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Target Tracking by Using Prediction and Sleep Scheduling In Sensor Networks

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Abstract: *Lifetime maximization is one key element in the design of sensor-network-based surveillance applications. We propose a protocol for node sleep scheduling that guarantees a bounded-delay sensing coverage while maximizing network lifetime. One of the most important applications of wireless sensor Network is tracks mobile target in surveillance system. Each sensor has a duty cycling requirement of being awake for only given time slots on an average. When nodes operate in a duty cycling mode, tracking performance can be improved if the target motion can be predicted and nodes along the trajectory can be proactively awakened. However, this will negatively influence the energy efficiency and constrain the benefits of duty cycling. In this paper, we present a Probability-based Prediction and Sleep Scheduling protocol (PPSS) to improve energy efficiency of proactive wake up. Based on the prediction results, PPSS then precisely selects the nodes to awaken and reduces their active time, so as to enhance energy efficiency with limited tracking performance loss. We evaluated the efficiency of PPSS with both simulation-based experiments.*

Keywords: *Energy efficiency, Target prediction, Sleep scheduling, Target tracking, Sensor networks*

1. INTRODUCTION

WIRELESS sensor networks (WSNs) are increasingly being envisioned for collecting data, such as physical or environmental properties, from a geographical region of interest. WSNs are composed of a large number of low-cost sensor nodes, which are powered by portable power sources, e.g., batteries [1]. Measurements on existing sensor device radios show that idle listening consumes nearly the same power as receiving.[2]. In sensor network applications where the traffic load is very light most of the time, it is therefore desirable to turn off the radio when a node does not participate in any data deliver.[3],[2]. A sensor network is composed of a large number of sensor nodes, which are densely deployed either inside the phenomenon or very close to it. The position of sensor nodes need not be engineered or pre-determined. This allows random deployment in inaccessible terrains or disaster relief operations. On the other hand, this also means that sensor network protocols and algorithms must possess self-organizing capabilities [4].In current literature employing redundancy to allow some nodes to go to sleep without jeopardizing sensory coverage. These approaches imply that a minimum number of nodes must remain awake for the right degree of coverage to remain satisfied. A trade-off exists between energy savings and coverage. [3]. in a target tracking system required to ensure continuous monitoring [1].Exist nodes that can detect the target along its trajectory with low detection delay [1], [5] or high coverage level [3]. Therefore, the most stringent criterion of target tracking is to track with zero detection delay or 100 percent coverage. In target tracking applications listening of idle nodes is major source of energy waste. For reduction of energy consumption during idle listening, duty cycling is one of the most commonly used approaches [3]. The idea of duty cycling is to put nodes in the sleep state for most of the time, and only wake them up periodically. In certain cases, the sleep pattern of nodes may also be explicitly scheduled, i.e., forced to sleep or awakened on demand. This is usually called sleep scheduling [1] [3].

As a compensation for tracking performance loss caused by duty cycling and sleep scheduling, proactive wake up has been studied for awakening nodes proactively to prepare for the approaching target. However, most existing efforts about proactive wake up simply awaken all the neighbor nodes in the area, where the target is expected to arrive, without any differentiation [1]. In fact, it is sometimes unnecessary to awaken all the neighbor nodes based on target prediction; it is possible to sleep-schedule nodes precisely, so as to reduce the energy consumption for proactive wake up. For example, [3], [4] if nodes know the exact route of a target, it will be sufficient to awaken those nodes that cover the route during the time when the target is expected to traverse their sensing areas. In this paper, we present a prediction based target prediction and sleep scheduling protocol (PPSS) to improve the efficiency and enhance the energy

1.1. Sensor Networks Applications

Sensor networks may consist of many different types of sensors such as seismic, low sampling rate magnetic, thermal, visual, infrared, and

acoustic and radar, which are able to monitor [1] a wide variety of

Ambient conditions that include the following [4]:

• Temperature,

• Humidity,

• Vehicular movement,

• Lightning condition,

• Pressure,

• Soil makeup,

Noise levels,

• The presence or absence of certain kinds of objects,

• Mechanical stress levels on attached objects, and

• The current characteristics such as speed, direction, and size of an object.

Scheduling sensor activities is an effective way to prolong the lifetime of wireless sensor networks (WSNs).

Functions in our Project:

1. Mobile Target Prediction.
2. Setting up Local Active Environment.
3. Sleep scheduling.

2. Related Works

Probability base prediction and sleep scheduling for energy efficient target tracking in sensor network was presented also in other papers.

The solution from [2] focuses on Delay efficient sleep scheduling and also show that by carefully choosing multiple wake-up slots for each sensor significant delay savings can be obtained over the single wake-up schedule case while maintaining the same duty cycling. In [3] describes, the framework is optimized for rare event detection and allow favorable compromises to be achieved between event detection delay and lifetime without sacrificing coverage for each point. [4] Reports describe the concept of sensor networks which has been made viable by the convergence of micro electro-mechanical systems technology, wireless communications and digital electronics.

The paper from [5], analyze and evaluate the energy consumption models in wireless sensor networks with probabilistic distance distributions.

In [6], derive closed form results for predicting surveillance performance attributes, represented by detection probability and average detection delay of intruding targets, based on tunable system parameters, represented by node density and sleep duty cycle. In [7], examine the fundamental theory of sleeping in sensor networks for tracking, as opposed to the design of protocols for this sleeping. Although sleep scheduling and target tracking have been well studied in the past, only a few efforts [17], [18] investigated them in an integrated manner. In [17], the authors utilize a “circle-based scheme” (Circle) to schedule the sleep pattern of neighbor nodes simply based on their distances from the target. In such a legacy Circle scheme, all the nodes in a circle follow the same sleep pattern, without Distinguishing among various directions and distances. In [18], Jeong et al. present the MCTA algorithm to enhance energy efficiency by solely reducing the number of awakened nodes. MCTA depends on kinematics to predict the contour of tracking areas, which are usually much smaller than the circles of Circle scheme. However, MCTA keeps all the nodes in the contour active without any differentiated sleep scheduling. Typical target prediction methods include kinematics based prediction [18], [19], dynamics-based prediction [21], and Bayesian estimation methods [20], [22].

3. Design Overview

In this section, we introduce system models, our assumptions, and overview the design of PPSS protocol.

3.1. System Models and Assumptions

We consider a homogeneous, static sensor network, in which sensor nodes work in a duty cycling mode. In each toggling period (TP), a node keeps active for TP _ DC, where DC is the duty cycle. Although the active period of neighbor nodes may be different, the communication among them can be guaranteed based on a MAC protocol such as B-MAC [2], [1].

3.2. PPSS Design

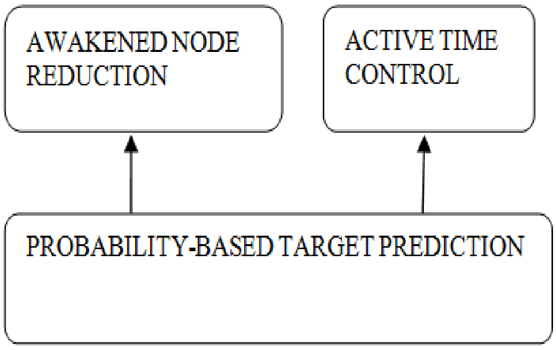

Figure 1. *PPSS design overview.*

PPSS is designed based on proactive wake up. When a alarm node detects a target, it broadcasts a alarm signal to proactively waken its neighbor nodes awakened node to prepare for the approaching target. To enhance the energy efficiency we modify this basic proactive wake up method to sleep scheduling nodes precisely. Particularly, PPSS selects some of the neighbor Candidate node that is likely to detect the target to awaken. A decision on whether or not to be an awakened node, and if yes, when and how long to wake up.

For reduction of energy consumption during this proactive wake up process:

a) Reduce the number of awakened nodes.

b) Schedule their sleep pattern to shorten the active time.

Both of these energy reducing approaches are built upon target prediction results.

Figure. 1 shows the three components of PPSS:

1. Target prediction. This target prediction scheme consists of three steps: current state calculation, kinematics-based prediction, and probability based prediction. After calculating the current state, the kinematics-based prediction step calculates the expected displacement from the current location within the next sleep delay, and the probability-based prediction step establishes probabilistic models for the scalar displacement and the deviation.

2. Awakened node reduction. The number of awakened nodes is reduced with two efforts: controlling the scope of awake regions, and choose a subset of nodes in an awake region.

3. Active time control. Based on the probabilistic models that are established with target prediction, PPSS schedules an awakened node to be active, so that the probability that it detects the target is close to 1.

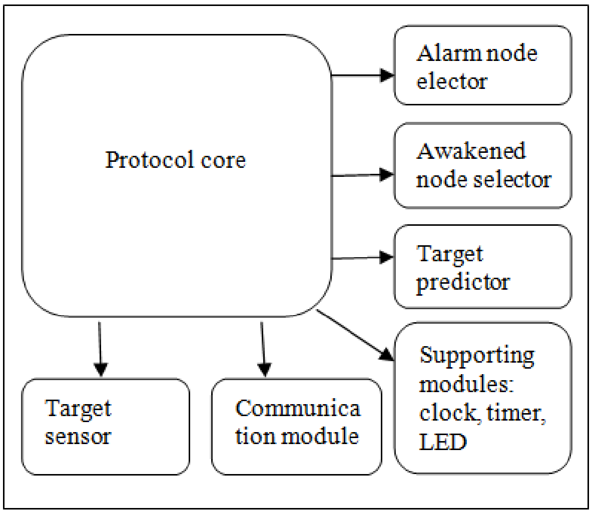

Figure 2. *Protocol Structure.*

3.2.1. Modules

1. Topology Formation.

2. Predicting the target and creating Local Active environment.

3. Probability prediction and sleep scheduling.

4. Modified PPSS protocol.

1. Topology Formation:

All sensors are deployed initially. Each sensor updates their information to its neighbor sensor. This is called Initial Neighbor Discovery.

2. Predicting the target and creating Local Active environment:

All sensors communicate with each other and updates the routing information once object is detected creates a Local Active environment predicts the Target movement and sends the information to base station.

3. Probability prediction and sleep scheduling:

Once Target is detected creates an Awake region and based on the prediction results assigns Sleep scheduling to individual sensors at synchronized time and the graph is plotted for Energy efficiency in comparison with the Existing concept along with Throughput, Packet Delivery ratio.

4. Modified PPSS protocol:

In this phase we are synchronizing the proposed PPSS protocol, i.e., Local Active environment with Boundary selection nodes in which the sensors along the boundary of the field region are activated, thus the Mobile target that comes from different directions are detected, once it detects the Moving object along the boundaries, it will start sending the information about the mobile target to the base station, so we are enhancing the proposed concept to detect multiple target along with improved power efficiency.

3.3. System Requirements

HARDWARE USED:

Processor	: Pentium III
Processor speed	: 1.5 GHZ
Memory (RAM)	: 256MB
Hard disk	: 40GB

SOFTWARE USED:

Operating System	: Linux 8.0(fedora 8.0)
Language	: TCL Scripting
Software	: ns2.35

3.3.1. Software Description:

The Network Simulator (NS2):

Network Simulator (NS2) is a discrete event driven simulator developed at UC Berkeley. It is part of the VINT project. The goal of NS2 is to support networking research and education. It is suitable for designing new protocols, comparing different protocols and traffic evaluations. NS2 is developed as a collaborative environment. It is distributed freely and open source. A large amount of institutes and people in development and research use, maintain and develop NS2. This increases the confidence in it. Versions are available for FreeBSD, Linux, Solaris, Windows and Mac OS X.

4. Further Discussion and Conclusion

In the proposed concept, by using PPSS algorithm it is possible to save more energy by reducing energy consumption i.e., if we are able to predict the probability by which the Mobile target moves, we can make the sensors along that direction to be active and putting rest of the sensors in sleep mode, so we can save comparatively more energy than the existing work, this can be achieved by creating a Local Active Environment and sleep scheduling. for e.g., a wireless sensor which detects the mobile target will create a Local active environment i.e., by awakening the neighbor sensors or next hop sensors and sensors in the routing table to send the information about the target to the base station, putting the remaining sensors to sleep mode. By this way the sensors that are close to mobile target will predict the direction in which mobile target moves and creates a Local Active Environment dynamically each time the target moves. Thus the energy efficiency is increased to great extent compared to the Existing works which maximizes the network lifetime.

The proposed Concept has a limitation of detecting only single target so in order to detect the multiple numbers of Mobile targets; we enhance the proposed concept of Local Active Environment and sleep scheduling with boundary selection nodes. i.e., Modified PPSS Algorithm. In the proposed concept when a Mobile Target enters the field region or surveillance region the first sensor that detects the Mobile target will create Local Active Environment putting the remaining sensors to sleep mode, the limitation here is if another mobile target enters the surveillance region the sensors that are in sleep mode cannot detect the Target, so to overcome this we are synchronizing this Local Active environment with Boundary selection nodes in which the sensors along the boundary of the field region are allowed to remain active, since the Mobile Target can enter the field region only through the boundaries, so when we are activating the boundary selective nodes we can detect multiple number of Target entering the Surveillance region from different direction and once the Mobile Target is detected it will be informed to the base station.

This paper proposed modified PPSS algorithm which helps to save more energy than the existing PPSS algorithm by reducing energy consumption.

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