Computer Networks 91 (2015) 407–424

Contents lists available at ScienceDirect

Computer Networks

journal homepage: www.elsevier.com/locate/comnet

Mobile sensor relocation problem: Finding the optimal (nearest) redundant sensor with low message overhead

Chien-Fu Cheng*, Chih-Wei Huang, Lung-Hao Li

Department of Computer Science and Information Engineering, Tamkang University, No. 151, Yingzhuan Rd., Tamsui Dist., New Taipei City 25137, Taiwan

ARTICLE INFO

Article history:
Received 25 February 2015
Revised 26 June 2015
Accepted 27 August 2015
Available online 8 September 2015

Keywords:
Mobile wireless sensor networks
Mobile sensor
Sensor failure
Sensor relocation problem
Optimal (nearest) redundant sensor
Low message overhead

ABSTRACT

In the sensor relocation (SR) problem, advertisement packets are used to inform the locations of redundant sensors and request packets are used to inform the locations of requesting places. When redundant sensors move to requesting places, their location information will change. So, the message with redundant sensors information is not reusable. This is also why locating redundant sensors with low message overhead is of high importance. In this paper, we revisit the matching problem of SR in mobile wireless sensor networks. In order to reduce the amount of message exchange, we employ the concept of quorum to send advertisement packets (in columns) and request packets (in rows). With the proposed stopping criteria, the proposed algorithm can further reduce the amount of these two types of packets to send. In performance evaluation, we consider three scenarios of different shapes, including a square plane, a rectangular plane and a circle plane. The simulation results show that the proposed algorithm can effectively and significantly reduce the number of advertisement and request packets to find the optimal (nearest) redundant sensor for each requesting place.
© 2015 Elsevier B.V. All rights reserved.

1. Introduction

With the improvement of production processes, the hardware cost of wireless sensors has reduced significantly, which has in turn facilitated applications of wireless sensor networks (WSNs) across a wide range of areas [1,12]. Common applications of WSNs include environmental monitoring [9,20], public engineering [15,18], health monitoring [2,19], smart home [3,8,16], military [5,6], etc.

In WSNs, if any sensor fails due to damage or energy depletion, the system needs to look for redundant sensors that can take over its task. This problem of identifying redundant sensors and moving them to replace failed ones is called the sensor relocation (SR) problem [7,11,17]. In previous works, sensor deployment (SD) algorithms are used to address the SR problem. In other words, they solve the SR problem using algorithms designed for the SD problem [13,14]. Because the strict response time requirement of the SR problem is ignored in this approach, later researchers have attempted to design algorithms for the SR problem with consideration of the strict response requirement. In mobile WSNs, sensors have mobility, so they can perform sensor relocation by themselves. Hence, the SR problem with mobile sensors is also called the self-relocation problem. The works related to the self-relocation problem can be classified into three categories: (i) Voronoi-based SR algorithm, (ii) the virtual force-based SR algorithm and (iii) the grid-based SR algorithm. Below is a brief review of some works related to the self-relocation algorithms [7,11,17].

Li et al. [11] proposed a Voronoi-based SR algorithm to solve the self-relocation problem in mobile WSN. The proposed algorithm is called wireless array-based sensor relocation (WA-SR) algorithm. The WA-SR algorithm is based on the wireless array-based cooperative sensing model (WA-CSM) [10]. In WA-SR algorithm, the WA-CSM model is used

* Corresponding author. Tel.: +886 2 2621 5656, ext 2668; fax: +886 2 2620 9749.
E-mail address: cfcheng@mail.tku.edu.tw (C.-F. Cheng).

http://dx.doi.org/10.1016/j.comnet.2015.08.022
1389-1286/© 2015 Elsevier B.V. All rights reserved.

to group sensors into wireless arrays (WAs). The WA-CSM model makes use of the collaboration of closely located sensors to form a WA. Li et al. [10] pointed out that compared to individual sensors, WA offers a higher degree of sensing performance. After building WAs, we can use the Voronoi diagram to partition the WSN into Voronoi polygons [4]. Next, these Voronoi polygons are checked for presence of redundant sensors and coverage holes. The relocating the redundant nodes (RRN) algorithm proposed by the author is then used to match redundant sensors with coverage holes for sensor relocation. Sensor movement consumes a lot of energy, so the RRN algorithm determines the distance of movement of each redundant sensor based on its remaining energy. In other words, redundant sensors with different remaining energy levels have varying upper limits of moving distance. The main drawback of the WA-SR algorithm is that the location information of sensors is communicated by broadcasting, which requires a huge amount of message exchange.

Garetto et al. [7] proposed a virtual force-based SR algorithm to solve the self-relocation problem in mobile WSNs. Their distributed algorithm is used to relocate sensors in response to an occurred event so as to provide the necessary monitoring. In the virtual force-based algorithm, each sensor is given a directed force combining attractive and repulsive forces [21]. The combined force allows mobile sensors to perform sensor relocation without location information. In the virtual force-based SR algorithm, the oscillation check and the stability check are essential for determining whether a sensor has moved to its final location. For example, if sensor s_i moves back and forth in a small region, sensor s_i is in an oscillation state; if s_i has a total movement within a period of time smaller than a certain threshold, it is in a stability state. In either state, sensor s_i must terminate its movement. Because sensors acquire the information of attractive and repulsive forces by exchanging messages with neighboring sensors and they need to exchange new information of attractive and repulsive forces to avoid oscillation, the amount of messages to exchange is usually considerable and not easy to estimate. Moreover, the virtual force-based algorithm has the static equilibrium problem. The static equilibrium problem refers to the situation when all the forces on an object offset, therefore putting the object in a static state. If sensors in the field are very unevenly distributed, that is, most sensors concentrate in certain areas, sensors in the densely-deployed areas will enter a static equilibrium, and there will also be a large number of redundant sensors in these areas. Meanwhile, other areas in the field will have a large number of coverage holes due to lack of sensors. That is, in this state, the field has a high concentration of redundant sensors in some areas and coverage holes in others.

Wang et al. [17] proposed a grid-based SR algorithm to solve the self-relocation problem in mobile WSNs. In their study, the target field is divided into grids, each having a header. A grid header is responsible for the communication between grids to reduce amount of message exchange. In order to further reduce message exchange for sensor relocation, Wang et al. [17] used a Grid-Quorum solution as an alternative to the flooding approach of transmitting advertisement packets (containing location information of redundant sensors) and request packets (containing location information of requesting place). The advertisement packets and request packets are only sent to headers in a column or row.

As mentioned above, the Voronoi-based SR algorithm by Li et al. [11] delivers the location information of sensors by broadcasting, and the virtual force-based SR algorithm by Garetto et al. [7] requires constant exchange of new information of attractive and repulsive forces to avoid oscillation of sensors. It can be found from the above three types of SR algorithms that the quorum approach can effectively reduce the amount of message exchange. The BCS algorithm [17] is a graceful and practical protocol, but it has one problem and one aspect that need improvement as follows.

The problem with the BCS algorithm is that each grid is required to have one header, which is responsible for communication between grids. If all sensors in a grid become faulty, no sensor can be the header for the grid. The absence of the header that sends request messages will cause the coverage hole problem. As shown in Fig. 1, both sensors s_h and s_k in *Grid*(i,j) are faulty, and no sensor can be the header for the grid. In this case, *Grid*(i,j) is unable to send request messages. The detail description of how to solve the problem is shown in Section 3.2.

The amount of messages exchanged for locating the redundant sensors is the aspect that needs improvement. More specifically, the amount of advertisement packets and request packets should be further reduced. Why is it important to reduce the amount of these packets? The answer is that when redundant sensors move to requesting places, their location information will change. So, the message with redundant sensors information is not reusable. This is also why locating redundant sensors with low message

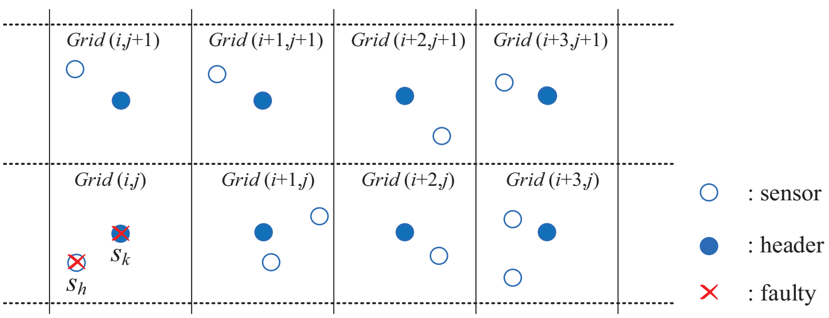

Fig. 1. All sensors in *Grid*(i,j) are faulty.

Download English Version:

https://daneshyari.com/en/article/450713

Download Persian Version:

https://daneshyari.com/article/450713

Daneshyari.com