Monitoring On Moving Object Tracking Using Wireless Sensor Networks

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Abstract -- We study the problem of localizing and tracking multiple moving targets in wireless sensor networks. We apply sensor networks to the problem of tracking a moving objects. We describe reporting mechanism, in which both sensor nodes and the base station predict the future movements of the objects. Transmissions of sensor readings are avoided as long as the predictions are consistent with the real object movements.

Keywords: Energy Consumption, Tracking objects.

I. INTRODUCTION

Their low cost and wireless communication capability make it feasible to deploy them in large numbers, and without preexisting infrastructure. With more sensors available in the environment, it is more likely that phenomena of interest are near some sensors, there by leading to the main appeal of wireless sensors compared to the tethered ones. On the other hand, such sensors relay on limited sources of power, and so energy efficiency becomes an important feature of the systems that use them.

Tracking consists of detecting and monitoring locations of real-world objects, possibly numerous applications of tracking are currently in use; for example, air traffic control, fleet tracking, monitoring, mobile telephony, etc. Networked sensors have recently been used for this purpose.

We are interested in designing an efficient tracking method, based on networked sensors, that has the ability to cover large regions of interest by using many sensors with small detection range. The method will need to handle a large number of moving objects at once. To address the scalability goals, we use hierarchical organization, similar to schemes previously used in cellular telephone systems. We focus on improving the energy efficiency of such schemes.

Object tracking sensor networks mainly two regional operations:

1) Monitoring: Sensor nodes are required to detect and track the movement states of mobile objects.

2) Reporting: The nodes that sense the objects need to report their discoveries to the applications. These main operations are interleaved during the entire object tracking process. Our focus, in a prior study, has been on developing strategies for reducing the energy consumption in monitoring operations. In this paper, we expand our study to the energy management in reporting operations.

II. OBJECT TRACKING SENSOR NETWORKS

Object tracking sensor networks (OTSNs) have widespread use in applications such as security surveillance and wildlife habitat monitoring. Therefore, a new networking paradigm for OTSNs, with a focus on the energy efficiency of reporting operations is studied in this paper. In the following, we first provide some background of OTSNs for this paper, and describe a monitoring mechanism underlying the DPR mechanism.

A. Background

The Object tracking sensor networks (OTSN), a number of sensor nodes are deployed over a monitored region with predefined the geographical boundaries. The main base station acts as the interface between the OTSN and applications by issuing commands and collecting the data of an interests. A sensor node has the responsibility for
tracking the object intruding its detection area, and reporting the states of the moving objects with certain reporting frequency, it is adjustable to the network and application requirements. Deciding the states of the tracked objects may need several sensor nodes to work together. This is an important area of research (called sensor fusion) in the sensor applications, but out of scope of this study. Thus, in this paper, we assume that each sensor node is a logical representation (i.e., sensing leaders or cluster heads) of a set of sensor nodes which collaboratively decide the state of a moving object. We also assume that the moving objects are identifiable so that sensor nodes are able to store the moving objects’ movement history, which is used for make predictions for objects’ future movement.

B. Impacting Factors

In this section, we discuss various factors that have impacts on the energy consumption in OTSN:

- **Network workload** is an related to the number of moving objects inside the network, which has an impact on the overall energy dissipation of OTSNs due to the amount of monitoring and reporting activities.

- **Reporting frequency** of sensor nodes is determined by application requirements. Since higher than the reporting frequency implies more update packets, keeping reporting frequency as low as application allows can conserve energy of OTSNs.

- **Data precision** is closely relevant to the location models (see below) and the frequency of sampling performed by the sensor nodes. The application can depict the moving objects’ movement in more details by asking for the location information more frequently and/or a location model with higher granularity, which in turn consumes extra energy and requires more computations.

- **Location models** are used to present the location information of moving objects. Additional movement states, e.g., speed and direction, can be derived from the location changes.

C. Monitoring Mechanism

In a previous study, the authors studied several energy-saving schemes for monitoring operations.

A prediction-based energy saving scheme (called PES) for monitoring has been shown to achieve high energy efficiency by minimizing the energy dissipation in the micro-controller unit (MCU) and sensor components. However, the energy-saving schemes for monitoring are orthogonal to the reporting mechanism are addressing in this paper.

To focus on the energy optimization for reporting operations, we adopt one of the basic monitoring schemes, called continuous monitoring scheme (CM). The advantage of CM is that it involves only one sensor node for monitoring each moving object, while other sensor nodes can switch to sleep mode and save energy. However, to ensure no missing reports, the active sensor has to stay awake all the time as long as the object stay in its detection area, even if the application requires only a very low reporting frequency.

D. Reporting Mechanism

The Dual Prediction based Reporting (called DPR) mechanism has two main components: location models which regulate the granularity of the location information that the system desires; and prediction models that analyze the moving history of tracked objects and estimate their future movement states. In the DPR mechanism, a prediction model is deployed at both sensor nodes and the base station. By using the same historical data, the sensor nodes and the base station consistently make the same prediction of any moving object’s future movements. This way, the sensor nodes are able to avoid transmitting its sense data to the base station, as long as their predictions about the object’s movements match their readings. Meanwhile, the base station always assumes its prediction reflects the real movements of moving objects, unless it receives the corrections (called update packets) from the sensor nodes.

III. PROPOSED SYSTEM

The proposed work is an energy efficient prediction-based method in a clustered network which consists of nodes at same energy level and range of communication. Initially the nodes are clustered using LEACH-R (LEACH- Reward) protocol in which a node is selected as a Cluster Head (CH). When a target enters the wireless sensor network, the CH that detects the target becomes active while other nodes are in sleep mode. Then the active CH selects three sensor nodes of its members for tracking in which one node is selected as Leader node. The selected nodes sense the target and current target location is calculated using trilateration algorithm.
In this algorithm three sensor nodes are selected each time in which two nodes calculates its distance from the moving object and sends the data to the leader node. The localization of the moving object is done by leader node whereas in previous methods it’s done by CH.

Using prediction based clustering method energy consumed in the network will be reduced since the transmission power of the nodes is directly proportional to the distances. The three nodes selected for tracking are close to each other, thus the energy consumed for sending a data between the nodes is lower than sending a data from one of the selected nodes to its CH. In LEACH-R, a reward value is calculated by each CH every time in order to eliminate the cluster that has no members and thereby save the energy.

### A. Clustering Of Nodes

Clustering is a technique used to extend the lifetime of a sensor network by reducing energy consumption. The LEACH-R (Low-Energy Adaptive Clustering Hierarchy-Reward) algorithm, involves four phases are as follows.

- **Reward Phase - Reward Calculation**
- **Advertisement - Elections and membership**
- **Set-up phase - Schedule creation**
- **Steady state phase - Data flow between the nodes**

![Figure 1: Architecture Diagram](image)

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![Figure 2: Block Diagram](image)

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In LEACH-R, each sensor nodes generate a random value x between 0 and 1 which is compared with the probability value P. If the x is less than P, then the node announce itself as CH and calculate its reward values as

\[
\text{Reward}_i = \text{Old Reward}_i + \text{Cluster member} + \text{Energy} + \text{Distance from BS}
\]

The relation consist of 4 parts, first is the old reward value assigned for the node. Second part is the members in the cluster. Third part is the energy of the node and last is the distance of the node from the BS. While broadcasting the reward value is also sent along with the join request. The members join with the CH that has biggest reward by comparing the reward values. Then the CH creates a TDMA schedules for its members and send it to its cluster members. The data flow occurs between members and CH. In LEACH, the cluster that doesn’t have members is also considered and schedule is created. By using reward value the CH that doesn’t have any members is removed and energy is saved.

![Figure 3: Flow Diagram for LEACH-R](image)
B. Target Detection

The target detection is done using Received Signal Strength Indicator [RSSI] method. It estimates the distance between two sensors by measuring the power of the signal transmitted from sender to receiver. Theoretically, the signal strength is inversely proportional to squared distance, and a known radio propagation model can be used to convert the signal strength into distance. The main advantage is its low cost, because most receivers are capable of estimating the received signal strength. In some cases, there may be inaccuracies of distance estimation due to noise and interference. But, considering its low cost, it is possible that a more sophisticated and precise use of RSSI (e.g., with better transmitters) could become the most used technology of distance estimation. In the Figure 3.4, a sender node sends a signal with a determined strength that fades as the signal propagates. The bigger the distance to the receiver node, the lesser the signal strength when it arrives at that node.

C. Prediction Mechanism

A prediction-based algorithm uses a prediction mechanism that predicts the next location of target is a linear prediction method. This mechanism with current and previous location of target, predicts next location of target. Using \((x_i, y_i)\) and \((x_{i-1}, y_{i-1})\), coordinates of nodes i and i-1 at time ti and ti-1 the target’s speed \(v\) and the direction is calculated. The predicted location \((x_{i+1}, y_{i+1})\) of the target after the given time \(t\) is calculated using the target speed and direction. If the predicted location is within the current cluster, then the active CH selects the three nodes which are nearest to the location. If the predicted location is placed out of the current cluster, active CH selects nearest CH to that location as next active CH and gives the tracking task to the new active CH.

D. Trilateration Algorithm

After receiving the distance message from two other selected nodes, the leader node calculates current location of moving object using trilateration algorithm. Trilateration algorithm forms relation between three nodes and by solving three formed relations the coordinate of target \((x, y)\) is obtained.
IV. PERFORMANCE EVALUATION

A. Energy Consumption

In the proposed algorithm the energy consumed is reduced since only activated nodes in the network is involved in tracking and rest of nodes remain in standby mode. Figure 5 show the graph comparing the energy consumption before and after the proposed algorithm. It consumes more energy than any other task. It covers the communications in terms of emission and reception. The energy consumed for the calculation operation is very low as compared with the communication energy.

B. Number of Alive Nodes

The number of alive nodes decreases as the time increases. In the proposed algorithm, there is a steady decrease in the number of alive nodes. Figure 6 show the comparison by taking time versus number of live nodes as (x,y) co-ordinates.

C. Network Lifetime

The network lifetime is directly proportional to the number of nodes in the network. Figure 7 show the increase in the network lifetime as number of nodes in the increase.

V. CONCLUSION

Object tracking sensor networks have two primary operations: monitoring and reporting. This paper addresses the energy conservation issues in the reporting operations. This Dual Prediction Reporting mechanism, in which the sensor nodes make intelligent decisions about whether or not to send updates of objects movement states to the base station and thus save energy. In target tracking in WSN is done in efficient way using an energy efficient prediction-based clustering algorithm. Energy efficient prediction based Clustering algorithm, reduces the average energy consumed by sensor nodes and there by increase the lifetime of the network. The tracking of the moving object is accurately done.

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**BIOGRAPHY**

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