An Overview of a Method for Increasing Performance and Energy Efficiency of Geographic Routing Protocol in Sensor Networks

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ABSTRACT

This paper presents a review of geographic routing protocol for wireless sensor networks which includes the greedy forwarding method, its limitations and methods to overcome these limitations. Accurate location availability is an important criterion in any location-based routing protocol of WSN. Also energy efficiency is required for increased lifetime of a network; this paper focuses on these two aspects and also presents a new routing method that has enhanced topology awareness with energy efficiency.

Keywords

Energy efficiency, sensor networks, routing, topology embedding.

1. INTRODUCTION

Routing in WSN has been studied vastly over many years till now. They have been characterized based on the network structure of the nodes or their protocol operation ranging from flat based routing, hierarchical routing to multipath based routing including energy aware and location based algorithms. This is due to the inherent characteristics of the sensor networks and large deployment of sensor nodes.

Location based methods such as geographic routing protocols contain greedy forwarding technique in which the node sends the packet to the neighbor that is assumed closest to the final destination. Location information, in the form of coordinates, is exchanged between the nodes. Also the location information can be derived from specific devices such as GPS or can be modeled by virtual coordinates.

In this paper we study the various protocols that have been developed so far and their limitations in the next section. Then we will see the new protocol that works on the limitations of these previous protocols that is based on topology awareness to improve the performance of routing in WSN and also make it energy efficient.

2. PREVIOUS WORK

In this section the location based geographic routing is explained, its limitations and previous work performed on this limitation

2.1 Shortest Path Routing

In this approach a classical method is used in which a distributed form of Dijsktra's algorithm is used to compute the shortest path between the source and destination. The protocols are Distance Vector and Link State in which the shortest path between all source to destination pairs is maintained. Also every node in the network needs to store the next hop to its destination. Therefore for a network with n nodes this results in n^2 messages to be exchanged and n number of states to be stored at each node. This overhead scales poorly to large networks[2].

2.2 GPSR

Greedy Perimeter Stateless Routing Protocol (GPSR) [3] is a novel routing protocol that uses positions of routers and packet and destination to make forwarding decisions. It uses greedy forwarding strategy to select the next hop that is closest to the destination. If the greedy forwarding fails then the algorithm recovers by routing around the perimeter region. The algorithm uses right hand rule for tracing its perimeter. The overhead of large number of states is reduced in this algorithm but this algorithm does not provide global optimum.

2.3 CLDP

Cross Link Detection Protocol [4] is an corrected version of all previous protocols that depend upon the assumption about radios and resulting connected graphs. But it is tested that these idealized assumptions are violated by real radios and thus cause failures in routing. These are fixed by CLDP that enables correct geographic routing. This protocol produces a subgraph on which arbitrary face traversals does not cause a routing failure regardless of radio irregularities and localization errors.

2.4 LCR

Logical Coordinate Routing(LCR) [5] constructs coordinates of nodes based on some landmarks. Based on these coordinates a distance function is created and routing is performed to minimize this function. When greedy routing fails then the algorithm backtracks the packet along the path until a suitable path is found.

2.5 BVR

Beacon Vector Routing [2] is a scalable technique for point-to-point routing in wireless sensor networks. It assigns coordinates to nodes based on the hop distance o particular nodes called beacons and then constructs a distance metric on these coordinates. It incorporates the greedy forwarding strategy to send packets to the next hop that is closest to the destination.

2.6 Limitations and Advantages

Table 1. Limitations and advantages of previous protocols.

Sr.no.	Protocols	Limitations	Advantages
1	Shortest Path Routing	Large number of states required to be stored	Simple to Implement
2	GPSR	It incurs permanent delivery failures	Reduces number of states to be stored and provides solution to local minima problem
3	CLDP	Based on face routing that is not so efficient than greedy forwarding.	It supports the GPSR and other algorithms and avoids routing failures.
4	LCR	Coordinates assignment does not reduce the size of states significantly	Reduces state size as compared to SPF,GPSR and CLDP
5	BVR	Coordinates assignment does not reduce the size of states significantly	Reduces state size as compared to SPF,GPSR and CLDP

Table explains in brief the limitations and advantages of protocols that are explained above.

2.7 Comparative analysis

Table 2. Comparative analysis of all protocols with the new protocol proposed in this paper

RP / Metrics	SPR	GPSR	BVR/LCR	New RP
Routing failure ratio	High	Medium	less	Very less
Per-node state	Number of nodes n	Number of neighbors N	Number of beacon nodes B	Less than number of anchors M due to topology embedding
Delivery guarantee	Yes	Assuming unit graph topologies	yes	Yes
Configuration	No	Geographic positions	Select r random nodes	Select r anchors

Table explains the comparison of different routing protocols with respect to different metrics[1][2].(RP: Routing Protocol

3. PRELIMINARIES

3.1 Geographic Routing

Geographic routing [3] [6] which is also known as position based routing uses geographic position to route packets. In this, the source sends packets to the geographic location of the destination instead to its network address. Each node in the network should be able to determine its own location and also the source node should know the location of the destination so that the source can directly send packets to the destination and there is no need of determining the path previously.

Greedy Forwarding is a technique of geographic routing in which greedy approach is used to send the packets. In short, the node sends packets to that neighbor which is closer to the destination as compared to other neighbors of that node. The most suitable neighbor will be the one who minimizes the distance to the destination in each step.

The advantages of this technique is seen when the network scales to thousands of nodes and for that method relies on keeping small routing states which is suitable for the limited memory of sensor nodes. In addition, the route can be computed when it is required which eliminates the overhead for updating the routing table.

3.2 Limitations

Greedy forwarding is an efficient technique but with some limitations that are listed below:

3.2.1 Local minimum problem

Local minimum problem [2] is the one where the current node has no neighbor closer to the destination than the node itself.

The node x does not contain any neighbor node that is closer to the destination node D than itself. Nodes w and y are neighbors of x but they are farther from D. Node x can also be called as the local maximum node [2]. The result is that a void or hole is created.

3.2.2 Location availability

Although many localization methods have been proposed to infer the nodes' locations with GPS enabled nodes there has been less accurate localization leading to route failures

4. NEW ROUTING PROTOCOL

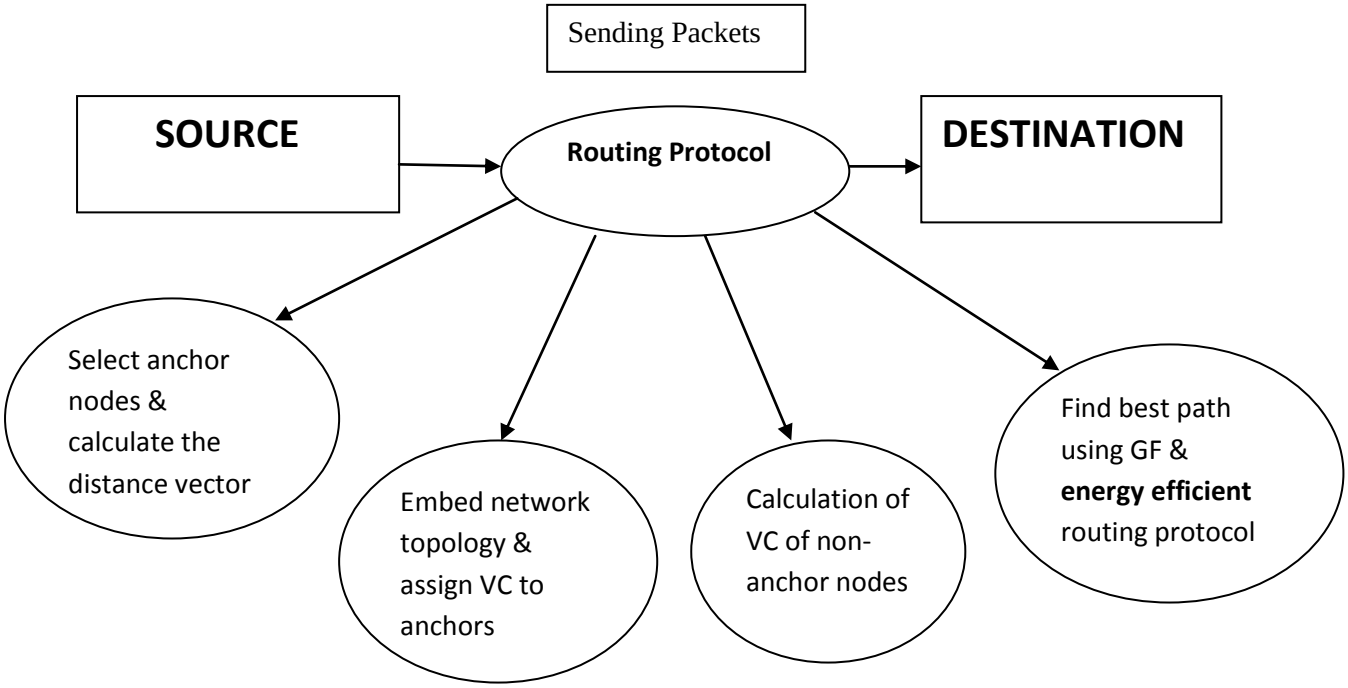

Fig 1. Data Flow Diagram of the new protocol (VC: Virtual coordinates, GF: Greedy Forwarding)

The geographic routing method can be improved by assigning coordinates to nodes and representing the network into a low dimensional space. Along with this, the energy efficiency of the entire network is increased by applying the energy consumption parameter in the entire process. A set of special nodes is created that will calculate the entire topology of the network and give it to the sender node. This facilitates the accurate collection of location information of the entire network.

4.1 System Features

The new protocol presented in this paper is an efficient method of Greedy Forwarding both in terms of performance and energy efficiency. This protocol is an improved version of greedy forwarding method. The main idea is to generate coordinates that are accurate and of minimum dimension. This enhances the performance and reduces the storage required to store minimum number of states per node [1].

The protocol works in stages as shown in figure 1.

1) Calculation of distance vector by anchor nodes.
2) Calculation of entire topology by the base station
3) Embedding the network topology into low dimension using MDS [8].
4) Assigning virtual coordinates to all nodes.
5) Using this topology information finding the best possible route to the destination using greedy forwarding and that is energy efficient.

The previous methods have limitations as we have seen in the previous section. In this new method the limitation of local minima and location availability is removed by having correct location coordinates through virtual coordinate assignment. Also the dimensionality of these coordinates is reduced by embedding the network topology into low dimension. Also an additional feature of energy efficiency is added while finding the best route towards destination.

4.1.1 Algorithm

Here we see the steps that will be performed by this new algorithm[1].

Step 1: Select M anchor nodes from N number of nodes

Step 2: Collect distances from all nodes at these anchors and create distance vector

$$x_i = [x_{i1}, x_{i2}, \ldots, x_{iM}]$$

x_{ij} is the shortest hop distance from node i to anchor j.

Step 3: Calculate distance matrix X at the base station by collecting this vector from all anchor nodes

$$X = [x_1, x_2, \ldots x_M]$$

Step 4: Use MDS to embed the distance metric space (X, ∂) to a low dimensional Euclidean space (P, d) and assign virtual coordinate v_j of $m << M$ dimension to each anchor.

Step 5: All non anchor nodes calculates their virtual coordinates based on the coordinates of the anchor nodes.
Step 6: In this step after embedding the network topology the next hop is chosen as the neighbor node that is closest to the destination(Greedy forwarding) along with it the nodes remaining energy is calculated that should be maximum than the remaining energy of other neighbor nodes.

$$\text{next hop} = \max \text{energy}(x_1, x_2, \ldots\ldots, x_N)$$

N is the number of neighbor nodes closest to destination.

The last step is the proposed work that enhances the energy efficiency of the forwarding process.

5. CONCLUSION

In this paper we have seen a new method of routing that is an improvement to the Greedy Forwarding strategy. This paper gives a review of the previous work that has been developed for geographic routing and their comparative study. The new protocol tries to remove the limitations of these previous methods in all aspects. Also one new feature of energy efficiency is added along with performance improvement. The future enhancement to this method can add a method that works on the irregularities of radio signals and that avoids the failures due to this reason. Also we can calculate the number of packets transferred to check the transmission rate and accordingly transfer the packets.

6. REFERENCES

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