



MOBILITY BASED ENERGY UTILIZATION IN WIRELESS SENSOR NETWORK

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Abstract: Energy efficient and mobility information is a key problem in wireless sensor networks. Save more energy in network processing such as mobility is a widely used technique. The large- scale deployment of wireless sensor networks and the need for mobility controlling and also necessitate to deploying the gateways among the network, for the purpose of balancing the load and prolonging the lifetime. In this paper, a new approximation algorithm named as Mobile Sink Energy Algorithm (MSEA) to propose approach the mobility control of sensor nodes. According to the recent study, it has been proved that the sink mobility along a constrained path, can improve energy effectiveness in wireless sensor networks. The performance of proposed system also has been discussed.

Keywords: Sensor Nodes, Mobility , Approximation Algorithm.

I. Introduction

Wireless sensor networks (WSNs) consist of hundreds to thousands of battery-powered tiny sensors that are endowed with a multitude of sensing modalities including environmental monitoring and security surveillance purposes [1]. Although there have been significant progress in sensor fabrications including processing design and computing advance of battery technology still lag behind, making energy resource the fundamental constraint. To maximize the network lifetime, energy conservation is of paramount importance in WSNs. Most existing studies assume that the sink (the base station) in WSNs is static, which is a gateway between the sensor network and users and all sensing data from the sensors are relayed to it through multi-hop relays. As a result, the sensors near to the sink become the bottlenecks of energy consumption since they have to relay the data for other remote sensors. Once they deplete their energy, the sink will be disconnected from the rest of the network while the rest of sensors are still fully operational with sufficient residual energy [1]. The fundamental goal of a sensor network is to produce, over an extended period of time, globally meaningful information from raw local data obtained by individual sensor nodes [2]. Importantly, this goal must be achieved in the context of prolonging as much as possible the useful lifetime of the network and ensuring that the network remains highly available and continues to provide accurate information in the face of security attacks and hardware failure [2]. The unique number of sensor nodes in a sensor network combined with the unique characteristics of their operating environment (anonymity of personage sensors, limited power resources and a possibly hostile environment), pose unique challenges to the designers of protocols. For one thing, the limited power budget at the individual sensor node level mandates the design of ultra-light weight data gathering, fusion, and communication protocols [2].

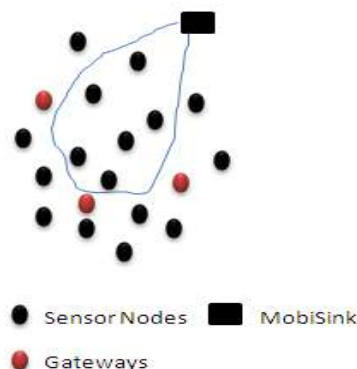


Fig. 1. Sensor Network Model

An important guideline in this direction is to perform as much local data processing at the sensor level as achievable, avoiding the transmission of raw data through the sensor network. Recent advances in hardware technology are making it plain that the biggest challenge facing the sensor network community is the development of ultra-lightweight communication protocols ranging from guidance, to identity organization, to

network protection, to security, to data gathering and fusion, to routing, along with many others. Most research works for wireless sensor networks often assume that the data collected by sensors are transmitted to one or several sink nodes in some specific location in the WSNs. In most of previous studies, the static sink was widely adopted to conduct data collection in WSNs [5]. Due to the multihop data transmission style, however, severely unbalanced energy consumption is caused with the node-to-sink traffic flow [5]. Sensor nodes close to the sink node have to carry much more traffic overhead compared with distant sensor nodes [5]. Since sensor nodes are highly restricted to the limited battery power furnish, such unbalanced energy consumption results in the quick power depletion on part of the network, and dramatically shortens the lifetime of the network as a whole [5]. To reduce the negative impact, recent research works introduce the mobile sink as a potential solution to the data collection problem. Each mobile node is assumed to have a portable set with transmission, reception, and processing capability. In addition, each has a low-power global positioning system (GPS) receiver on board, which provides position in order within at least 5 m of accuracy [6]. The recent low-power implementation of a GPS receiver makes its presence a viable option in minimum energy network design.

The fundamental operation in such applications is datagathering, i.e., collecting sensing data from the sensor nodes and conveying it to a base station for processing. In this process, data aggregation can be used to fuse data from different sensors to eliminate redundant transmissions. The critical issue in data gathering is conserving sensor energy and maximizing sensor lifetime. For example, in a sensor network for seismic monitoring or radiation level control in a nuclear plant, the lifetime of each sensor significantly impacts the quality of surveillance.

The main contributions of this paper are as follows: first consider the deployment of wireless sensor networks with a mobile sink for large-scale monitoring, by proposing a heterogeneous architecture, where the mobile sink travels along a predetermined trajectory for data collection. Under this paradigm of data gathering, formulate a novel, the Mobile Sink Energy Clustering algorithm problem, for which we devise approximation algorithms with guaranteed approximation ratios. Finally, we evaluate the performance of the proposed algorithms through experimental simulation. The proposed algorithms are the first approximation algorithms for this fundamental problem, and our techniques may be applicable to other constrained optimization problems beyond wireless sensor networks.

The rest of the paper is organized as follows. Section II discusses the related work. Section III introduces the system model and defines the problem. Section IV formulates the problem with mobility and data aggregation. Section V evaluates with the performance measures. Section VI in that performance of proposed algorithm compute through the experimental simulations. Section VII concludes the paper.

II. Related Work

Extensive studies on optimizing critical network resources in wireless sensor networks with mobile sinks, such as maximizing the network lifetime and/or minimizing the number of mobile sinks employed, have been conducted in the past few years. For example, the studies in [3], [18], [19], [20], [25], and [29] focus on the network lifetime maximization, while other studies focus on minimizing the travel distance of mobile sinks [21]. Very few take both of the aspects into consideration [16], [17]. Most of these studies are based on homogeneous sensor networks that consist only of one type of sensor. Although the homogeneous architecture works very well for small to medium-size networks, it may not be appropriate for large-scale monitoring due to poor scalability, long data delivery delay, and so on. With the increase of network size, the average length of routing paths from remote sensors to the mobile sink(s) (in terms of the number of hops) is longer, and the chance of link failures increases, leading to a much longer data delivery delay. When deploying wireless sensor networks for large-scale monitoring to mitigate the drawbacks of homogeneous architectures, heterogeneous sensor networks with mobile sinks have been introduced and studied [7], [13], [26]. In [13] and [26], it is assumed that the speed of each mobile sink is controllable. This implies that the amount of data collected by each mobile sink from a gate way is controllable through adjusting the speed of the mobile sink. In [13], Xing et al. consider the network lifetime maximization problem by devising an approximation algorithm for finding an optimal trajectory for the mobile sink, subject to the trajectory length constraint. The approximate solution obtained is based on a tree routing structure with the assumption that the forwarding load of each relay node is identical, independent of the number of descendants the relay node has. In contrast to this, by assuming that the mobile sink travels along a predetermined trajectory with constant speed,

LEACH is one of the most famous hierarchical routing protocols for wireless sensor networks, which can guarantee network scalability and prolong network lifetime up to 8-fold than other ordinary routing protocols. The energy can be well balanced among sensors takes turn to become the cluster head at different rounds. However 5% of cluster head nodes are randomly chosen and the cluster heads use direct transmission to send their data to the sink node.

First proposed the basic idea of mobile sink for wireless sensor networks where the authors call them. The mules use random walk to pick up data in their close range and then drop off the data to some access points. The energy consumption for sensors can be largely abridged the transmission range is short.

III. System Model

Suppose a stationary sensor network that consists of a large number of low-cost sensor nodes for sensing and a few powerful, large-storage gateway nodes has been deployed for the purpose of monitoring a region of interest. The sensing data generated by the sensors will be immediately relayed to their nearby gateways. The nodes are used to store the sensing data temporarily, perform data aggregation if needed, and eventually transmit the stored data to mobile sinks when the mobile sinks are within their transmission range. It is assumed that there are mobile sinks that travel along predetermined trajectories (tours) to collect data from the gateways on the trajectories. We further assume that the speed at which a mobile sink traverses along its trajectory is fixed and does not vary from tour to tour. The data collected by the mobile sinks is finally uploaded to a mainframe computer for further processing. The advantage of this heterogeneous wireless sensor network architecture is its capability to deliver a desired tradeoff between the energy consumption of sensors and the data delivery latency, making it appropriate for large-scale monitoring. For simplicity, in the remainder of this paper, assume that there is only one mobile sink. However, our discussion and the presented approximation algorithms can be adapted to networks with mobile sinks.

A. Network Design

Considering till now functions for involving the usage are more than one variable. For example, the area of coverage is a function of two variables. If G be a function of two variables N and S . Let s assume the functional relation as

$$G = (N, S) \quad (1)$$

Here N alone or S alone or both N and S simultaneously may be varied and in each case a change in the value of G will be different in each of these three cases. Since N and S are independent, N may be supposed to vary, when S remains constant.

Where, N - Node is varies, S - Mobile Sink. G - Approximate Rate

Just wrote relation with Function of,

$$G = f(N, S) \quad (2)$$

Let assign the function of approximate rate with n number of range

$$G_n = f(N, S) \quad (3)$$

∂N and ∂S are said to be differentiate in N and S if they be any two small quantities such that the ratio of ∂S and ∂N is the derivative,

$$G_n = \frac{\partial G}{\partial N} \cdot \frac{dN}{dt} + \frac{\partial G}{\partial S} \cdot \frac{dS}{dt} \quad (4)$$

$$\Delta G = \left(\frac{\partial G}{\partial N} + \epsilon \right) \Delta N + \left(\frac{\partial G}{\partial S} + \delta \right) \Delta S \quad (5)$$

Where, ϵ and δ are very small variables. $\epsilon = \Delta N, \delta = \Delta S$

Here Formulate the ΔG ,

$$\Delta G = \left(\frac{\partial G}{\partial N} \right) \Delta N + \left(\frac{\partial G}{\partial S} \right) \Delta S \quad (6)$$

First, it will describe the general assumptions about the WSN models. Let the set of sensor nodes be denoted by N . For experimental convenience, suppose they are uniformly randomly deployed into a circular area with radius R . Let the center of the disk be the origin. Each node i is assumed to generate data at a constant rate of d_i during its life span and the initial energy of i is denoted by E_i . Furthermore, the nodes have the ability of adjusting their transmission power level to match the transmission distance. Similar to [14], the energy required per unit of time to transmit data at the rate of x_{ij} from node i to j can be determined as follows.

$$E_{ij}^t = C_{ij}^t \cdot x_{ij} \quad (7)$$

Where C_{ij}^t is the required energy for transmitting one unit of data from node i to j and it can be modeled as follows.

$$C_{ij}^t = \alpha + \beta \cdot d(i, j)^e \quad (8)$$

Where $d(i, j)$ is the Euclidean distance between node i and j , α and β are nonnegative constants, and e is the path loss exponent. Typically, e is in the range of 2 to 6, depending on the environment. Here, the energy cost per unit of data does not depend on the link rate, and this is valid for the low rate regime. Hence, need to assume that the traffic rate x_{ij} is sufficiently small compared to the capacity of the wireless link. The energy consumed at node i per unit of time for receiving data from node k is given by

$$E_{ki}^r = \gamma \cdot x_{ki} \quad (9)$$

Where γ is a given constant, Hence the total energy consumption per unit at node i is

$$\sum_{j \in N} E_{ij}^t + \sum_{k \in N} E_{ki}^r = \sum_{j \in N} C_{ij}^t \cdot x_{ij} + \sum_{k \in N} \gamma \cdot x_{ki} \quad (10)$$

Assume that each sensor node has the same transmission range. We define the neighbors of node i as $N(i) = \{ j \in N \mid d(i, j) \leq \bar{d} \}$, when the transmission range is $\bar{d}$.

IV. Mobility and Data Aggregation

Compared with the traditional static data collection setting, data collection performed by the mobile sink is more complicated in the following two aspects: mobile sink trajectory planning and network load balancing [5].

According to the typical moving velocity of a mobile sink is around 0.1~2.0 m/s. It will lead to an extremely long data collection delay if the mobile sink visits a large portion of the network, which is normally unable to meet the delay requirement of many practical applications [5]. As a matter of fact, the small moving velocity is the fundamental design restriction, since increasing the moving speed of the mobile sink will lead to a significantly increased manufacturing cost and energy consumption.

Mobile sink and relay nodes can achieve balanced energy consumption by relieving heavily loaded areas or paths in a way dual to the optimization deployment. However, additional mechanisms need to be devised to support node mobility [13].

A. Static Sink Model

In the Static Sink Model (SSM), the sink is located at the origin and remains stationary during the operation of the WSN. Data originated from the sensor nodes flow into the sink in a multi-hop fashion. As soon as the data becomes available at a node, it gets transmitted toward the sink. Typically, the rate at which each sensor node i harvests data from the outside world is a constant. It denotes it by d_i . The problem of maximizing the lifetime in this model is formulated as follows.

$$\text{Max} \quad \text{s.t.} \sum_{j \in N(i)} x_{ij} - \sum_{k: i \in N(k)} x_{ki} = d_i, \quad j, k \in N \quad (11)$$

$$\left(\sum_{j \in N(i)} C_{ij}^t \cdot x_{ij} + \sum_{k: i \in N(k)} x_{ki} \cdot \gamma \right) \cdot T \leq E_i \quad (12)$$

The constraint (11) is the “flow conservation constraint”, which states that, at a node i , the sum of all outgoing flows is equal to the sum of all incoming flows plus flows generated at node i itself, or d_i . The inequality (12) is the energy constraint and it means that the total energy consumed by a node during the lifetime (T) cannot exceed the initial energy of the node. With this formulation, the routing is dynamic and allows multipath communications. There is no assumption on fixed path routing, such as the shortest path routing. The above optimization problem can be easily converted into a linear programming (LP) problem.

B. Mobile Sink Model

In the mobile sink model (MSM), assume that the sink can move around within the sensor field and stop at certain locations to gather the data from the sensor nodes. It ignores the traveling time of the sink between locations. Let L be the set of possible locations where the sink can stop. The sink does not necessarily stop at (i.e., stays for a positive duration) all locations in L in the interest of maximizing the network lifetime [1], [9]. In this model, the order of visit to the stops has no effect on the network lifetime and can be arbitrary. The sink node time at a location $l \in L$ is denoted by z_l ; it is the time that the sink spends at l to collect data from the sensor nodes. The overall network lifetime $T = \sum_{l \in L} z_l$. To find the optimal network lifetime, in this need to consider the routing of the traffic as well as the duration of stay by the sink at each stop [9], [2], [1], [7]. Let $x(l)_{ij}$ be the flow rate from node i to j while the sink is at stop l . Let $\tilde{N} = N \setminus L$. The lifetime maximization problem can be formulated as follows.

$$\text{Max } T = z_1 + z_2 + z_3 + \dots + z_n \quad (13)$$

$$\text{s.t.} \sum_{j \in N(i)} x_{ij}^{(l)} - \sum_{k: i \in N(k)} x_{ki}^{(l)} = d_i, \quad k \in N, \quad j \in \tilde{N}, \quad l \in L \quad (14)$$

$$\sum_{l=1}^{|L|} z_l \left(\sum_{j \in N(i)} C_{ij}^{(l)} \cdot x_{ij}^{(l)} + \sum_{k: i \in N(k)} x_{ki}^{(l)} \cdot \gamma \right) \leq E_i \quad (15)$$

The energy required for transmitting one unit of data when the sink is at L can be expressed as,

$$C_{ij}^{(l)} = \begin{cases} C_{ij}^t & \\ \infty & \text{if } j \in L \\ C_{il}^t & \end{cases} \quad (16)$$

Where C_{ij}^t is the same as in the SSM.

V. Performance Measures

In exploring the gains and tradeoff involved in data collection approach, it's need to specify performance measure of interest four are examined in some details in this paper,

Energy Saving: By aggregating the data coming from the sensor nodes, the number of transmission is reduced, translating to saving in energy.

Mobile sink: The sink can move to several locations to collect data. When the sink is at each location, all sensors participate in the communication, sending and relaying traffic in to the sink.

Node Mobility: Node mobility can affect the performance of topology control algorithm. In the presence of node mobility topology control algorithm require frequent message exchanges to continuously update topology changes. This could entail significant message overheads and increases energy consumption. A simple topology control algorithm that exchanges few messages with neighbors requires little maintenance in the presence of mobility.

VI. Simulation Results

There are 100 sensor nodes deployed in a (200,200) to (300, 300) networks with mobile sink nodes placed either inside or along the periphery of the area. The maximum transmission range is assumed to be 100 meters to cover the data travel length.

The two algorithms are compared with other popular algorithm like LEACH in the terms of energy consumption and network lifetime. The total energy consumption in the unit of joule unit it will measure the MSCA algorithm under different sensor networks. The whole is divided into several clusters and the mobile sink nodes are randomly deployed in the networks. There are 200 nodes randomly deployed in a R= 500 m circular sensor networks. The mobile sink node can either move with different direction or move along the periphery of each circle with different direction. The total energy consumption decreases as the sensor nodes mobility speed decreases as the sensor nodes mobility speed decreases.

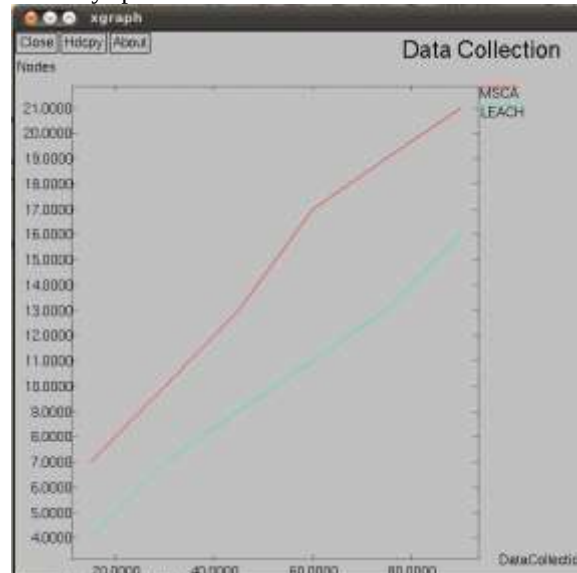


Fig. 2. Data Collection Vs. Node

If mobility speed control mobile sink are deployed the total energy consumption became small enough that introduction of mobile sink will hardly make any reduction of energy consumption.



Fig. 3. No of Node Vs. Speed of mobility

Thus it is concluded that mobile sink are actually enough regarding R= 200m and R= 400m networks. Finally the influence of mobile sink nodes on network lifetime is studied under R=200m in sensor networks.

It can be seen that the MSCA has much better performance than LEACH in terms of number of nodes alive and average of residual energy. If network lifetime is defined as the time when the first nodes dies out of energy, the lifetime of MSCA is two times (1500 rounds) longer than LEACH (600 rounds), the average residual energy of LEACH also decreases more sharply than MSCA, which means that the LEACH consumes more average energy than MSCA during data collection process. One way to quantify the effect of aggregation delay is to examine the difference Max (d_i) and Min (d_j). Similar figures obtain for the random source model as well. The upper curve in all these representative of the latency delay in DC Scheme with non-trivial aggregation function and the lower curve is representative of the latency delay in AC Schemes.

VII. Conclusion

In this paper the deployment of wireless sensor networks with mobile sinks for large –scale monitoring. The proposed an approximation algorithm named as MSCA (Mobile Sink Energy Algorithm) to approach the mobility control of sensor nodes. Mobile Sink Clustering algorithm methods consists of sensor nodes and mobile sink , where the mobile sink travel along predetermined trajectories to collect data from the gateways. The experimental results demonstrate that the inputs are improving the energy controlling and show the aggregation ratio. To validate the proposed framework, conducted extensive experiments and found the proposed framework to the models. The lifetime gain of the proposed model is significant when compared to other models.

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