A Coverage Issues Based on Computational Geometry in Wireless Sensor Networks: A Review Study

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Abstract - In Wireless Sensor Networks for the issue of coverage, recently, a great enhancement has to be seen due to introduction of geometrical structures like Voronoi diagram, Convex hull, Delaunay triangulation etc. which are the components of Computational geometry. In this paper, we present a survey on the contribution of Computational geometry for WSNs regarding coverage problem. Computational geometry follows algorithmic approach to solve problems in which execution of instruction is to be done in stepwise procedure. To design energy-efficient algorithms while maintaining network connectivity computational geometry playing a challenging role. This article represents how wireless sensor networks, coverage and computational geometry are in relation with each other.

I. Introduction

1.1 Wireless Sensor Networks(WSNs) and Coverage

A wireless sensor network consists of a number of autonomous sensor nodes which are distributed in the targeted region for continues supervision. These nodes are tiny electrical devices which are equipped with battery power and have the ability to process and communicate the data. WSNs have a large number of applications in the field of military, health, environment etc., which realize the development of efficient communication protocols. Coverage in wireless sensor network reflects the property how to schedule the sensors so that an interested region or a set of objects can be monitored up to the desired level. Efficient coverage also dealswith the removal of redundant sensors while maintaining the network connectivity. For the evaluation of the quality of service coverage and network lifetime are basic metrics. Network lifetime can be defined as the duration up to which the deployed sensors work out properly. Mostly, sensor nodes are deployed densely in a random manner and this leads to overlapping of sensing area of nodes. So, an effective scheduling of node placement strategy is also the fundamental issue in coverage problem in wireless sensor networks. To obtain a level of quality, deployment of sensor nodes should be with least possible overlapped area. Coverage problem also classified in many different forms like area coverage, point coverage, barrier coverage etc. [11].Area coverage aims to cover a specified region and is greatly influenced by the factors such as sensors sensing range, their location and their direction. Point coverage works with the objective to sense a given set of points. Target coverage resembles to the point coverage as in the former one some specific targets are defined already. And, barrier coverage determines the sensing probability while an intruder crossing a given area which is under the supervision. The issues related to coverage have a significant influence on the network performance. Thus, coverage and sensor's deployment strategies are closely related with each other. The modern technologies also trying to defuse the different sensor deployment strategies in practical applications to obtain desired level of quality of service in different kinds of coverage and up to certain level these technologies are successful to do so. A number of challenges are discussed in [9] in the terms of factors like coverage ability, network connectivity, algorithm accuracy, complexity and implementation strategies etc. Presently, computational geometry in the development of energy-efficient algorithm is emerging field in which algorithm in geometrical terms studied out. Line segment, Convex hull, Voronoi diagram and Delaunay triangulation etc. are some basic objects of computational geometry. To solve the coverage problems, theuse of computational geometry results significantly.

II. Basics structures of computational Geometry

The origin of computational geometry is from the field of algorithm design and analysis in 1970s. Earlier solutions for geometrical problem were complicated and complex to understand and implement. The authors in [12] defined some geometrical structures which resolves the previous difficulties and emerges out new algorithmic techniques. Some of which are as follows:

2.1 Convex hull

The convex hull of a set S, C(S), is the smallest convex set containing the set S. A subset S of a plane is said to be convex if and only if for any pair of points a, b ε S, the line segment ab, is completely contained in S. Convex hull of a set of points P is a convex polygonand way of representing a polygon is by listing its vertices in clockwise order starting arbitrarily.

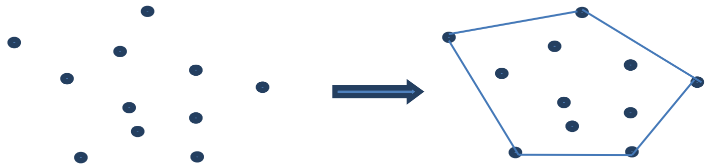

Fig.1- Convex hull

2.2 Voronoi Diagram

Voronoi diagram is known as one of the versatile geometric structure. Voronoi diagram for a set of points S, is defined as the division of plane into n cells having the property that a point 'a'that lies in the cell corresponding to a site si if and only if dist(a, si) <dist(a, sj) for each sjε S, j ≠ I, for each site in S. Here the dist(a, si) represents the Euclidian distance between two points.All the points belonging to same site forms convex Voronoi region.

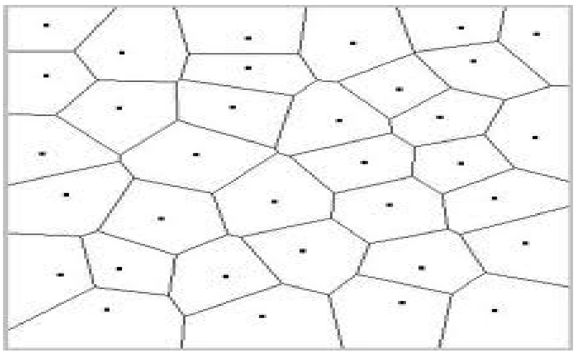

Fig.2- Voronoi diagram

2.3 Delaunay triangulation

Height Interpolation is one of the examples to explain the role of Delaunay triangulation. It is consist of two terms Delaunay and Triangulation. Firstly, Triangulation of a plane is the planar subdivision whose faces are bounded by triangles and vertices are the point of the same plane. Delaunay triangulation is the triangulation obtained by addition of edges to Delaunay graph. The Delaunay graph of a finite set S is an embedding of the dual graph of the Voronoi diagram.

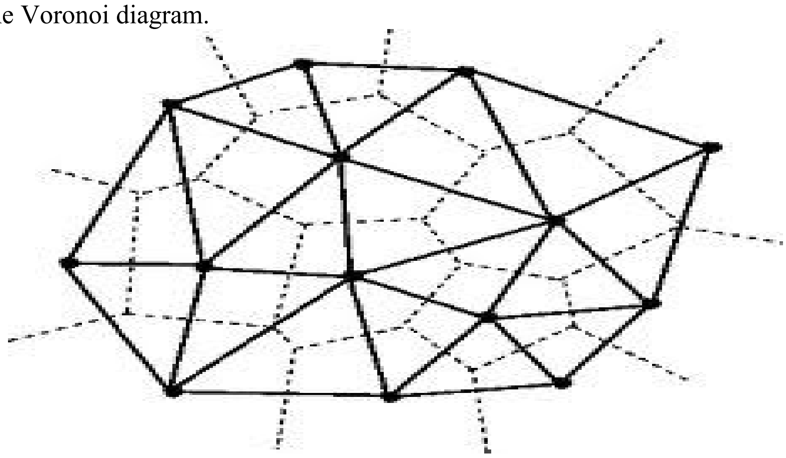

Fig.3- Delaunay triangulation

III. Coverage and Computational Geometry

Using the concept of Voronoi, an optimal coverage approach for Directional Sensor Networks (DSNs) is represented in [5]. The authors proved that coverage in DSNs is NP-completeand for the solutionthey have provided Voronoi-based centralized approximation and Voronoi-based distributed approximationalgorithms. Both the algorithms work on the aim of maximizing the Voronoi cover edges as possible as much. Here, optimality stands for minimizing the number of activated sensors. An extension of calculating minimal exposure path for single sensor from a square sensing field to convex polygon is given in [4]. As informally, exposure measures the expected ability to detect a moving target in an interested sensing field. Also, a discussion about maximal exposure path and maximal breach path using Voronoi diagram and Delaunay triangulation is given. One of the important factors for energy saving and balancing the load in the entire network is the knowledge about the Voronoi boundaries and Voronoi neighbours. In regards to this, the authors in [7] presented the concept of distributed computation of Voronoicells which provide the exact method to eliminate inaccuracies, while it costs in terms of increased overhead without making the entire network connectivity as compulsory.A network density control mechanism based on Voronoi diagram is presented in [6]. The authors have given an algorithm which results in the number of nodes should be turned off and that can be used as back up nodes. The algorithm is based on division of entire network into sub-regions as Voronoi cells using the concept of Voronoi diagram. In the paper [10], the modified version of existing directional methods to determine exactly the neighbour of a destination which acts as the best possible choices is given. These methods are VD-GREEDY and CH-MFR based on Voronoi diagram and Convexhull respectively. Both the methods are based on appropriate selection of a number of points on the boundary of circle and calculating the nearest neighbour for each of them.In spatial networks, to find the K nearest neighbours of a given query object, computational geometry is helpful. In the paper [3], the authors have presented how K nearest neighbours (KNN) queries in spatial networks can be evaluated using the first order Voronoi diagram. The given approach is based on division of larger network into Voronoi regions and then calculating the distances within and across the regions. The coverage which is done by the deploying the sensors under the water is known as coverage in under water sensor networks. In regards to the same, a depth-adjustment scheme to maximize the coverage in 3D region is given in paper [1]. For this scheme, the usage of Voronoi diagram has been done. Voronoi diagram has been used to determine the redundant nodes in 2D and making the use of these redundant nodes for the coverage in 3D. Voronoi diagram can also be used to detect coverage hole and for the estimation of the hole size. A discussion on the healing coverage hole is presented in paper [2].

IV. Conclusion

A number of features such that self-organization capability, reliability and flexibility are responsible for research attention and rapid development of new paradigms, in the form of geometrical structures for wireless sensor networks. The paper describes the role of computational geometry to solve coverage problem. The important aspects that are closely related with wireless sensor networks are energy-efficiency and network connectivity which, in turn, evaluate the quality of service for the network. Both the factors are concerned with the issue of coverage and responsible for the emergenceof new techniques of the development. As coverage is a measure of quality of service, this article provides a survey for existing algorithm and helpful to open new ways for developing new methods that are efficient and plays a vital role in improvement of quality of a network. In this way this article contributes a little for future research.

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