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A Review on Hole Detection and Healing in Wireless Sensor Network

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Abstract— A wireless sensor network (WSN) comprises of nodes, each node is connected to one or more sensors. Occurrence of fault in a single node is called as cut. And the fault occurred in multiple nodes in a particular region which is called as hole. The region under surveillance is considered as region of interest (ROI). There are various methods for detecting and healing the holes. We study the different methods for hole detection and healing in WSN in this paper.

Keywords—Hole detection, Hole healing, region of interest, boundary detection, coverage area, nodes, wireless sensor network, sensor.

INTRODUCTION

ireless sensor network (WSN) consist of large number of nodes, where a single node is connected to one or more sensors. These Wsensors help to sense various physical parameters like temperature, pressure. The nodes in the Wireless Sensor Networks (WSNs) are usually battery powered. These nodes often suffer from disrupted connectivity caused by its numerous aspects such as limited battery power of a node and unattended operation vulnerable to hostile tampering. The disruption of connectivity, often referred to as network cut, leads to ill-informed routing decisions, data loss and waste of energy. Fault occurred in a single node is called as cut. This paper considers fault occurred in multiple nodes in a particular region which is called as hole.

Monitoring the region of interest (ROI) is the service provided by the wireless sensor network (WSN). The main role of this service is sensing the environment condition and sending the sensed information to the destination node. The ROI must be entirely covered all the time. Holes occur in the ROI cannot be avoided. The occurrence hole is mainly due to nature of WSNs or attacks on WSN network. Hence this affects communication between the nodes. Thus, it is necessary to detect and heal the holes in the network for an effective communication to take place. In this paper the various methods of detecting and healing holes in the WSN is studied.

TECHNIQUES

A. Hole and boundary detection

The various methods involved in the hole detection along with its boundary is studied and the drawbacks of each method is also analyzed.

1. Communication topology graph:

B. Kun, T. Kun, G. Naijie, L.D.Wan and L. Xiaohu [1] presented a distributed scheme based on communication topology graph. In this scheme the problem of detecting topological holes in sensor networks with no localization information in any node. To detect the holes in the network, each node only needs to exchange information with its 1-hop and 2-hop neighbors. In this the node decides if it is on the boundary of a hole. This is done by comparing its degree with the average degree of its 2-hop neighbor.
Drawback: The main drawback of this [1] method is that not all the nodes can identify its boundary.

2. Heuristic Based communication topology graph:

Funke [2] proposed a heuristic based technique for detecting holes based on communication topology graph. The hole detection algorithm is based on the topology of the communication graph, that is, the only information available is which nodes can communicate with each other.
Drawback: This approach is not localized as it requires the computation of distance fields over the whole network.

3. Unit disk graph model:

Funke and Klein [3] proposed linear-time algorithm for hole detection. This method required communication graph that follows the unit disk graph model. The authors had proved that by using a very simple linear-time algorithm that helps to find the boundary of the holes in the sensor network. [3] Also states that there is enough geometry information hidden in the connectivity structure to identify topological features. When comparing with the previous method, the algorithm has worst case.
Drawback: This technique works for only high node density. If the density of the node in the network decreases the algorithm breaks

down.

4. Co-ordinate free boundary method:

Fekete et al.[4] described the co-ordinate free technique to detect the boundary of the hole in WSNs. The assumption made here is that the nodes are uniformly distributed in non-hole areas. The methods used in this method rely on a number of natural assumptions that are present in densely distributed sets of nodes, and make use of a combination of stochastic, topology, and geometry.

Drawback: The drawback of this technique [4] is that it requires a high node density.

5. Bound Hole algorithm:

Fang et al. presented bound hole algorithm [5] using right-hand rule to identify nodes on the boundary of geometric holes.

Drawback: The drawback of this method is that it has high message complexity.

6. Hole boundary detection algorithm:

Shirsat and Bhargava[6] proposed this algorithm assuming the relative geographic information of 2-hop neighbors. The hole boundary detection algorithm takes best approach in detection process.

Drawback: The flaw in this paper [6] is that the algorithm requires synchronization among nodes.

7. Distributed algorithm:

Wang et al. proposed boundary algorithm to find the information of the connectives [12]. For the hole detection process the author had used special structure of the shortest path tree.

Drawback: The author did not make an analysis on its complexity. This algorithm relies on repetitive network flooding.

8. Self-organizing method:

A. Kroller, P.Fekete, D. Pfisterer, and S.Fischer used deterministic method for boundary recognition and also used topology extraction technique for larger network of sensors. The authors had dealt with the self-organization considering its topology and also geometric packing arguments to find the Boundary nodes and also the structure of the sensor network.

Drawbacks: Though, authors [13] had made assumptions, they have considered complex structures like flower structure which is the drawback of this paper.

B. COVERAGE ENHANCEMENT AND HOLE HEALING:

The several movement strategies for improving network coverage are discussed in this section

1. Movement-assisted sensor deployment:

G. Wang, G. Cao and T.F.L. La Porta described three different types of deployment protocols [7]. These protocols use voronoi diagrams to relocate the nodes at once the holes are being detected.

Drawback: The main drawback of this method is that, this technique cannot be used for large holes. And also this method requires global computation.

2. Decentralized and Energy Balanced Algorithm:

C.Y. Chang and co-authors [8] proposed three algorithms for maintaining temporary coverage in WSNs. Authors proposed strategies for hole movement for the large hole. This is done in such a way that either the power consumption of the sensor or the energy consumption of the node is balanced or reduced respectively.

Drawback: The drawback of this proposed algorithm [8] is that there is a requirement of synchronization among the nodes in the network.

3. Robot Repair Algorithm:

C.Y. Lin and co authors proposed tracking mechanism and robot repair algorithm. By using this technique [9] the coverage problem is solved using a moving robot. The robot's footmark is left behind on the sensors during the tracking mechanisms. This helps the sensors to find better routes for sending repairing requests to the robot. The healing algorithm helps to develop an efficient path for communication.

Drawback: The main drawback of this technique [9] is that the authors make an assumption that the WSN has been deployed using robot deployment mechanisms.

4. Pragmatic Approach to Area Coverage:

A. Nadeem, S.K. Salil and J.Sanjay proposed a pragmatic approach [10] to area coverage in hybrid wireless sensor networks. This

paper proposed MAPC- Mobile-Assisted Probabilistic coverage. The MAPC maintained the coverage by moving the sensor nodes to strategic positions in the uncovered area.
Drawback: Using this technique [10] only the sink can involve in the triggering of the hole detection and healing and the source cannot involve in triggering process.

5. Randomized Carrier-Based Sensor Relocation:

X. Li et al. proposed a randomized carrier based sensor relocation [11] where the robots picks up passive sensors and replaces them in the holes. This is done in an random manner and hence called as randomized relocation.
Drawback: This relocation technique [11] assumes that the boundary of the wireless sensor network is known in earlier which is the main drawback of this paper.

6. Sensor deployment algorithm:

Z. Yong et al. proposed a virtual force algorithm (VFA) [14] as a sensor deployment strategy to improve the coverage after an initial random placement of sensors. The VFA attempts to improve the coverage area of the sensors.
Drawback: The disadvantage of this proposed algorithm [14] is that it is a centralized approach.

7. Scan-based sensor deployment method:

S.Yangy et al. proposed scan-based movement-assisted sensor deployment technique for wireless sensor networks [15]. In this paper the region of interest is divided into many small grid cells. And the number of nodes in the grid cell is the load of the grid cell.
Drawback: This technique generates a enormous message overhead in a denser network since the number of rounds of scan is being increased. And at the final stage of clustering process, if two nearby clusters are empty the scanning process will be incorrect.
This is the major drawback of the scan-based method [15].

8. Strictly localized self deployment method:

X. Li et al. proposed two strictly localized solution algorithms, Greedy Advance (GA), and Greedy-Rotation-Greedy (GRG) for sensor deployment problem [16]. These two algorithms drive sensors to move along the TT (triangle tressellation) graph to surround POI (point of interest).
Drawback: This paper [16] considers only point coverage problem and it does not consider the region of interest which is a disadvantage.

9. Bidding protocol for sensor deployment:

G. Wang, G. Cao, P. Berman and T. La Porta had proposed two bidding protocol for sensor deployment [17] in wireless sensor network. Here, static sensors detect coverage holes locally by using Voronoi diagrams and bid mobile sensors to move. And these mobile sensors accept highest bids and help to heal the bigger holes.
Drawback: This method requires global computation which means that all the nodes in the network needs to run the algorithm [17].

RESULT OF SURVEY

In this paper comparison between various techniques involved in hole and boundary detection process has been done. Each method has its own benefit and drawback. The various method studied here are communication topology graph method [1], heuristic based method[2], linear-time algorithm[3] and co-ordinate free method[4]. And also the survey of various techniques involved in hole healing process has been done. The coverage and hole detection technique studied in this paper are movement assist sensor deployment [7], energy balance algorithm [8], robot repair algorithm [9] etc. And the conclusion is that hole detection can be done with the help of stuck nodes and healing can be done with the help of neighboring nodes located at a distance.

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