Optimization of Router Deployment
For Wireless Sensor Networks

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Abstract
This paper presents the optimization of router deployment for Wireless Sensor Networks (WSN). The sensor nodes in the WSN are placed appropriately to measure environmental data. The sensed data are transferred from the sensor nodes to a base station via the routers, whose deployment has great effects on network connectivity and lifetime performance. In this work, the router deployment is optimized to maximize the lifetime of WSN using the genetic algorithm.

Keywords – Wireless Sensor Networks, Genetic Algorithm, Positioning, Optimization

1 Introduction
Recent advances in wireless sensor networks (WSNs) have enabled various applications, particularly an efficient ambient monitoring application [1]. The sensor topology of WSNs has a great impact on the network performance such as network lifetime and network stability because sensor devices have limited energy sources. One of the optimal design strategies is deterministic deployment of the sensor nodes in order to meet the desired performance goals [2]. Using clustering technique in the sensor network, we can expand the level of coverage and connectivity and reduce energy consumption at the sensor nodes.

In the case of forest fire detection, the maximum lifetime for the monitoring of wildfire can be ensured through careful planning of node deployment. Optimization of router and sensor node deployment is a challenging problem. For the optimization in the development of a sensor network, a candidate for the position on the sensor network can be determined by the structure of the quality of metrics such as distance, and network topology in the environmental condition. The distance between the router and sensor nodes has an impact on the power of energy transmission, because the communication range decreases in forests and bushes.

In this paper, we consider a WSN based on the Zigbee protocol, which consists of a base-station, routers and sensor-nodes. The data sensed by the sensor nodes are transferred to the base station through the routers. We optimize the position of the routers using genetic algorithm to maximize the lifetime of sensor networks.

2 Analysis of Simulation Results
We consider a WSN whose field size is 500 x 500 m². The base station is at (500,250), and 100 sensor nodes and 10 routers are scattered in the field. The covering range of the sensor nodes is 150 meters, and that of the router nodes is 300 meters. We optimize the position of the routers to minimize the total distance between the sensor nodes and base station. The optimization problem is formulated as follows:

\[ F = \sum_{i \in \text{sensor}} d_i + \sum_{i \in \text{router}} d_i \rightarrow \min, \quad (1) \]

where \(d_i\) denotes the distance between node \(i\) and the node to which \(i\) is connected. The router positions are represented by the real-valued genes. The position of the sensor devices is generated randomly. The optimized result is shown in Fig.1, in which green and yellow rectangles represent the base station and routers, respectively, while the red circles are the sensor nodes. Fig. 2 represents the evolution of the best fitness.

Fig. 1. An example of optimized sensor topology

Fig. 2. Evolution history of fitness

In the full paper, we also discuss optimization of the router deployment in WSNs for wildfire detection, in which the communication distance highly depends on the environmental conditions such as density of trees and vegetation.

References