researches. GEAR minimizes delay due to distance traveled on geographic routing and improving energy balancing and improves energy balancing. The main contribution of this GEAR protocol is experimental analysis and investigates the optimization problem and tradeoffs between distance and energy balancing. The paper also narrates the impact of the preference metric in the system performance. The preference parameter α is defined and it is used to manipulate static, dynamic and adaptive assignment approaches. The paper concludes that the preference choice in the static approach or in the dynamic or adaptive approaches does not have a major impact on the optimality of GEAR operation.

Ana Maria Popescu et al [17] surveys almost 50 protocols and considers the position based routing with many advantages worth considering. Position based protocols have application potential in networks with demanding requirements. Of all the position based protocol the geographic approach is the one which captures the attention in the context of location aided routing. The authors say that geographic routing is an elegant way to forward packets from source to destination in very demanding environment without wasting network resources or creating any impediment in the network design. The paper gave application suggestions for position based routing protocols, like industrial, home, health, environmental, military, automotive and commercial. The authors suggested future work in geographical routing. Position based algorithms have to consider the intrinsic error of inaccurate localization techniques. They say more practical solutions are needed which maintain energy consumption low and preserve the packet delivery ratio even when nodes are mobile. The paper also discusses about 3D applicability and secure routing.

B.Shanmuga Raja et al [18] discuss about modified GPSR (Greedy perimeter Stateless Protocol). In traditional GPSR nodes advertise their availability to update the routing table. Here the authors introduce modified GPSR, which identifies optimal route based on energy utilization. The energy and delay are minimized and substantially increases the network lifetime of sensor node. But it still uses GPSR with bulk of overheads. In the proposed scheme is the energy consumed to send a message to a distant node is greater than the energy needed for a short transmission. Here GPSR is extended using aggregation node or head set node. It is proved in this algorithm that Modified algorithm produces good performance in routing path lengths compared to previous protocols.

Rong Ding; Lei Yang [19] clearly highlight two types of mechanisms in routing- Geographical routing and Reactive approach. Geographic routing is used to find the optimal path. In reactive routing, routing occurs only on demand. The RGRP (Reactive Geographical Routing protocol) proposed by the authors reduce the packets for routing discovery and end to end delay and hence possible to get low routing protocol overhead and more reliability for long link. They suggest two steps to find the shortest path-first, calculating the shortest path between source and destination, and second, to create the reverse route. The performance characteristics like packet loss, average end to end delay, and route discovery overheads are compared with the GPSR and proved them to be better.

IV.CONCLUSION

WSNs have seen tremendous developments in design and applications over the recent years. This speedy progress has resulted in the stress towards solving the hurdles that this area has to face. Routing is an important issue in WSNs. Thus we have presented an extensive overview of geographic protocols for wireless sensor networks. Utilizing the geographic information is necessary for building scalable and efficient protocols in these environments. This study shows that there is a significant amount of work done in this area. Nevertheless, in order for geographic protocols to be implemented in the real world, a higher degree of robustness to the realistic environmental conditions is required. Assessing the robustness of geographic protocols to non-ideal conditions corresponding to the real-world environments and designing new strategies and protocols that take these conditions into account is vital for the geographic protocols to be deployed.

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ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

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Vol. 3, Issue 11, November 2015

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