A Grid-Based Hole Detection Scheme in WSNs

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ABSTRACT

Wireless Sensor Networks (WSNs) can be widely utilized in many applications, especially in environmental surveillance. However, some holes exist within the WSNs caused by factors like non-uniform deployment of sensor nodes, depletion of energy from sensor nodes, the destruction from external forces, and the existence of physical obstacles, such as mountains and lakes. These holes degrade the performance of wireless sensor networks (WSNs). Hence, finding the position of the holes and utilizing the information to improve the performance of WSNs is a significant issue. To solve this problem, the authors propose a detection scheme for grid-based hole in WSNs. By means of grid architecture, they use the grid head to broadcast and forward the request and respond the holes detection. Sink then calculates the position of the holes for improving the performance of the WSNs.

Keywords: Coverage Hole, Environmental Surveillance, Grid-Based Network, Hole Detection, Wireless Sensor Networks

1. INTRODUCTION

Recently, because of advancing technology, not only the whole world goes mobile, but also the development of network becomes mature. The network has becomes an essential part in life, and is an important way to communicate.

Wireless sensor network (Akyildiz et al., 2002; Sankarasubramamiam et al., 2002) is a wireless network which is more specific fields. Network consists of sensor nodes, and the sensor nodes communicate each other. Through the feature of wireless, making the wireless sensor network is a wide range of applications. As potential for widespread application of sensor networks, it has been forecast that WSN would be an emerging technology directly involving in human life.

Recent years, because the wireless sensor network applications become quite wider, therefore, related-research technologies are also relatively much more important. About wireless sensor network routing protocols are also constantly being raised (Lin et al., 2005; Wang et al., 2011). The covered area which sensor nodes sense decide effect of the detection network of the whole network (Ghosh et al., 2005; Wang et al., 2007). With the scale getting bigger, the way of wireless sensor network deploying must
be deployed regularly or placed arbitrarily, and even the use of aircraft for air-throw (Shih et al., 2001). Therefore, the random deployment of sensor nodes easily causes the circumstances of non-uniform deployment, which led to generating Coverage Hole in the entire network, resulting in the interruption of data transmission and bad inefficiency of the sensor. The existence of holes has an influential impact on the effect of wireless sensor network, such as trails of targets, the inspections of the environment, the patrol of the military, etc. Therefore, how to use limited resources to improve the coverage of sensor networks is an important issue (Ahmed et al., 2005). In this paper, we design an effective and efficient grid-based hole detection scheme for WSN to detect the hole. The sink grounds on the result of assessment to decide which areas require additional sensors to support so as to improve the coverage ratio of the network. Through the regular grid, is applied to the random deployment of wireless sensor networks. Grid information is planned by Sink node. Sink node broadcasts a request message to each sensor node in order to know what information there is in the grid, detect whether the sensor is there for each grid, and provides also the location and size of holes. It makes data packets avoid the holes to go around, and notify the mobile sensors to cover an empty grid to improve the efficiency of the transmission network.

In the rest of the paper, the related works including the virtual grid idea, the hole problems in WSNs, previous researches, etc., are presented in Section 2. Section 3 proposes the design of Grid-based Hole Detection Scheme. Following this, the simulation experiment for this mechanism and results analysis are illustrated in Section 4. Finally, we give the conclusion in Section 5.

2. RELATED WORK

2.1. Grid

Grid is a relatively simple structure. The sensors deployment area can be cut into the same square. Each square can set the size which will influence computational complex and accuracy. Such as it needs more power energy consuming in a larger grid, but the necessary computation are fewer. In opposite, the smaller grid will increase computation, but it also increase forecast accurately (Tilak et al., 2002). The proposed mechanism builds a virtual grid scheme in whole WSN topology, represented in Figure 1. Sink is located at the origin in Euclidean coordinate. The unit length is \( d \) in this coordinate. Using \( d \) to draw vertical and horizontal lines then we have the same size of grids. These are the same size block which is sensing area cut by square. Each block is a grid in the network.

As shown in Figure 1, the grid size is defined by grid edge, \( d \). Our instruction to ratio \( (d / R) \) is less than or equal to \( \sqrt{2}/2 \). Here \( R \) is sensor transmission radius. It can sufficient to cover sensing area with a grid needs at least one sensor in this assumption (Wang et al., 2011).

2.2. Hole

In many applications, human do not deploy sensor one by one, for example: rain forests environmental monitoring, fire detection temperature. Sensor node deployment is random from plane to scatter or human. Random deployment has non-uniform density distribution (Ahmed et al., 2005). In this case, wireless sensor network often has the region which was not covered with sensor node called coverage hole in Figure 2(a). The region does not have route can directly pass message called routing hole, that in Figure 2(b). The wireless sensor network has coverage hole when the object moving as in the hole, we will lose its message. If occurs routing hole the message transmission will around the hole. We must find the hole which is hazardous to detection moving object and information updated.

2.3. Coverage Hole

At present has some research about the coverage hole detection scheme. In (Shakkottai et al., 2003; Kumar et al., 2004) proposed wireless sensor network in determining the effective
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