ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

*International Journal of Advanced Research in Computer and Communication Engineering*
*Vol. 4, Issue 7, July 2015*

# Efficient Mobile SinkTrail Data Reporting Protocol for Wireless Sensor Networks

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**Abstract:** In wireless sensor networks, data gathering using mobile sink, has drawn significant amount of interests in recent years. To achieve this, some of the approaches focus on scheduling the mobile sink's moving path in advance or focus on gathering little amount of data in the network. In certain cases when the mobile sink moving trajectory cannot be planned in advance, in order to avoid the traffic in updating sink locations, an energy efficient data reporting protocol is designed. This protocol is called as SinkTrail and is mainly used for collecting the data using multiple mobile sinks. SinkTrail protocol constructs a logical coordinate system without using GPS devices. SinkTrail-S protocol is designed which is an improved version of SinkTrail protocol, reduces the energy consumption and eliminates the unnecessary control messages in the network. Mobile sinks are positioned at certain node locations so that the route length in transmitting the data packets would be reduced and reduces the total energy consumption.

**Keywords:** Wireless sensor networks, mobile sinks, logical coordinate system, data reporting.

## I. INTRODUCTION

A wireless sensor network is an accumulation of distributed sensors that are organized into a network. These sensors monitor physical or natural elements as sound, temperature, humidity, pressure and forward their information through the system to the main location. Wireless sensor network applications are divided into two types: monitoring and tracking. Monitoring applications include indoor or outdoor environmental checking, health awareness checking, area monitoring, air pollution monitoring, water quality monitoring, habitat monitoring, industrial monitoring, precision agriculture, military applications and traffic management. Tracking applications involves tracking of objects, vehicles, humans and animals.

Sensor nodes main objective is to examine the surrounding environment and to forward estimations and information towards the sink. In the wireless sensor network with mobile sink, sensors are not aware of the mobile sink location. Therefore it is difficult for sensor nodes to find out the sink location to forward the estimations and data to the sink. This problem can be overcome by constructing a virtual base over the physical system, and this structure is utilized to determine the sink location during data forwarding process.

Instead of sending the data through multi-hop and along error routes to static sink, using sink mobility achieves efficient data collection and reduces energy consumption [1]. Mobile sinks like vehicles or animals are provided with radio devices and are allowed to enter the network in order to interact with the sensor nodes. Data reporting is based on occurrence of event, time or it is based on query. Several data dissemination protocols were proposed with a static sink, such as directed diffusion. But these methods assume that sink needs to forward its location information periodically in the network. Many methods such as mobile element scheduling (MES) methods were proposed to achieve efficient data gathering by controlling the sink mobility. But in some cases the mobile sink may not be able to move across restricted areas and to adapt to changing network situations.

SinkTrail is a data reporting protocol that is capable of adapting to different network situations. Using this protocol, data can be transmitted along shortest path to the location of mobile sinks. This protocol provides flexibility for mobile sinks to adapt to various network scenarios and also reduces control overheads. Mobile sinks move constantly around the sensor nodes and collect the data. SinkTrail-S protocol is an improvement to the SinkTrail, and it eliminates the flooding of control messages.

## II. RELATED WORK

Using sink mobility for data collection has drawn enormous interest and many researches are being carried out. This approach must be capable of handling the control overheads that result by the movement of the sink. Several methods are used to minimize the control messages.

Fan Ye proposed two tier data dissemination (TTDD) approach [2] for large scale wireless sensor networks which is used to develop a two level data dissemination framework in prior to facilitate fast data transmission. TTDD protocol leads to overflow of control messages since mobile sink location information is propagated throughout the network. T.Park proposed a Dynamic Routing protocol for Mobile Sink (DRMOS) [3]. This method incorporates wake-up-zone to wake up the sensor nodes for approaching sink. It assumes mobile sinks move at a particular speed and a specific direction, which limits their application as well as mobile sink movement. K.Fodar proposed a simple effective routing protocol [4].

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In this protocol, when there is a change in topology the routes are updated. Ming Ma and Y.Yang proposed new data gathering mechanism for large scale wireless sensor networks [5]. Mobile data collector called M-collector is a mobile robot or vehicle provided with effective transceiver and battery and collects data by moving around field. A.A.Somasundara proposed mobile element scheduling method [6] for collecting the data. In MES methods, single mobile sink is required to collect data from every sensor node, hence it would be difficult to use this method in large scale wireless sensor networks and leads to high latency in collecting the data. J.Luo proposed a joint mobility and routing method [7] for improving the lifetime of the wireless sensor networks. It is assumed that sensor nodes are arranged in the form of circle. C. Intanagonwiwat proposed directed diffusion method [8] for wireless sensor networks.

It is data-driven where the communications is for named data. D. Shah proposed a routing approach with mobile fusion centres [9]. In this approach the problem of aggregating data at a mobile fusion centre which moves within a spatial region is considered. It depends on topology of network and density, and leads to scalability issues when more number of data packets needs to be transmitted in the network. Q. Huang introduced spatial-temporal multicast protocol [10] that builds a delivery zone before mobile sink enters into network.

## III. PROPOSED SYSTEM

SinkTrail is a data reporting protocol that can adapt to different applications and allows the sensor nodes to forward data to nearest mobile sink. Multiple mobile sinks are utilized to gather the data. It achieves more flexibility without restricting the movement of mobile sink. SinkTrail-S protocol reduces the flooding effect of control messages by eliminating the unnecessary trail messages. It builds a logical coordinate framework for forwarding the data. SinkTrail predicts the location of the sink and selects the shortest data forwarding paths using greedy forwarding algorithm.

### A. SinkTrail Protocol Design

An uniformly distributed large scale sensor network N is considered, which is deployed in an outdoor environment. To gather information from the nodes, multiple mobile sinks are sent into the network. The data collection procedure starts once the mobile sinks enter the network and ends when either sufficient amount of data are collected or when none of the data packets are sent in a particular period of time.

In the process of data collection, multiple mobile sinks keeps on moving in the network with low speed, and receives the data. Mobile sink stops at certain region in the network for a short period of time, sends message to the entire network, and later moves to some other place. The places at which the mobile sink stops are called trail points, and the messages are called trail messages. Each of the trail messages from mobile sink includes sequence number (msg.seqN) along with hop count (msg.hopC) to sink. To reduce the energy consumption mobile sinks are moved to certain node locations. In this case the number of hops from nodes to mobile sink will be reduced and results in faster data transmissions. Trail references are used to indicate the logical coordinates of nodes, which is utilized as location information for transmitting the data packets. Trail reference represents the information which contains the hop count. The data reporting procedure is divided into two stages. The first stage is called logical coordinate construction stage. During this stage, trail references of the nodes are updated whenever they receive trail messages from mobile sinks. After hop counts have been collected, the next phase is the data reporting phase. In this phase the nodes decide the way to send data to the nearest sink.

### B. Logical Coordinate Constructor

In this stage sensor nodes will update the trail references when they receive trail messages from mobile sink. Initially the trail references of all sensor nodes are set to -1. Variable λ is used for recording the recent sequence number of the message and initially its value is recorded as -1. When mobile sink enters the sensor system, it chooses one spot as the first trail point and transmits trail message to the entire sensor network. Message sequence number (msg.seqN) initially is set to 1 and hop count (msg.hopC) is set to 0, which indicates that is the first message from first trail point, and the hop count distance to mobile sink will be initially zero. Since there are multiple mobile sinks, sensor node consists of many trail references where each of them belongs to a different mobile sink.

The nodes that are closer to sink will hear the message first. The message sequence number is compared with previous sequence number recorded (λ), and if this is new message then λ is updated by newly received sequence number. The node $n_i$ reference $v_i$ is updated by calculating the hop count to the present location of mobile sink through the neighbor node which is closer to that mobile sink. The hop count is increased by one in the trail message that is received. Once the node $n_i$ update the trail reference, the message will be retransmitted with same sequential number but with hop count that is updated. This process occurs at all the sensor nodes. All the nodes update the trail references corresponding to the hop count value to current locations of the mobile sinks. If the trail message received by the node contains the same sequence number as λ and with a smaller hop count when compared to the previous hop count recorded, then that hop count field is updated with this smaller hop count. Then this trail message is retransmitted. If sequence number in the received trail message is less than λ, then those messages will be eliminated to reduce the number of control messages in the network.

### C. Data Reporting

Once the node finishes updating its trail reference, it starts a timer function. It is used to ensure that data packets are received in sequential order. When the node's timer ends,

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it begins the data transmitting process. All the nodes in sensor network exchange the trail references with its neighbour's. Sensor nodes predict mobile sink location with the help of the logical coordinates. If the mobile sink is found inside the radio range of it, it directly transmits the data to mobile sink.

If none of the mobile sinks are within the range of it, then it compares the trail references of its neighbour's with the destination reference and calculates their distances to the locations of the mobile sink. Then it selects the node with the minimum distance to one of the mobile sinks as the next hop to forward the data. If the node has neighbours with the same hop count distance, then the neighbour node can be chosen arbitrarily.

D. SinkTrail-S Protocol

In SinkTrail protocol, broadcasting trail messages to entire network leads to more energy consumption. In order to eliminate unnecessary control messages in the network and to minimize the energy usage, SinkTrail-S protocol is designed. This protocol depends on the following two factors. Firstly, in the large-scale wireless sensor network, when mobile sink moves to a new trail point the sensor nodes that are far will not have any impact. Secondly, once a node finishes forwarding the data, updating its trail reference becomes unnecessary and hence results in wastage of energy. Therefore in order to overcome these two circumstances, a message suppression policy is proposed.

In case of first situation, every sensor node compares current hop count measurement with the recently received hop count to the mobile sink. If both the hop counts are equal, it indicates that the distance from the node to the mobile sink remains the same and hence eliminates the unnecessary rebroadcasting of trail message. To handle the second situation, once a node completes sending the data it informs to all neighbor nodes. Therefore a node stops updating its trail reference and rebroadcasting of trail messages at the point when itself and every neighbour of it have finished sending the data.

## IV. RESULTS AND ANALYSIS

The SinkTrail protocol is developed using NS-2 simulator. SinkTrail is compared with SinkTrail-S protocol to evaluate the performance in terms of energy consumption. Also the energy consumed when the mobile sinks are at random positions is compared with the positioning of mobile sinks and the performance is evaluated.

Figure 1 shows snapshot of trail reference update of nodes. Nodes 1,9,13 are mobile sinks. Each node updates its trail reference which represents the hop count distance to the location of the mobile sinks. Therefore each node consists of multiple trail reference corresponding to the different mobile sink locations.

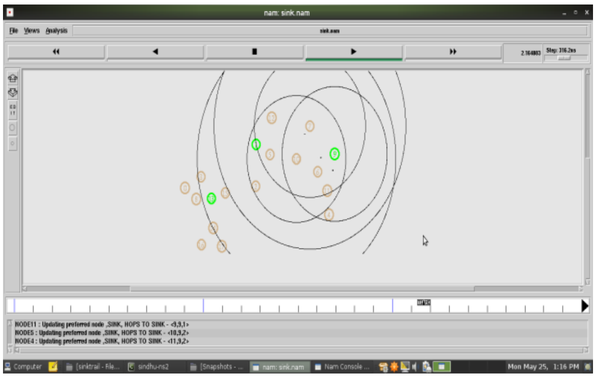

Fig.1: Snapshot for trail reference update

Figure 2 shows snapshot of data reporting. Nodes 1,9,13 are mobile sinks. For node 7 the nearest mobile sink within the range is 9. Hence node 7 directly sends data to mobile sink node 9.

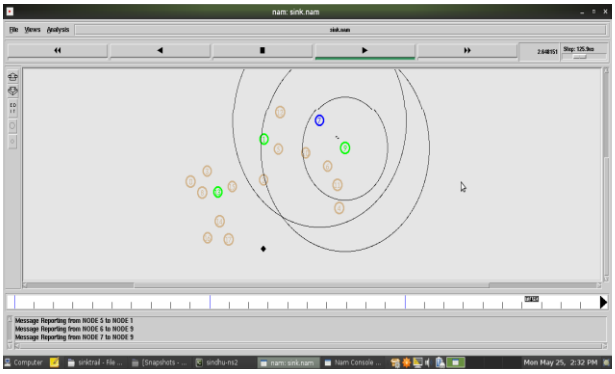

Fig. 2: Snapshot for data reporting

Figure 3 shows the comparison of energy consumed for SinkTrail and SinkTrail-S protocol. It shows that energy remaining in the network for SinkTrail-S denoted by S1, is more compared to SinkTrail protocol denoted by S0 in the graph. Therefore the energy consumed by SinkTrail-S protocol is less when compared to SinkTrail protocol. X-axis represents total energy in network and Y-axis represents transmissions.

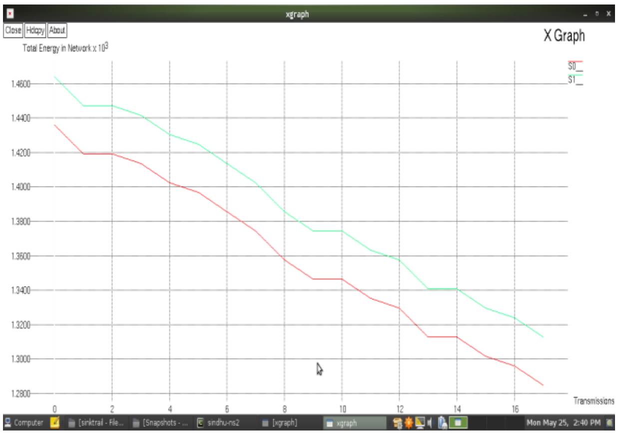


Fig. 3: Comparison of total energy consumption between SinkTrail and SinkTrail-S protocol

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ISSN (Print) 2319 5940

*International Journal of Advanced Research in Computer and Communication Engineering*
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Figure 4 shows comparison of energy consumed when the mobile sinks are at random points and when the sinks are positioned at certain nodes. It can be observed that when the mobile sinks are positioned denoted by E1, the energy consumption is reduced when compared to energy consumed when the sinks are at random points denoted by E0. Therefore the energy remaining in the network is more when the mobile sinks are positioned.

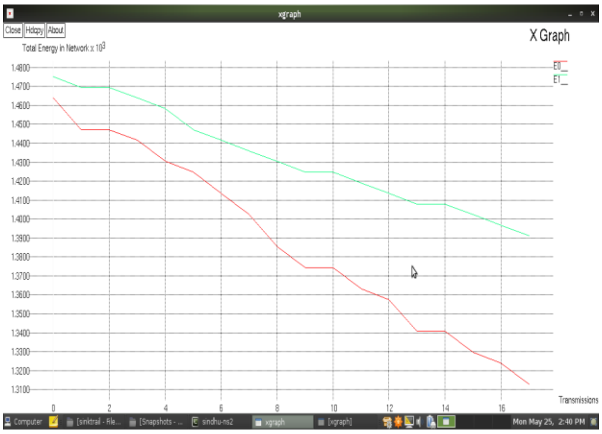


Fig. 4: Comparison of total energy consumption for without sink positioning and with sink positioning

## V. CONCLUSION

SinkTrail is an energy efficient data reporting protocol which enables sensor nodes to forward data to nearest mobile sink. It builds a logical coordinate system which helps in tracking the location of the mobile sinks and selects the shortest path to transmit data to the mobile sink. It is capable of handling multiple mobile sinks. SinkTrail-S protocol reduces the energy usage and eliminates the unnecessary broadcasting of trail messages in the network. In both the protocols instead of random movement of mobile sinks to stop at trail points, the mobile sinks are positioned at certain node locations to decrease the total energy consumption and also to minimize the route length for data transmission. The results show that total energy consumed in SinkTrail-S protocol is less compared to SinkTrail protocol and also the energy consumption is less when the mobile sinks are positioned at particular node locations when compared to the random locations of the mobile sinks. The future enhancement is to provide security to prevent the data from being transmitted to the malicious nodes entering the network and to prevent unauthorized users from accessing the data.

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