Chapter 19
Analysis of Sensors’ Coverage through Application-Specific WSN Provisioning Tool

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ABSTRACT
This paper presents an automated provisioning tool for the deployment of sensors within wireless sensor networks (WSN) where we have employed evolutionary approach as a search technique to find the maximal coverage under minimal deployment cost. The coverage area is partitioned into M by N cells to reduce the search space from continuous to discrete by considering the placement of sensors at the centroid of each cell. The author has explored the relationship between various cell’s sizes versus the total number of deployed sensors. The experimental results show that when the number of cells to cover the service area from X by X cells to 2X by 2X cells is increased, on average this increases the cost by 3 folds. In this regard, it is due to the increase of the number of required sensors by an average of six folds, while improving the coverage ratio by only 9%. A custom-made graphical user interface (GUI) has been developed and embedded within the proposed automated provisioning tool to illustrate the deployment area with the placed sensors at step of the deployment process.

INTRODUCTION
Wireless sensor network (WSN) offers a platform for many civilian and military applications for monitoring hazard areas with minimal human interventions. The sensors are scattered over the monitoring area with the expectation to adequately cover the target region (Crossbow). This is very challenging problem to ensure that the area to be monitored is covered adequately; therefore, we have developed and utilized a custom-made provisioning tool to find feasible deployment of minimal sensors to cover the given area. The initial deployment of WSN involves a fundamental problem, which is known as the coverage. The coverage problem has a number of interpretations...
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depending on the characteristics and applications of sensors. However, many researchers have considered the coverage as the measure of quality of service of a sensor network (Dasgupta, Kukreja, & Kalpakis, 2003). For example, in the battlefield monitoring, one may ask how well WSN can observe the activity of a tank’s movements in the battlefield (area to be monitored), and what is the likelihood that a tank’s movements in a specific location will be detected in a given time frame.

We used the analogous of placing and integrating modules of integrated circuit (IC) into a circuit board as placing sensor devices in a monitoring area. Since both problems are known to be NP-complete; there is no known polynomial time algorithm to solve either problem. To simplify the placement and integration modules of integrated circuit (IC) into a circuit board, researchers have divided the problem into two sub-problems: floorplan and placement. The floorplan problem is to divide the area into well-defined cells, and then it determines the best cells to place the sensors with maximal coverage, minimal number of deployed sensors. In this paper, we are extending further our previous work (Habib, 2007; Habib & Safar, 2007) by analyzing sensor’s coverage with respect to various cell’s sizes.

We have employed an evolutionary approach to search the design space for the best coverage, and we have explored the relationship between various cell’s sizes versus the total number of deployed sensors. Our experimental results show when we increase the number of cells to cover the service area from X by X cells to 2X by 2X cells, on average this increases the cost by 3 folds. Thus, it is due to the increase of the number of required sensors by an average of six folds, while improving the coverage ratio by only 9%. A custom-made graphical user interface (GUI) has been developed and embedded within the proposed automated provisioning tool to illustrate the service area with the deployed sensors at step of the deployment process.

The rest of the paper is organized into sections. Next, the literature survey of the provisioning tools employed to analyze the coverage problem within WSN is described, followed by the description of typical coverage problem in WSN. Next, the internal view of the provision tool to solve the floorplan and placement sub-problems in an optimal way is presented, followed by the illustration of experimental results generated by the proposed evolutionary methodology. Finally, the conclusion and future developments are presented.

RELATED WORK

Many researchers (Bhardwaj & Chandrakasan, 2002; Haenggi, 2003; Kalpakis, Dasgupta, & Namjoshi, 2002; Krishnamachari & Ordonez, 2003; Pan, Hou, Cai, Shi, & Shen, 2003; Sadagopan & Krishnamachari, 2004) focused their efforts on increasing the lifespan of sensor devices by reducing the coverage. Researchers (Shih, Cho, Ickes, Min, Sinha, Wang, & Chandrakasan, 2001; Woo & Cullar, 2001; Ye, Heidemann, & Estrin, 2002) focused on the physical and media access layers within WSN, where others focused their research on routing and transport protocols (Braginsky & Estrin, 2002; Ganesan, Govidan, Shenkar, & Estrin, 2001; Heinzelman, Chandrakasan, & Balarishnan, 2000). Also, researchers (Bahl & Padmanabhan, 2000; Nicules & Nath, 2003; Savvides, Han, & Strivastava, 2001) focused on localization and position applications of WSN. However, all the above research activities have assumed that the coverage problem is predetermined.

The sensor devices can be deployed in the service area either in arbitrary or random fashion. When we employ either arbitrary or random sensors placement, the service area should be well-covered or monitored by the sensors devices. Thus, the coverage has been formulated in various ways. The coverage problem has been formulated as a decision problem by Huang and Tseng (2005), with