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A Self-Configurable Event Coverage Approach for Wireless Sensor Networks

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ABSTRACT

Sensing and data aggregation capabilities of wireless sensor networks (WSNs) depends on efficient deployment of sensor nodes (SNs) in an area. In a large surveillance space, there is a need for more SNs to cover important crucial events despite of the optimum coverage. The authors propose an event-based efficient deployment algorithm (EEDA) for relocation of redundant sensors to the event location to achieve full coverage. They divide the deployment region into small square cells that allows individual cells to be efficiently monitored, instead of considering the whole scenario as one unit. EEDA ensures efficient coverage of the entire deployment region and senses the occurrence of any static or dynamic event with an optimum number of sensors. EEDA with square cells performs better than existing hexagon cell algorithm by 39%. EEDA is validated by simulation as well as by experimental results.

KEYWORDS

Coverage, Deployment Area, Dynamic Event, Redundant Nodes, Sensor Node, Static Event, Wireless Sensor Network

1. INTRODUCTION

WSNs consist of a group of sensors that interact with each other to extract useful information from real time data where data can be either a natural phenomenon or an event of useful information (Fellah, & Kaddour, 2017). WSNs transmit the sensed data to the sink in an energy efficient manner but sometimes the sink is located far away from the sensors, which results in high consumption of sensor energy in data transmission. Since the sensors in WSN have very limited energy, this kind of scenario is not desirable. In many scenarios, an intermediate cluster head (CH) exists between sensor nodes (SNs) and sink (Kaushik et. al., 2019). The purpose of the CH is to collect data from the

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sensors assigned to it and transmit the collected data to the sink. This reduces energy consumption of the sensors, as CHs can be located near the sink.

The primary objective of a WSN is to accurately detect an event behavior and transmit it to the sink (Ahmad et. al., 2013). This collaborative behavior of SNs gives itself an edge over traditional sensing where only a few powerful nodes are distributed in an area, which can lead to loss of data due to insufficient coverage. Static sensors that have fixed locations are commonly used for sensing an event due to their low cost; but static sensors have some drawbacks. Static sensors can't be used in large areas due to its limited range of operation for detecting an event and accurate tracking of an event in large area requires numerous static sensors which increases the cost of a WSN exponentially. In addition to this, deployment of static sensors is often difficult in unknown and hostile regions such as toxic and disaster-hit areas where the manual effort of deploying the sensors will be too costly. One way to deploy the SNs in such areas is to airdrop the sensors using either a UAV or air drone, which decreases manual effort by humans and also saves time. However, this technique has its flaw as the actual landing positions of the sensors cannot be controlled due to wind flow and obstructions such as trees and buildings, which can lead to uneven coverage of the network, resulting in loss of information due to inefficient coverage of the region of interest (Howard et. al., 2002; Paradiso & Starner, 2005; Krishna et. al., 2004).

To overcome the issue of static sensors, we aim to have SNs with mobile platforms for efficient deployment and event tracking. Mobility helps SNs to self-configure and adapt according to the scenario and move towards the event of interest to cover a large area especially when sensors are limited and events are dynamic whose locations vary with time. Sensor mobility allows more sensors to reach the event of interest.

The proposed algorithm is capable of detecting both static and dynamic events. Static events are the events which are known to occur only at a particular location and whose dynamics doesn't vary with time. It is relatively easy to monitor the static events because of known event dynamics. Dynamic events don't have a fixed location and their position vary with time. Since, these events are random in nature and can occur at any cell in the scenario, it is very important to monitor these events with sufficient accuracy and resolution. To improve the accuracy and coverage of dynamic events we have used mobile sensor nodes, which give better coverage in the scenario because of their dynamic location and ability to reach multiple points in the deployment region. We ensure that a minimum number of mobile sensor nodes sense the event and extract useful information. Our contributions to the paper are following:

- Paper presents an efficient deployment algorithm that divides a deployment region into multiple square cells. Division of a sensor field into multiple square cells not only improves the coverage capabilities of the SNs but also saves WSN memory since the memory requirement for storing information of the end coordinates of the square cell scenario is much less in comparison to the hexagon cell scenario. A Significant saving of memory also decreases the cost of WSN;
- Paper proposes a framework that tracks and sense any randomly generated static or dynamic event in the deployment region with optimum number of sensors. Our approach enables the redundant sensors to move near an event with shortest possible time and distance. Proposed work consumes $(2*(\sqrt{3}-\sqrt{2}))$ times less energy in sensor movement as compared to past algorithms;
- The proposed algorithm is validated by both simulation and hardware experiments, which proves its utility for the real-time applications.

Rest of the paper is organized as follows. A literature review of the recent research in this field is presented in Section 2. Problem formulation is presented in Section 3. The proposed algorithm is presented in Section 4. Hardware and simulation results and their comparison with the existing work is presented in Sections 5 and 6. We conclude our work in Section 7.

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