Local Maximum Lifetime Algorithms For Strong *K*-Barrier

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ABSTRACT

Barrier coverage of wireless sensor networks are been studied intensively in recent years under the assumption that sensors are deployed uniformly at random in a large area. In this paper a new network construction method of sensor nodes for Border Security Systems is proposed. This Barrier coverage are known to be a appropriate model of coverage for sensor barriers to detect intruders moving along restricted crossing paths, which is achieved by barriers of sensors. A Border Security System watches intruders by using sensor nodes with communication function. The detection of some intruders and the use of a long-term operation system are required in this system. This paper suggests a new Divide-and-Conquer scheme. Based on it, a new local maximal lifetime algorithm can be designed and following protocol for strong k- barrier with coordinated sensors. By computer simulation, we try to show that the proposed barrier coverage network construction methods are suitable for Border Security Systems and reduce the power consumption of the whole network system by effective control of sensor nodes.

KEYWORDS: barrier coverage, data fusion, local algorithm, security, wireless sensor network;

I.   INTRODUCTION:

The main applications of wireless sensors involves movement detection, such as when deploying sensors along international borders to become aware of illegal intrusion, around a chemical factory to identify the spread of lethal chemicals, on both sides of a gas pipeline to detect potential damages, etc. barrier coverage, which guarantees that every movement crossing a barrier of sensors will be detected, which is known to be an appropriate model of coverage for such applications [1]. Chen et al. [2] devised a centralized algorithm to find out whether a region is k-barrier covered, and resulting the critical conditions for weak barrier coverage in a randomly deployment sensor network. But the centralized algorithm could acquire high communication overhead and computation cost on large sensor networks, and conditions for strong barrier coverage remain an open problem. Liu et al[3]., first discussed the strong barrier coverage problem. They map the strong barrier coverage as a discrete bond percolation model and derive the conditions of having multiple disjoint sensor barriers.
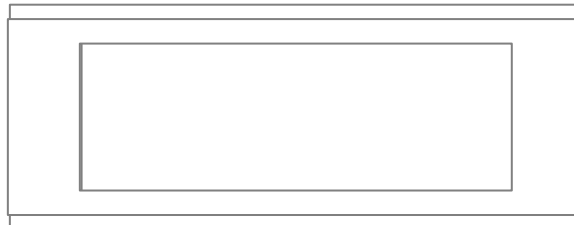

Figure 1: Weak coverage and Strong coverage.

In Figure 1, it illustrates [3] the difference between strong barrier coverage and weak barrier coverage. In the top figure, the network has weak barrier coverage for all orthogonal crossing paths (dashed paths). However, there is an uncovered path (solid path) through the region. The bottom figure shows an example of strong barrier coverage where no intruders can cross the region undetected, no matter how they choose their crossing paths. The barrier is highlighted using shaded sensing areas.

In [3], they proposed a critical condition for weak barrier coverage. But conditions for strong barrier coverage remain an open problem. In [5-8], detection coverage models have been suggested based on different event scenarios and detection techniques. In [8], Yang and Qiao first induced the detection coverage model into barrier coverage and theoretically analyzed the constraints between data fusion algorithm and coverage regions. By considering the above reasons, this paper talks about the setbacks of constructing strong *k*- barrier based on detection coverage model. We consider neighboring sensors can cooperate in surveillance by data fusion.

In particular, our contributions are as follows:

- First work is the problem of constructing strong *k*- barrier based on detection coverage model and data fusion.
- Second to formalize a coordinated detection coverage model, where the data fusion rule is described by a general function f(x).
- Third is to analyze the influencing factors of barrier coverage lifetime, and transfer it to a multi-objective optimization problem.
- And fourth to introduce a new Divide-and-Conquer scheme to design a new local maximal lifetime algorithm.

II.   EARLIER METHODOLOGY:

The local barrier coverage algorithms that been introduced in [1, 2, 3, 4, 5, 6, 8] have introduced the centralized algorithms. One of algorithms for local barrier coverage, called RIS (Random independent sleeping algorithm). This algorithm is based on a power saving method, in which the sensor nodes are scheduled and switch between two modes, Active and Sleep. RIS provides weak barrier coverage with the high probability of intrusion detection, in such a way that each sensor, in certain periods, selects Active or Sleep mode, with a predetermined probability rate, P. The presented method will be based on the power saving method, used by RIS. However, the modes considered in sensor nodes have been changed to Active and Passive modes. It must be noticed that RIS does not guarantee the barrier coverage, deterministically. Initially global active scheduling algorithms are not achievable in a large scale sensor network. Second, [1] proved that one sensor cannot locally determines whether the surveillance field is k-barrier covered or not.

2.1.Traditional Activity of Scheduling Strategy

One traditional method is to start the nodes with highest left energy [1,2,3,4], which can avoid the nodes with less left energy died too early and prolong the barrier coverage lifetime. Yet there usually exists the situation that the horizontal projection of above-mentioned nodes is relative small, i.e. the count of active nodes is not optimal. The other method is to activate the least nodes by greedy algorithms [8][9]. The nodes in suitable location can been activated frequently and died untimely, which affect the sensor network connectivity, and further shorten barrier coverage lifetime.

2.2. Proposed work:

The main problem to be solved includes providing a k-barrier graph which creates and describes k-barrier coverage in a barrier area. As a result, all paths crossing through the barrier area are covered k-times, by the network sensors. The proposed method consists:

2.3.Modeling Maximum Barrier Coverage Lifetime

An effective sensor activity scheduling should tradeoff the count of nodes in a cover set, their left energy and consumed energy in one cycle. As a result, maximum of barrier coverage lifetime essentially is a multi objective optimization problem. We can form the problem as three minimizing objectives and one maximization objective, i.e. minimizing the count of active nodes ,minimizing the total energy used in one cycle, minimizing the ratio of an active node's consumed energy in one cycle and its left energy, the maximizing minimum ratio of an active node's left energy and its initialized energy. The *n* nodes only can switch between active state and sleep state, and the active nodes whose count is less than *n* can make up not less than *k*-disjoint barrier, *n* and *k* are constraints.

2.4.k-CLBCS Algorithm

In this paper, it suggests a global *k*-CLBCS algorithm for constructing Local *k*-Barrier with Coordinated Sensors, the main idea of *k*-CLBCS algorithm is described as follows:

step1: Calculate every edge's capacity, and construct the coverage graph *G(N)*;

step2: Search *k* disjoint paths from *s* to *t* in the *G(N)*;

step3: If the *k* disjoint paths are found, return the nodes *ID* that should be activated to form *k*-barrier, otherwise, return constructing failure.

2.5.k-SBCCS Protocol

Based on the overlapped divide-and-conquer scheme and *k*- CLBCS algorithm, we propose a practical protocol. A sink and n sensors are assumed in the rectangle belt, at the beginning, all sensors are active. The main idea of *k*-SBCCS Protocol (Protocol of Strong *k*-Barrier Coverage with Coordinated Sensors) is described as follows:

step1: Sink divide the belt region into v equal-width sub-regions, and broadcast the value of (width of each sub region),(width of overlapped strip)and v(equal width sub-regions).

step2: Every node calculates which sub-region it belongs to, judge if it is located in the overlapped strip, and reports its information to the sensor which have highest energy.

step3: In each sub-region, the sensor who has the highest energy runs k- CLBCS algorithm .If k disjoint barriers are found, it activates these sensors, otherwise, it reports the failure information to sink.

step4: The activated sensor who has the highest energy in every overlapped strip checks if the overlapped strip is strong k-barrier covered or not. If it found the overlapped strip not strong k-barrier covered, some other nodes will be activated to form strong k-barrier coverage in the overlapped strips. If all live sensors in the overlapped strip can't form strong k-barrier, the above sensor reports the failure information to sink.

step5: Repeat step3 and step4 until all sensors die.

III.   RESULTS:

The advantage of this divide-and-conquer over centralized approach is:

- **Lower communication overhead and computation costs.** By dividing the large network area into small segments, the message delay, communication overhead, and computation cost can be significantly reduced. The location and sensing area information of a sensor node only need to be broadcast within the strip segment (or within the thin vertical strip) where the node is located, resulting in a smaller delay and communication overhead compared to the whole network broadcasting.

- **Improved robustness of the barrier coverage.** In a centralized approach which constructs global horizontal barriers for the whole strip, a horizontal sensor barrier could be broken if some nodes on the barrier fail, or become compromised or displaced by adversaries. In our divide-and-conquer approach, the original strip is divided into segments by interleaving vertical barriers. In case of node failure, these vertical barriers act as firewalls" that prevent intruders from moving from its current segment to adjacent segments. This limits the barrier damages within the local segment and hence improving the robustness of the barrier coverage .improving the robustness of the barrier coverage.

- **Strengthened local barrier coverage.** By dividing the original strip into small segments and computing barriers in each segment, a larger number of local horizontal barriers will be found in each segment than for the whole strip. These local barriers are not necessarily part of the global barriers for the whole strip, whose number remains unchanged. Since adjacent segments are blocked by interleaving vertical barriers, a larger number of local barriers results in strengthened local barrier coverage for each segment.

IV.   CONCLUSION

In this paper, we introduce a k-barrier coverage protocol, called *k*-SBCCS, for prolonging the network lifetime. The proposed protocol tries to prolong the network lifetime by establishing a balance in using nodes energies. The proposed protocol maximum lifetime scheduling for strong *k*- barrier coverage based on detection coverage model, which is more appropriate for intrusion detection scenarios. we transfer maximal barrier coverage lifetime to a multi objective optimization problem, and model the evaluation function as the capacity of coverage graph.Moreover, based on the enhanced coverage graph, we propose *k*- CLBCS algorithm of maximum network lifetime. Theoretical proof shows that the activated nodes by in every overlapped strip can form k-barrier. At last, we design a new Divide-and-Conquer scheme and *k*- SBCCS protocol for strong *k*-barrier with coordinated sensors.

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