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Geographic Routing Oriented Intrusion Detection In Mobile Sensor Networks

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ABSTRACT-The research focus on geographic routing, a promising routing scheme in wireless sensor networks (WSNs), is shifting toward duty-cycled WSNs in which sensors are sleep scheduled to reduce energy consumption. However, except the connected-k neighborhood (CKN) sleep scheduling algorithm and the geographic routing oriented sleep scheduling (GSS) algorithm, nearly all research work about geographic routing in duty-cycled WSNs has focused on the geographic forwarding mechanism; further, most of the existing work has ignored the fact that sensors can be mobile. In this paper, we focus on sleep scheduling for geographic routing in duty-cycled WSNs with mobile sensors and propose two geographic-distance-based connected-k neighborhood (GCKN) sleep scheduling algorithms. The first one is the geographic-distance-based connected-k neighborhood for first path (GCKNF) sleep scheduling algorithm. The second one is the geographic-distance-based connected-k neighborhood for all paths (GCKNA) sleep scheduling algorithm. By theoretical analysis and simulations, we show that when there are mobile sensors, geographic routing can achieve much shorter average lengths for the first transmission path explored in WSNs employing GCKNF sleep scheduling and all transmission paths searched in WSNs employing GCKNA sleep scheduling compared with those in WSNs employing CKN and GSS sleep scheduling.

I. Introduction

Sensor networks are usually deployed in areas that are dangerous or even unreachable to humans, such as volcanos, outer space, the seabed and so on. In such environments, human beings may not move close to the sensing field. A mobile observer, or SenCar, will be sent out to gather data from sensors periodically. Since the network may contain a large number of nodes, each tour may take a long time. In order to save energy, sensors may turn on their transceivers only when they need to send or relay packets. Except for the transmission period, the transceivers of sensors could be turned off.

The entire sensor network can be divided into several clusters, where sensors in each cluster must be connected to SenCar while it is moving through the cluster. When SenCar moves close to the cluster, all sensors belonging to the cluster will be woken up and will prepare to send packets. Sensed data can be collected by SenCar while it is traversing the cluster. To make this scheme work, two issues must be resolved here. The first issue is how the user can wake up and turn off sensors only when needed. A radio wakeup scheme allows the transceivers of sensors to be deactivated when they are idle.

The recent emergence of small embedded-sensing devices will fundamentally change the way to approach many scientific problems, some of them that were totally intractable in the past. One such family of scientific problems collectively is known as environmental monitoring, in which scientists must collect environmental data over long temporal and spatial scales. Today, such experiments are infeasible because they require significant manual labor and perturb the environment under observation.

With sensor network technology, scientists can deploy sensing motes close to the phenomenon they want to observe and collect measurements from the motes' onboard sensors.

Because the motes are physically small, battery-operated and include a wireless radio, deploying such a wireless sensor network perturbs the environment minimally and reduces the installation and maintenance costs. Furthermore, the inexpensive nature of these devices enables scientists to place a high resolution mote grid in the field and obtain frequent measurements, providing an extremely rich data set about the dependencies and subtle differences among many correlated parameters.

II. Related Work

A. Geographic Routing

The basic idea of geographic routing is greedy routing. Specifically, each packet is tagged with the coordinates of its destination, all nodes know their own coordinates, and a node forward the packet to its neighbor that is geographically closest to the destination.

The earliest proposal for geographic routing is a local minimum problem in that a node may have no closer neighbor to the destination. For this reason, face routing and its variants are proposed to use geometric rules to route around voids near the local minimum in case it happens. These algorithms require converting the network into a planar graph or removing the first path searched by geographic routing. These include all the paths found by geographic routing. Problematic cross links from the network, which are not very applicable in realistic conditions [11]. Moreover, there is also a hole problem in geographic routing, in that a hole can be formed by a set of dead sensor nodes running out of energy or being damaged. To solve this problem, some research work try to identify the hole boundary nodes first and then use these boundary nodes to avoid the hole. Others try to use geometric modeling to find an optimized hole by passing routing path. Recently, by using a *step back and mark* strategy when it cannot find the next-hop node, a two-phase geographic forwarding (TPGF), which does not have the local minimum or the hole problem. With a *labelbased optimization* method, TPGF can optimize the routing paths by finding one with the least number of hops. All these works only consider WSNs with static nodes.

Recently, many opportunistic routing protocols [8], [1] have been proposed to extend geographic routing to duty-cycled WSNs. They all try to achieve this goal by dynamically choosing the forwarding node based on the best potential node that can transmit packets. Specially, these protocols typically take into account such factors as link uncertainty to adapt routing accordingly. Few of these works address the local minimum or hole problem, and nearly all these works do not consider the situation that sensor nodes can be mobile.

B. Sleep Scheduling

The basic mechanism for sleep scheduling is to select a subset of nodes to be awake in a given epoch while the remaining nodes are in the sleep state that minimizes power consumption, so that the overall energy consumption can be reduced.

Existing works on sleep scheduling in WSNs mainly focus on two targets: *point coverage* and *node coverage*. For *point coverage*, the awake nodes in each epoch are chosen to cover every point of the deployed field. Existing *point coverage* oriented algorithms differ in their sleep scheduling goals: minimizing energy consumption or minimizing average event detection latency. For *node coverage* (also called network coverage), awake nodes are selected to construct a globally connected network such that each asleep node is an immediate neighbor of at least one awake node [3]. All these works generally focused on the medium access layer of static WSNs with static nodes.

The only recent works addressing sleep scheduling in dutycycled WSNs employing geographic routing are the CKN scheme proposed and the GSS method presented in [5]. CKN is a sleep scheduling method providing node coverage and a probabilistic point coverage, which tunes the number of awake nodes in the network by changing the value of *k* in CKN. GSS is based on CKN and differs from CKN only by making the potential nearest neighbor nodes to the sink to be awake. However, both CKN and GSS do not consider the scenarios in which sensor nodes can be mobile, and both CKN and GSS determine the awake or asleep state of each node based only on a random rank, which may keep awake many nodes far away from the destination and thus degrade the performance of geographic routing.

III. Geographic Routing and Scheduling Concepts

Geographic routing is one of the most promising routing schemes in wireless sensor networks (WSNs), due to its simplicity, scalability, and efficiency. In this work, we propose two GCKN (Geographic-distance-based Connected-k Neighborhood) algorithms, which effectively extend existing geographic routing algorithms designed for static WSNs into duty-cycled mobile WSNs by applying sleep scheduling. The GCKNF sleep scheduling algorithm is designed to explore shorter first transmission paths for geographic routing in duty-cycled mobile WSNs. The GCKNA sleep scheduling algorithm aims at shortening all routing paths for multipath transmissions in duty-cycled mobile WSNs. These GCKN algorithms incorporate the connected-k neighborhood requirement and geographic routing requirement to change the asleep or awake state of sensor nodes.

3.1. Geographic Routing

The basic idea of geographic routing is greedy routing. Specifically, each packet is tagged with the coordinates of its destination, all nodes know their own coordinates, and a node forward the packet to its neighbor that is geographically closest to the destination.The earliest proposal for geographic routing is in , which has a local minimum problem in that a node may have no closer neighbhour to the destination. For this reason, face routing and its variants are proposed to use geometric rules to route around voids near the local minimum in case it happens. However, these algorithms require converting the network into a planar graph or removing the problematic cross links from the network ,which are not very applicable in realistic conditions. Moreover, there is also a hole problem in geographic routing, in that a hole can be formed by a set of dead sensor nodes running out of energy or being damaged [2]. To solve this problem, some research work try to identify the hole boundary nodes first and then use these boundary nodes to avoid the hole. Others try to use geometric modeling to find an optimized hole-bypassing routing path.

Recently, by using a step back and mark strategy when it cannot find the next-hop node, a two- phase geographic forwarding (TPGF), which does not have the local minimum or the hole problem, is shown in. With a label-based optimization method, TPGF can optimize the routing paths by finding one with the least number of hops. All these works only consider WSNs with static nodes. Recently, many opportunistic routing protocols have been proposed to extend geographic routing to duty-cycled WSNs. They all try to achieve this goal by dynamically choosing the forwarding node based on the best potential node that can transmit packets. Specially, these protocols typically take into account such factors as link uncertainty to adapt routing accordingly. Few of these works address the local minimum or hole problem, and nearly all these works do not consider the situation that sensor nodes can be mobile.

3.2. Sleep Scheduling

The basic mechanism for sleep scheduling is to select a subset of nodes to be awake in a given epoch while the remaining nodes are in the sleep state that minimizes power consumption, so that the overall energy consumption can be reduced. Existing works on sleep scheduling in WSNs mainly focus on two targets: point coverage and node coverage. For point coverage, the awake nodes in each epoch are chosen to cover every point of the deployed field. Existing point coverage oriented algorithms differ in their sleep scheduling goals: minimizing energy consumption, or minimizing average event detection latency. For node coverage, awake nodes are selected to construct a globally connected network such that each asleep node is an immediate neighbor of at least one awake node. All these works generally focused on the medium access layer of static WSNs with static nodes. The only recent works addressing sleep scheduling in duty- cycled WSNs employing geographic routing are the CKN scheme proposed and the GSS method presented .

CKN is a sleep scheduling method providing node coverage and a probabilistic point coverage, which tunes the number of awake nodes in the network by changing the value of k in CKN. GSS is based on CKN and differs from CKN only by making the potential nearest neighbor nodes to the sink to be awake. Both CKN and GSS do not consider the scenarios in which sensor nodes can be mobile, and both CKN and GSS determine the awake or asleep state of each node based only on a random rank, which may keep awake many nodes far away from the destination and thus degrade the performance of geographic routing.

* A node should go to sleep assuming that at least k of its neighbors will remain awake so as to save energy as well as keep it k-connected.

* The asleep or awake state of nodes should be allowed to change between epochs so that all nodes can have the opportunity to sleep and avoid staying awake all the time, thus distributing the sensing, processing, and routing tasks across the network to prolong the network lifetime.

* Although each node decides to sleep or wake up locally, the whole network should be globally connected so that data transmissions can be performed.

* Each node should have enough initial neighbors, in order to make it easier for the node to satisfy the connected-k neighborhood requirement; thus, it is more likely to be asleep after sleep scheduling. For GCKNF, which emphasizes the first transmission path of geographic routing, we further take the following factor into account.

* The neighbor of each node, which is closest to sink, should be awake so that geographic routing can utilize these nearest neighbor nodes to make the first transmission path as short as possible. For GCKNA, which considers all transmission paths, we further take the following factor into consideration.

* For each node, as many as possible of its neighbor nodes that are closer to the sink should be awake so that geographic routing can make all transmission paths as short as possible.

IV. Geographic Routing in Duty-Cycled Mobile Sensor Networks

Geographic routing [4] is one of the most promising routing schemes in wireless sensor networks (WSNs), due to its simplicity, scalability, and efficiency [6]. In such a scheme, regardless of the network size, the forwarding decision is determined purely based on the location of each node and it can be done even when there are irregular radio ranges and localization errors. Recently, the research focus of geographic routing is centering on WSNs with duty-cycles, since duty cycled WSNs have a natural advantage of saving energy by dynamically putting nodes to sleep and waking them according to some sleep scheduling algorithms [9],[10]. Nearly all these works overlook one important fact that sensors can actually be mobile to gain better energy efficiency, channel capacity, etc., and enable a lot of new application scenarios [12]. For example, because sensors can move, they can transmit their data from different locations and avoid the problem that sensors near the gateway or sink always exhaust their energy first; thus, energy usage can be more efficient. Also, mobile sensors such as mobile phones or cars can become the interface between the information center and the mobile customers; thus, real-time information transmitted from the information center to these mobile objects can be provided to nearby customers.

Moreover, almost all current works about geographic routing in duty-cycled WSNs try to change the geographic forwarding mechanism to deal with the dynamic topology caused by some nodes being cycled off or going to sleep mode. For instance, it is suggested to wait for the appearance of the expected forwarding successor first and select a backup node if the first mechanism fails. In [7], the sensor field is sliced into some *k*-coverage fields, then some always-on cluster heads are selected to collect the data from their nearby sensors and finally transmit all data to the sink. Apart from the connected-*k* neighborhood (CKN) sleep scheduling algorithm proposed and the geographic routing oriented sleep scheduling (GSS) algorithm presented in [5], few research works have tackled the node availability uncertainty issue in duty cycled WSNs from the view of sleep scheduling.

This paper addresses the sleep scheduling problem in dutycycled WSNs with mobile nodes employing geographic routing. We propose two geographic-distance-based connected-*k* neighborhood (GCKN) sleep scheduling algorithms. The first one is the *geographic-distance based connected-kneighborhood for first path*1 (GCKNF) sleep scheduling algorithm, aiming at geographic routing utilizing only the first transmission path in duty-cycled mobile WSNs. The second one is the *geographic-distance-based connected-kneighborhood for all paths* (GCKNA) sleep scheduling algorithm, for geographic routing concerning all paths explored in duty-cycled mobile WSNs. By theoretical analysis and performance evaluations by simulations, we show that when there are mobile sensors, geographic routing can achieve much shorter average lengths for the first transmission paths searched in mobile WSNs employing GCKNF sleep scheduling and all transmission paths explored in mobile WSNs employing GCKNA sleep scheduling compared with those in mobile WSNs employing CKN or GSS sleep scheduling. The main contributions of this paper are summarized as follows.

1) This paper is a pioneering work proposing and analyzing sleep scheduling algorithms for geographic routing in duty-cycled mobile WSNs, which take full advantages of both duty cycling and sensor mobility.

2) Specifically, this paper proposes two GCKN algorithms, which effectively extend existing geographic routing algorithms designed for static WSNs into duty-cycled mobile WSNs by applying sleep scheduling. The GCKNF sleep scheduling algorithm is designed to explore shorter first transmission paths for geographic routing in duty cycled mobile WSNs. The GCKNA sleep scheduling algorithm aims at shortening all routing paths for multipath transmissions in duty cycled mobile WSNs. These GCKN algorithms incorporate the connected-*k* neighborhood requirement and geographic routing requirement to change the asleep or awake state of sensor nodes.

V. Problem Statement

A wireless sensor network (WSN) comprises small sensors with limited computational and communication power. Existing works on sleep scheduling in WSNs mainly focus on two targets: point coverage and node coverage. For point coverage (also known as spatial coverage), the awake nodes in each epoch are chosen to cover every point of the deployed field. Existing point coverage oriented algorithms differ in their sleep scheduling goals: minimizing energy consumption, or minimizing average event detection latency. For node coverage (also called network coverage), awake nodes are selected to construct a globally connected network such that each asleep node is an immediate neighbor of at least one awake node. All these works generally focused on the medium access layer of static WSNs with static nodes.

- Existing system ignored the fact that sensors can be mobile.
- In geographic routing, forwarding decision in based on location of nodes even in irregular radio ranges.
- Sensors near the gateway exhaust energy first.
- Energy-more efficiently used.

VI. Geographic Routing Based IDS in Mobile Sensor Networks

6.1. Topology Formation

The wireless model essentially consists of the Mobile Node at the core with additional supporting features that allows simulations of multi-hop ad-hoc networks, wireless LANs etc. The Mobile Node object is a split object. The C++ class Mobile Node is derived from parent class Node. A Mobile Node thus is the basic Node object with added functionalities of a wireless and mobile node like ability to move within a given topology, ability to receive and transmit signals to and from a wireless channel etc. A major difference between them is that a mobile Node is not connected by means of Links to other nodes or mobile nodes. Mobile Node is the basic NS Node object with added functionalities like movement, ability to transmit and receive on a channel that allows it to be used to create mobile, wireless simulation environments .Constructing Project design in NS2 should takes place. Wireless Sensor Nodes are deployed over a region where some phenomenon is to be monitored. Each node in the Wireless Sensor Network maintains the details of neighbor node.

6.2. Broadcast Message

In Broadcast message, it will communicate to one hop neighbour node for the purpose of selecting a neighbour node for find the distance and Communicate Message to Neighbour nodes. In this Module, we using distance calculation d=(sqrt(pow(($x2-$x1),2)+pow(($y2-$y1),2))) in that equation (x1,y1) are x-axis and y-axis for node A and (x2,y2) are x-axis and y-axis for node B.

6.3. Sleep scheduling

The GCKNF sleep scheduling algorithm is designed to explore shorter first transmission paths for geographic routing in duty-cycled mobile WSNs. A node should go to sleep assuming that at least k of its neighbors will remain awake so as to save energy as well as keep it k-connected. The asleep or awake state of nodes should be allowed to change between epochs so that all nodes can have the opportunity to sleep and avoid staying awake all the time, thus distributing the sensing, processing, and routing tasks across the network to prolong the network lifetime. Although each node decides to sleep or wake up locally, the whole network should be globally connected so that data transmissions can be performed. Each node should have enough initial neighbors, in order to make it easier for the node to satisfy the connected-k neighborhood requirement; thus, it is more likely to be asleep after sleep scheduling. For GCKNF, which emphasizes the first transmission path of geographic routing, we further take the following factor into account. The neighbor of each node, which is closest to sink, should be awake so that geographic routing can utilize these nearest neighbor nodes to make the first transmission path as short as possible. For GCKNA, which considers all transmission paths, we further take the following factor into consideration. For each node, as many as possible of its neighbor nodes that are closer to the sink should be awake so that geographic routing can make all transmission paths as short as possible.

6.4. Routing Technique

Greedy Routing tries to bring the message closer to the destination in each step using only local information. Thus, each node forwards the message to the neighbor that is most suitable from a local point of view. The most suitable neighbor can be the one who minimizes the distance to the destination in each step.

* For each neighbor of Source node calculate the distance distance between the Destination node.

* Transmit the data to the node which is closest to the Destination node among all the Neighbor Node

* Then the node which receives data from the Source node will transmit the data to its neighbor node which is closest to the destination node.

* This procedure will repeated until the data reaches the destination.

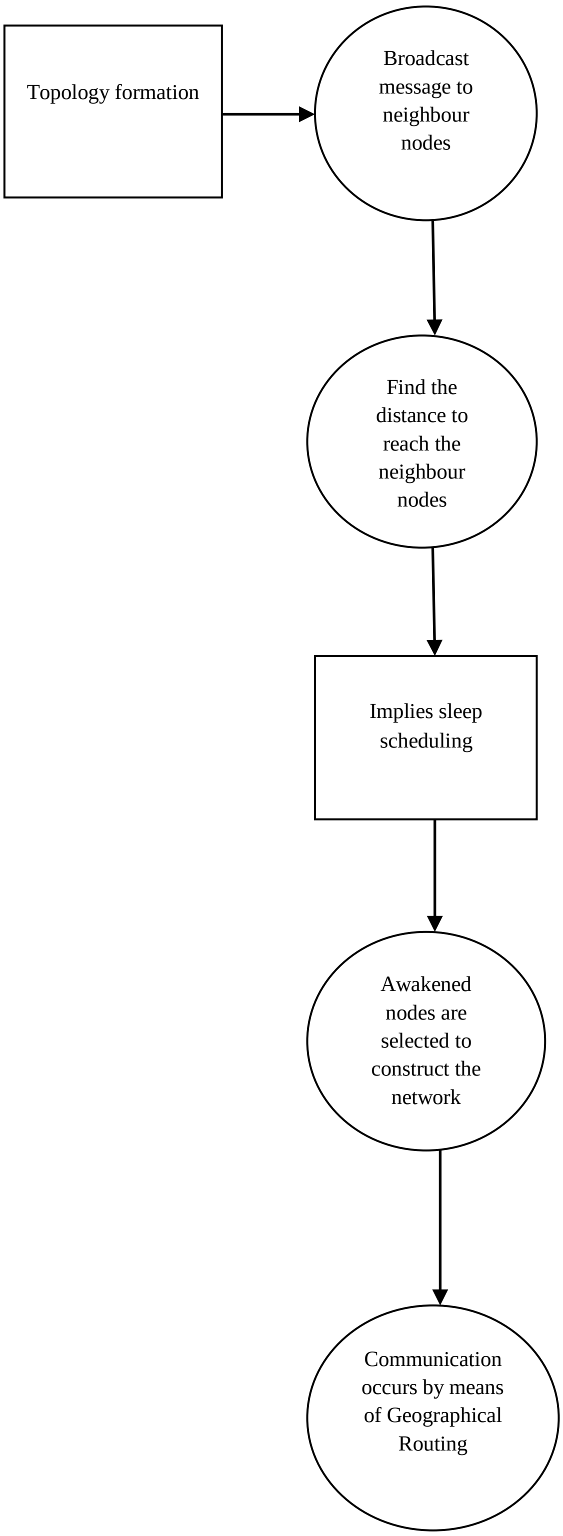

Figure 6.1. Geographic Routing Based IDS in Mobile Sensor Networks

VII. Conclusion

Geographic routing in duty-cycled mobile WSNs and proposed two geographic-distance-based connected-k neighborhood (GCKN) sleep scheduling algorithms for geographic routing schemes to be applied in duty-cycled mobile WSNs which can incorporate the advantage of sleep scheduling and mobility. The first geographic-distance-based connected-k neighborhood for first path (GCKNF) sleep scheduling algorithm minimizes the length of first transmission path explored by geographic routing in duty-cycled mobile WSNs. The second geographic-distance based connected- k neighborhood for all paths (GCKNA) sleep scheduling algorithm reduces the length of all paths searched by geographic routing in duty-cycled mobile WSNs. In duty-cycled mobile WSNs, from the view of sleep scheduling, GCKNF and GCKNA do not require the geographic routing to change its original geographic forwarding mechanism, and they both consider the connected-k neighborhood requirement and geographic routing requirement to change the asleep or awake state of sensor nodes. Detailed design of both GCKNF and GCKNA as well as further theoretical analysis and evaluation with respect to GCKNF and GCKNA has been shown in this paper. They demonstrate that GCKNF and GCKNA are very effective in shortening the length of the transmission path explored by geographic routing in duty-cycled mobile WSNs compared with the CKN sleep scheduling algorithm and the GSS algorithm. Our work has shown that sleep scheduling is a worthy research direction to adapt geographic forwarding methods into duty-cycled mobile WSNs.

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