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A Proactive Data Reporting Protocol for Wireless Sensor Networks

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Abstract - Power saving is a critical issue in wireless sensor networks since sensor nodes are battery-powered. To achieve optimized network performance at collecting a small portion of sensed data in network is in current researches. There are many protocols available for the successful communication. Sink trail and sink trail-s are the two energy efficient proactive data reporting protocols for mobile sink based on data collection with low complexity and reduced control overhead. Two unique aspects distinguish our approach from previous one. One is to dynamically adapt to various terrestrial changes, we allow sufficient flexibility in the movement of mobile sink. Other is that Sink trail establishes a logical coordinate system for routing and forwarding data packets which makes it suitable for various application scenarios without requirements of GPS devices. Minimizing energy consumption is a fundamental requirement when deploying WSN. Various topology control aim to conserve energy by turning off unnecessary sensors while simultaneously preserving a constant level of routing fidelity.In the proposed system we systematically analyze the several impacts of design factors. Also the system provides solution over mobility problems in wireless sensor network with energy saving methodology using aggregation technique.

Keywords- data aggregation, energy conservation, mobile sink, sensor network, WSN.

I. INTRODUCTION

A wireless sensor network consists of hundreds of sensor nodes, each equipped with the ability to sense the immediate environment, to communicate with nearby nodes through one to-all broadcasts and to perform local computations based on information gathered from the surroundings. Once a wireless sensor network has been deployed, network maintenance becomes difficult, since such networks are typically located in environments in which regular human intervention is either impossible or undesirable. In most cases the sensors are battery constrained which makes the problem of energy-efficiency of paramount importance. The nodes in the network are battery operated, and hence, they have a limited service life since it is generally impossible to recharge the batteries once the sensors have been deployed.
Accordingly, maximizing the lifetime of the network by improving the energy consumption of its nodes is a fundamental concern when designing and maintaining wireless sensor networks. Rather than reporting data through long, error prone, and multi hop routes to a static sink using tree or cluster network structure, allowing sink mobility which is more promising for energy efficient data gathering in the recent research on data collection [3].Resulting in shorter data transmission paths and reduced energy consumption, mobile sinks, such as animal or vehicles equipped with radio devices are sent into a field and communication directly with sensor nodes.

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Many research efforts have been focused on studying or scheduling movement patterns of a mobile sink to visit some special places in a deployed area, to minimize data gathering time, in order to get better benefit from the sinks mobility. To achieve efficient data collection via controlled sink mobility determining an optimal moving trajectory for a mobile sink is itself an NP hard problem and may not be able to adapt to constrained access areas and challenging field situation although several mobile elements scheduling protocols have been proposed.
The problem can be resolved by transmitting data via the shortest route to the mobile sink's future locations. Hence if sensors can predict the mobile sink's movement, the energy consumption would be highly reduced and data packets handoff would be smoother. A proactive data reporting protocol that is self adaptive to various application scenarios and its improved version, Sink Trail S with further control message suppression is proposed. Mobile sinks move continuously in the field in relatively low speed and gather data on the fly in SinkTrail. In existing data gathering protocols, control messages are broadcasted at certain points.
A problem of movement prediction for data gathering with mobile sinks solves the SinkTrail. This is surely a feasible technique for data transfer; it creates a bottleneck in the network. The nodes near the base station transmit the data from nodes that are farther away. This causes a non-uniform reduction of network resources and the nodes near the base station are the first to run out of batteries. If these nodes die, then whole the network is disconnected for all practical purposes. Periodically replacing the battery of the nodes for the large scale deployments is infeasible. Therefore we are proposed new system with energy efficient technique. Our protocol having very low complexity and reduce extra overhead of sensor network. Proposed system is useful for large scale multi hop wireless network with better mobility.
The main contribution of this paper is that we use data aggregation which reduces energy consumption by removing redundancy. Finally proposed system provides solution over mobility problems in wireless sensor network with energy saving methodology. Aggregation technique improves the lifetime of sensor network. Such protocols used to combine and summarize data packets of several sensor nodes to reduce the amount of data transmission. The data in wireless sensor networks is organized in an efficient manner using data aggregation and data dissemination protocols. Using additional sensor nodes in the network reduce the resource constraints but increase the rate of data redundancy. This limitation is overcome by the data aggregation technique in sensor networks. Data aggregation use cluster head node to collect, aggregate and forward the data to the base station.

II. RELATED WORK

In this paper we explore the mobility of a mobile sink in a wireless sensor network (WSN) to prolong the network's lifetime. As the mechanical movement of mobile sink is driven by petrol as well as electricity, the total travel distance of the mobile sink should be restricted. To minimize the loss of data during the transition of the mobile sink from its current location to its next, its moving distance must be bounded. The distance constrained mobile sink problem in a WSN is to find an optimal sojourn tour for the mobile sink such that the sum of sojourn times in the tour is maximized, accordingly the above described constraints. In this paper they developed the problem as a mixed integer linear programming (MILP). Finally conducted extensive experiments by simulations to evaluate the performance of the algorithm in terms of network lifetime. The experimental results logically proved that the solution delivered by heuristic is nearly optimal which is comparable with the one by solving the MILP formulation but with much shorter running time [1].

In WSN, the sensor nodes have a limited transmission range, their processing and storage capabilities also their energy resources are limited. It is then used as the starting point for a global topology construction process. In constructing the topology, neighboring nodes to the initial node are activated based on their ability to satisfy the Energy efficiency is a key concern and challenging research issue during the design of routing algorithms for wireless sensor networks (WSNs). They proposed a mobile-sink routing algorithm. By studying the influence of different mobile sink node number on energy consumption and network lifetime, the appropriate mobile sink node number has been elected. Then sojourn positions are chosen from park locations determined by the distribution of boundary neighbor nodes and their transmission range. To improve the energy utilization of each sensor node and network functioning, mobility technology has been largely concerned. Sink mobility technology has attracted much research interest in recent years as the implementation of mobile sink node is relatively easier than normal nodes. [4]

In paper [3], they presented the SinkTrail and its improved version, two low-complexity, proactive data reporting protocols for energy-efficient data gathering. It uses logical coordinates to deduce distances, and establishes data reporting routes by greedily selecting the shortest path to the destination reference. In addition, it is capable of tracking multiple mobile sinks simultaneously through multiple logical coordinate spaces. It holds desired features of geographical routing without requiring GPS devices or extra landmarks installed. It is capable of adapting to various sensor field shapes and different moving patterns of mobile sinks. They systematically analyzed energy consumptions of mobile sink and validated analysis through extensive simulations. The results demonstrated that Sink Trail finds short data reporting routes and effectively reduces energy consumption. [3]

Due to resource restricted sensor nodes, it is of prime importance to minimize the amount of data transmission so that the sensor's average lifetime and the overall bandwidth utilization are improved. Data aggregation is the process of collecting and combining sensor data in order to reduce the amount of data transmission in the network. This paper investigated the relationship between security and data aggregation process in wireless sensor networks. An example data aggregation scheme is presented in Fig. where a group of sensor nodes collect information from a target region. When the base station sends requesting information to the network, one of the sensor nodes, called data aggregator, gather the information from its neighboring nodes, aggregates them and sends the aggregated data to the base station over a multi-hop path, instead of sending each sensor node's data to base station. [5]

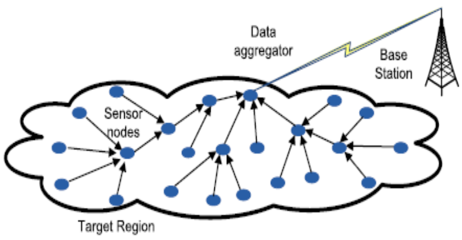

Figure 1. Data Aggregation for WSN

To optimize the energy usage and eliminate unnecessary control messages in the network, we propose new technique as an improvement to the original SinkTrail and SinkTrail-S. Technique is mainly based on the following two observations. First, for the large-scale sensor network, the sensor nodes that are at a long distance from a mobile sink may not be affected by a single movement of the mobile sink. Consider the sensor network shown in Fig 2,

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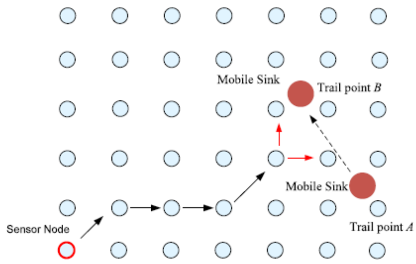

Figure 2. Example showing two mobile sinks

It shows an example of two mobile sinks. Two trail references, colored as black and red, exist in the same sensor node. Hence multiple logical coordinate spaces are constructed simultaneously. When a trail message comes, a sensor node checks the mobile sink's ID in the message to determine if it is necessary to create a new trail reference. It is well known that geographic routing and virtual coordinate-based routing ensure loop-free routes so does SinkTrail [3].

III. PERFORMANCE EVALUATION

There are many mobile sink oriented approaches for collection of data in WSN, e.g., Directed Diffusion, TTDD [6], and GRAB [6]. These protocols, as in SinkTrail, do not have any control on a mobile sink's movement and they don't require any special setup phase. Although SODD approaches may apply different aggregation functions for better performance, resemble strategies can be applied to SinkTrail as well. We are proposed a technique that minimizes the consumed energy in the network. So we used some mobile sink as a data aggregator who sends the data to the base station.

3.1. Theoretical Analysis

We consider a network IN that consists of N sensor nodes and M mobile sinks. All the sensor nodes are nothing but the data sources. We assumed that sensor nodes are deployed in a grid topology. Our analysis can be extended to uniformly distributed topology. Hence the edge of the grid is roughly $\sqrt{N}$. Let the energy cost for transmitting or receiving a control message is γ and the cost for a data packet is σ. As $\sigma >> \gamma$ compared to trail messages, data packets are larger in terms of data size, and is proportional to the energy cost for transmission.
In SinkTrail, energy consumption mainly has data packet forwarding cost, $E_{data,}$ routing table maintenance cost, $E_{routing}$, and trail message transmission cost, E_{trail}.
There are two factors that affect the energy cost of data forwarding: number of data packets and the average route length. The number of data packets is determined by the number of data sources in a network, N. The average route length may vary depending on the locations a mobile sink has travelled. We calculate an upper bound of the average route length by knowing the situation that a mobile sink appears randomly in an area. So we can find $\frac{N}{2}$ pairs of sensor nodes that any one pair of nodes' distances to the mobile sink added up to at most $\sqrt{2}$N. Thus, the average route length should be upper bounded by $\frac{N}{2}.\sqrt{2N} / N$. We use a coefficient c, where $0 < c \leq 0.5$ to describe the average route length. Hence, we have

$$E_{data} = \beta \cdot c \cdot \sqrt{2N} \cdot N.$$

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Increased number of mobile sink will only decrease the total energy cost for data reporting. According to SinkTrail protocol, the energy consumption for trail message transmission is given by

$$E_{trail} = \alpha \cdot M \cdot N \cdot D_{\pi}.$$

In SinkTrail if there are multiple mobile sinks, the energy consumption increases since each node keeps a different trail reference for each mobile sink. Because of the broadcast nature of wireless media, this type of control message only needs to be transmitted once by each sensor node. Therefore, the energy cost for routing information maintenance is summarized by

$$E_{routing} = \alpha \cdot N \cdot M.$$

The overall energy consumption of SinkTrail protocol is

$$E_{ST} = \beta \cdot c \cdot \sqrt{2N} \cdot N + \alpha \cdot M \cdot N \cdot D_{\pi} + \alpha \cdot N \cdot M.$$

3.2. Impact of number of mobile sinks

Our wide interest is in finding out how the number of mobile sinks affects the overall system performance. In such case several logical coordinate spaces are constructed concurrently and data packets are forwarded to the destination reference through the shortest path. It is natural that on increasing the number of mobile sinks reduces the average route length and thus reduces the total energy consumption shown in fig (a), (b). But more mobile sinks cause heavier burdens for trail message broadcasting and routing maintenance. To acquire visualized results, we simulate the multiple mobile sinks scenario. The number of mobile sinks used is up to three and they are injected into the network at the same time shown in fig (a) and (b) respectively. All the mobile sinks moved randomly with different routes, broadcasted at the same frequency. The trends shown in the figures confirm our analysis. The average route length is reduced by 46 and 52.3 percent for two and three sinks. According to this, we conclude that adding multiple sinks is more suitable for applications with tight data gathering.

3.3. Impact of Moving Patterns of a Mobile Sink

Directional change in a mobile sink's movement is unavoidable due to obstacles. So first we examine how the moving pattern of a mobile sink affects the energy consumption for data collection. We trace the moving trail of a mobile sink on a plain and measure the directional change at each trail point. The performance of SinkTrail is inspected in terms of average route length and overall energy consumption. Three moving patterns given as circular, random, and linear moves can be considered. The results are described in Fig. (c) From the figure, we come to the conclusion that, both the average route length and energy consumption increase as the network size grows. Linear movement incurs the least energy consumption and the shortest average route length. In the circular movement case, the mobile sink changes its direction smoothly and regularly, causing performance close to the linear movement case. It is more difficult to track and predict the behaviour of a randomly moving mobile sink. Hence, SinkTail's overall performance may suffer badly when the directional change is radical.

IV. RESULTS

We have made an assumption for the proposed system which results to preserve the same information contained at each node by reducing number of trail points. It minimizes the average route length. The comparison result is shown fig. (c).

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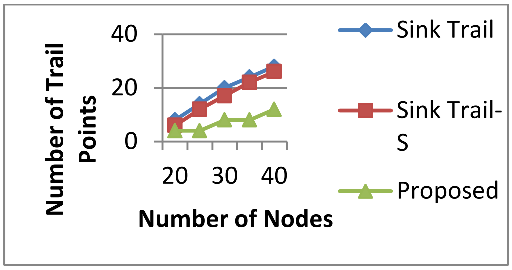
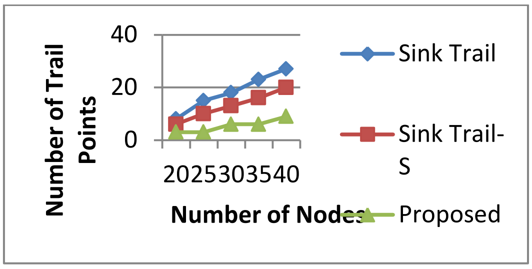
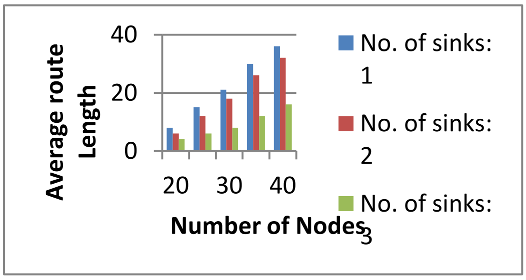




(a) Chart for Linear Movement for 2 mobile sinks *(b) Chart for Linear Movement for 3 mobile sink*



(b) Average Route Length for proposed methods

V. CONCLUSION

We presented the SinkTrail and its improved version, low-complexity, proactive data reporting protocols for energy-efficient data gathering. In addition, it is capable of tracking multiple mobile sink simultaneously through multiple logical coordinate spaces. SinkTrail is capable for adapting to various sensor field shapes and different moving patterns of mobile sinks.

We systematically analyzed energy consumptions of SinkTrail and other representative approaches. The results demonstrate that SinkTrail finds short data reporting routes and effectively reduces energy consumption. The impact of various design parameters used in SinkTrail and SinkTrail-S are investigated to provide guidance for implementation.

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