무선센서네크워크에서 커버리지 문제를 해결하기 위한 에너지효율적인 패턴

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Employing an Energy-efficient Pattern for Coverage Problem in WSNs

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Abstract

In wireless sensor networks, coverage problem is a fundamental issue that has attracted considerable attention in recent years. Most node scheduling patterns utilize the adjustable range of sensor to minimize the sensing energy consumption. However, a large source of consumption of communication energy of sensor is not strictly taken into account. In this paper, we introduce an energy-efficient pattern that is used to minimize the communication energy consumption of a sensor network. Calculations and extensive simulation are conducted to evaluate the efficiency of the new pattern comparing to existing ones.

1. Introduction

Wireless sensor networks (WSNs) are composed of a large number of sensor nodes, which are densely deployed in inaccessible and hostile environments. Sensor nodes usually operate by small and non-rechargeable batteries. Energy savings optimization is one of the criteria to evaluate the success of WSNs. Coverage problem considers how well the target sensing field is monitored by sensors. Recent coverage patterns only consider how to minimize the overlapped sensing areas of sensors, and thus optimize the sensing energy consumption of WSN. In [1], two node scheduling patterns are proposed to reduce the sensing energy consumption of WSNs.

However, recent analysis shows that each sensor uses a large portion of power for communication. Most patterns designed so far just take part in minimizing the coverage density or sensing energy consumption. This paper supplements this important limit by introducing a pattern which is considered as the best among the existing ones in terms of communication energy consumption.

2. Proposed Pattern

2.1 *System Model*

In this paper, we assume that the sensor nodes are randomly deployed in a two-dimensional target sensing field, where each node knows its own position by using the Global Positioning System (GPS) or a localization scheme. The sensing area of each sensor is a disk of a given sensing range. When calculating the communication energy consumption, we construct a minimal spanning tree among active nodes. We also assume that the energy consumed by communication for a sensor is proportional to the square of the distance from itself to its farthest node in the minimum spanning tree.

We construct the pattern based on regular polygons - tiles that cover the whole target sensing field without overlapping. We also suppose that all tiles are covered in the same manner. As shown in Fig. 1, model A based on a regular triangle and model B based on a square. Sensors are placed at the vertices of the polygons and the circles represent the sensing areas of sensors.

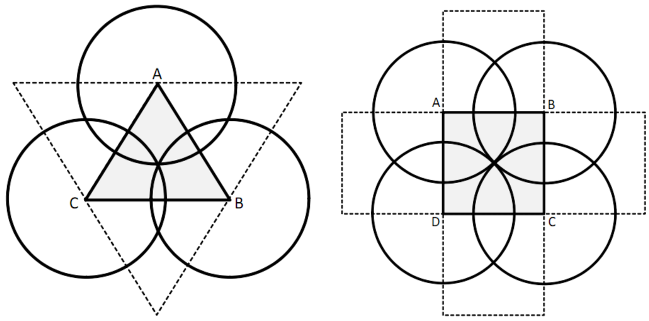
Before going into details of the proposed pattern, we introduce two important metrics that is used in [2] to compare the efficiency among models in terms of coverage density and communication energy consumption.

Definition 1. Sensing energy consumption per (unit) area (ES) is the part of the sensors' sensing energy used by the nodes inside a tile divided by the tile's area.

Definition 2. Communication energy consumption per (unit) area (EC) is the part of the sensors' communication energy used by the nodes inside a tile divided by the tile's area.

2.2 *Proposed pattern*:

According to [1], model A is the optimal topology, in the sense that it provides minimum number of sensors used to cover fully the whole target sensing field. However, model A has high communication energy consumption. As opposed to pattern A, pattern B has the best communication energy consumption among existing models designed so far. However, the coverage density of model B is worse than model A.



(a) Model A (b) Model B

Fig. 1. Two coverage patterns based on regular polygons

The following table summarizes the characteristic of the two patterns:

Model	*D*	*EC*	*ES*
Pattern A	1.2091	1.1547 μ_1	1.2091 μ_2
Pattern B	1.5708	μ_1	1.5708 μ_2

Table 1. Comparison between pattern A and pattern B

To extract the advantages of model A and model B, we construct another pattern based on a hexagonal structure, as shown in Fig. 2. As opposed to other models, we assign different tasks for sensors. In Fig. 2, only three sensors placed at A1, A3, and A5 keep both roles: sensing the monitored field and continuously communicating with other sensors. In contrast, sensors placed at A2, A4, and A6 just turn on the communication function. The main reason for this strategy is that the topology of all sensors keeping both roles is the same with the topology of model A. Therefore, the sensing energy consumption of the new model, called model AB, is $ES_{AB} \approx 1.2091\mu_1$.

Similar to [2], we apply the same method to calculate the communication energy consumption of pattern AB. The communication energy consumption of patter AB is $CE_{AB} \approx 0.7698\mu2$, where $\mu2$ is the communication power consumption per unit. Pattern AB is the best pattern in term of communication energy consumption so far.

3. Performance Evaluation

As shown in Fig.3 and Fig.4 our proposed pattern is the best pattern in term of communication energy consumption and total energy consumption. The result is consistent with our mathematic analysis before.

4. Conclusion

In this paper, we proposed an energy-efficient coverage pattern that minimizes the communication energy consumption. Thus, the total energy consumption is decreased.

ACKNOWLEDGEMENT

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Reference

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[2] V. Zalyubovskiy et al. “Energy-efficient Area Coverage by Sensors with Adjustable Ranges,” Sensors Journal, vol. 9, pp. 2446–2460, 2009.

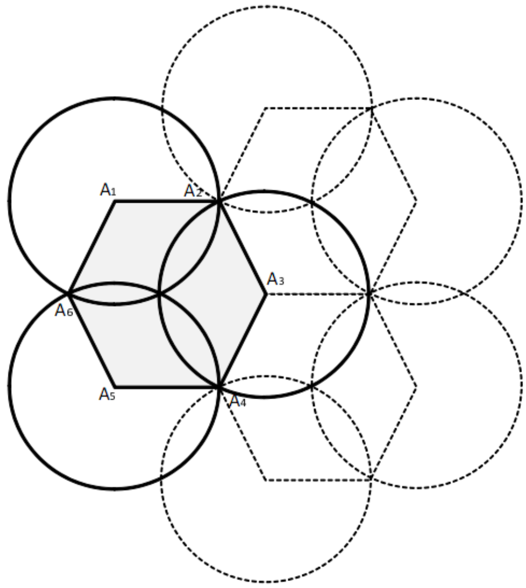

Fig. 2. Pattern AB

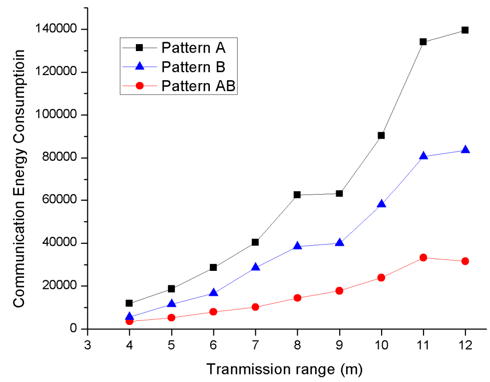

Fig. 3. Communication Energy Consumption

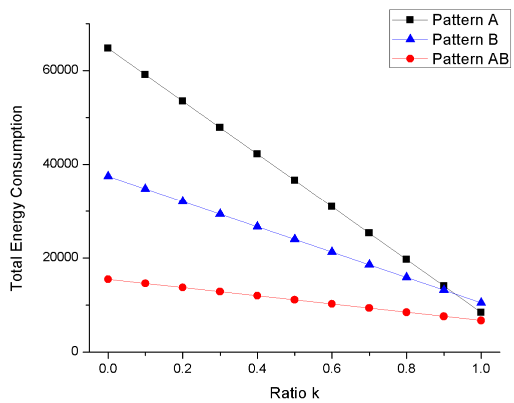

Fig. 4. Total Energy Consumption