



Sink node redeployment technique for upgrading Network Lifespan in Wireless sensor networks

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Abstract: Sensor nodes in Wireless Sensor Networks (WSNs) are normally battery-powered and remain stationary after initial deployment. Sensor nodes direct the sensed data back to sink via multihop links. While reporting tasks, sensor nodes nearby the sink will consume more battery power than other sensor nodes for forwarding their own sensed data and others data; subsequently battery power of these nodes will drain out early and cut down the network lifespan. Sensor nodes will no longer provide sensing and data processing, If it runs out of energy. Due to the routing path re-allocation and failure of sensing and reporting events in the environment, this can lead to a huge loss in the network. Hence energy conservation has been getting increased consideration in WSN research workings. The concept of mobile sink has been recently introduced for WSNs in order to improve the network lifespan and overall performance of WSNs as it moves the burden of energy consumption from the sensor nodes to sink nodes, which are usually considered to have unconstrained energy source and greater computational power. In this survey, we present various moving strategies, which are mainly focuses on selecting appropriate position for relocating sink based on the residual energy of the sensor nodes in the wireless sensor networks. This survey provides a thorough analysis of the metrics supported by each technique during sink relocation and presents the limitations of these techniques.

Keywords: Energy efficiency, mobile sink, sink relocation, wireless sensor networks.

I. INTRODUCTION

A Wireless Sensor Network (WSN) is a collection of sensor nodes organized in a surveillance area to extract information; where each sensor node has sensing, handling, communication, and movement abilities [1]. Each sensor node is capable of sensing events, implement processing on the detected data, interconnect with neighbor nodes, and change location when it is required. Sensor nodes measure various parameters of the environment and transmit data collected to one or more sinks, using hop-by-hop communication. Because sensor nodes are battery-powered Devices, charging batteries for sensor nodes is often difficult. Once a sink receives detected data, it processes and forwards it to the handlers. In general, after the initial positioning of sensors, they become unattended and also it is difficult to recharge them. After some degree of time they will reduce their energy and become nonfunctional. A sensor network is generally expected to be functional for more than a few months or one year without recharging [8, 16]. Optimizing energy utilization to extend network lifetime is a main issue in WSNs.

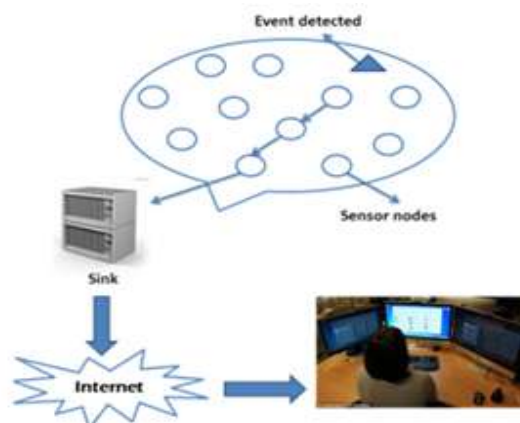


Fig 1. An operating scheme of a WSN

Consider a static sensor network deployed for periodic data reporting. While reporting tasks (fig 1), If sensors are uniformly deployed, then sensor nodes nearby the sink will consume more battery power than other sensor nodes for forwarding data on behalf of other sensors that are farther away from the sink and its own sensed data back to the sink; subsequently battery power of these nodes will drain out early and cut down the network lifespan [9, 11]. This uneven energy utilization will cause energy holes in the monitored area, resulting in network partitioning. In this case, the sensed data cannot be efficiently delivered to the sink node. The life span of the sensors near to the sink becomes the bottleneck for the network lifetime [9, 11]. Node mobility is one way to enlarge the network life span in mobile WSNs such that to balance the energy utilization.

II. MOTIVATION

A number of recent approaches, focus on changing the burden from the sensors to the sink node [5][2][6] for reducing energy utilization. In contrast to a traditional system model where the sink nodes remain stationary somewhere in the network and receive data from sensors, we can permit the sink node to be movable and navigate in the network vicinity to dynamically look for the sensors which are sending data and move closer to them. The general idea for this sink mobility approach is to shift the burden of data processing and energy utilization from the sensors to the sink in order to enlarge the network life span as sink nodes are generally much more productive in computational power and energy supply. Also, as transmission range is a significant parameter in determining energy consumption in data communication and relocation of sink nodes closer to active sensors result in reduced transmission distances, and less intermediate nodes to forward data. Therefore, the energy utilization tends to be more uniformly distributed in the network and the “Hotspot” problem is alleviated so that the performance of network can be improved in terms of life span and quality of service.

The key issues of maximum network life span with a sink mobility approach incorporate how to control the movement of the sink to achieve most efficient data gathering both to guarantee the quality of service and to reduce energy consumption. For example, based on the system requirements, the mobility approaches can decide

- i) When to move the sink node to respond, if any abnormal event detected or any changes in the network
- ii) The original position of a sink node and the routing paths back to the sink
- iii) The trajectory of the mobile sink node.

III. RELATED WORK

In general, WSNs contains two types of nodes: sensor nodes and sink (or base station) nodes. A sensor node is a small device that has limited battery power, sensing and computation or processing capabilities [7], where as a sink node has more resources in terms of computation, battery power, processing capabilities, and mobility. There are two different types of algorithm for sink mobility such as (1) algorithms where sinks are moving on predetermined paths and (2) algorithms where sinks move autonomously. Sometimes sensor nodes are grouped into clusters using various techniques and one of the sensors is selected as cluster head based on various criteria. A cluster head will responsible for managing the sensors in its cluster, collects information from them, and forwards data to/from the sink [12].

Sun et al. [15] have proposed two autonomous sink movement schemes, the One-step moving scheme and the Multi-step moving scheme. These strategies firstly compute a position for the destination of moving, which can be determined by the total residual battery energy of the sensor nodes. When a moving destination is determined, the One-step moving scheme will drive the sink to directly move to the destination in spite of the distance. For the Multi-step moving strategy, iteratively the sink will relocate its position from one intermediate moving destination to the other moving destination, and the distance of each relocating step will be restricted to the transmission range of the sink node.

For each of the relocating schemes, the determination criteria for choosing an intermediate moving destination are as follows. At first, the sink collects the information about residual battery energy from each sensor node within the transmission range of the sink. Then, it select the sensor node in the direction heading to the moving destination and within the communication range of the sink, such that it has the maximum residual battery energy among the sensor nodes.

Guo, Jingxing (13) have proposed the routing scheme called Residual Energy Aware Routing (REAR) scheme which mainly concentrations on choosing appropriate routing paths back to the sink node, based on the residual battery energy of the sensor nodes. So, this scheme reads the residual battery energy of a sensor node and goals to shrink the practice of those sensors nodes with reasonably low residual battery energy and instead of choosing those sensor nodes with higher residual battery energy when computing routing paths for transmit data. Therefore, all sensors can live longer based on this routing management scheme to increase the life span of network as well as sensor node. The goal of this scheme is to evenly distribute the energy consumption among the sensor nodes and further enhance the network performance in terms of lifetime.

Bari and Jaekel [2] have proposed the algorithm called multi-sink heuristic algorithm is used to find the best way to move the sinks in order to improve the life span of large scale sensor networks. This approach is based on number of hops and consists in relocating periodically the sinks towards the distant nodes, which are also having high residual battery energy. By using this scheme, there is no need for the sensors to drain their energy

in sending additional information to the sink node about their energy level. Each sink knows its own location, others sinks locations and the locations of all the sensors. Therefore, from the number of hops to reach the nearest sink, it is probable to predict which sensors are distant and may have more residual battery energy. Deepinder Kaur, Kamaljit Kaur [10] have motivated on the Energy Consumption in WSN via Mobile Sink and Hierarchical Clustering. This is based on carrying mobile sinks to sensing field to save energy of cluster heads while directing data to mobile sinks instead of static sink on base station. In this research they will split the sensing field into two equivalent grid levels. These two grid areas are independent to each other for sensing of data and communication by sensor nodes. Mobile sinks have been positioned in these grid areas for saving energy by collecting data from cluster heads only. Based on the density of the clusters in particular grid area, number of mobile sinks will be placed. Cluster heads have been chosen on the basis of residual battery energy which must be better than threshold energy decided by average residual battery energy. Data moved from cluster heads to nearby mobile sink in associated with their grid area only.

IV. ANALYSIS OF SINK NODE REDEPLOYMENT TECHNIQUE

A. Energy aware sink relocation method

In EASR scheme, the sink relocation method has two components. The first component is to find whether to initiate the sink relocation by determining whether a sink relocation condition is met or not. The second component finds which direction sink is heading in and the relocation distance. For the relocation condition sink will periodically collect information about the residual battery energy of each sensor node in the wireless sensor network. Then maximum capacity path (MCP) routing protocol is used to identify the maximum capacity path with respect to each sensor nodes neighbor of the sink. For each maximum capacity path maximum capacity value is identified. If maximum capacity value falls below a threshold value, then Sink relocation will occur. The sink relocation method takes into account the residual battery energy of the sensor node and then relocates the sink to a position with a huge amount of residual battery energy compared to remaining sensor nodes. Sink relocation happens when the residual battery energy of the neighboring sensor node of the sink becomes low and sink will move to a new position which can rise the network lifespan.

B. Half-quadrant-based moving strategy (HUMS)

In HUMS strategy, the sink moves proactively in the direction of the node that has the maximum residual battery energy to balance energy consumption among all sensor nodes. To make moving assessments with HUMS, the energy mower needs each data packet reported by the sensors contain two collections of information in addition sensed data: one consists of the residual energy of the sensor node and the position of the sensor node that has the highest residual battery energy among the nodes practiced by the packet, and the other is composed of the residual battery energy and the position of the node that has the lowest residual battery energy among the nodes practiced by the packet. Sensor nodes on the transmission path of the reported data packet can update the information of either of the two collections according to the comparison results between their own residual battery energy and that recorded in the data packet. If their residual energy is greater than the record of the highest energy in the first collection, they will swap the position and energy information in the first collection with their own. Similarly, if their residual energy is lower than the record of the lowest energy then they will replace the information in the second collection.

C. One-step Moving Scheme

This scheme initially evaluate a position for the destination of moving, which can be found by the total residual battery energy of the sensor nodes in the network. When a moving destination is found, the One-step moving scheme will drive the sink to directly move to the destination regardless of the distance. Hence, the sink will move into the transmission range of the Moving Destination to force it to spend much energy on sending data for other nodes, which is advantageous to balance the energy consumption among all the sensor nodes.

D. Multi-step Moving Scheme

This scheme initially evaluate a position for the destination of moving, which can be found by the total residual battery energy of the sensor nodes in the network. When a moving destination is found, In the Multi-step moving scheme the sink will move its position iteratively from one intermediary moving destination to the other, and the distance of each moving step will be bounded to the transmission range of the sink. In the multi-step moving scheme, the sink decides its moving direction according to the Moving Destination node, the location and the energy information of its neighbor nodes within two hops. Therefore, the multi-step moving scheme does not require the data packets to carry the information of the nodes with the lowest residual energy.

E. Energy Aware Multi-Sink Relocation

The proposed mechanism uses a new scalable multi-sink heuristic algorithm (Hop) which regularly moves the sinks towards the distant nodes and may have more residual energy. Based on this, the proposed mechanism will adaptively adjust the transmission range of sensor nodes and the relocating scheme for the sink in accordance. The proposed method will adapt maximum capacity path (MCP) routing protocol is used to identify the maximum capacity path with respect to each sensor nodes neighbor of the sink. For each maximum capacity path maximum capacity value is identified. If maximum capacity value falls below a threshold value, then Sink

relocation will occur. This technique guide the sink when and where to move to. Therefore for the reduction of energy consumption of nodes, this approach trades data delivery latency.

V. NUMERICAL RESULTS

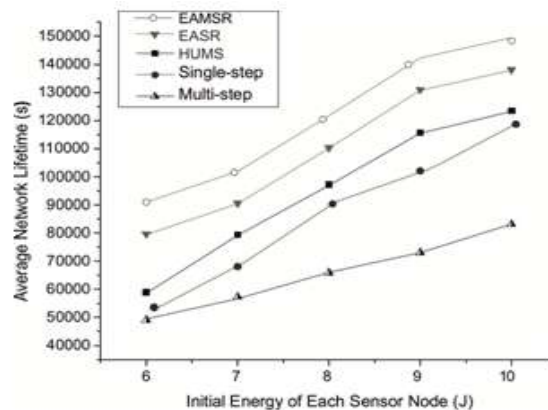


Fig. 2. The network lifetime performance with different initial energy for each sensor node (Nodes number 100)

Fig 2 shows the network lifetime performance of the five schemes with different initial battery energy for each sensor node. The results show that the EAMSR moving schemes can prolong the network lifetime remarkably. The EASR moving strategy performs better than HUMS strategy. The single-step moving scheme performs a little better than the multi-step moving scheme mainly because the former affects the middle nodes between the sink and the Moving Destination less than the latter.

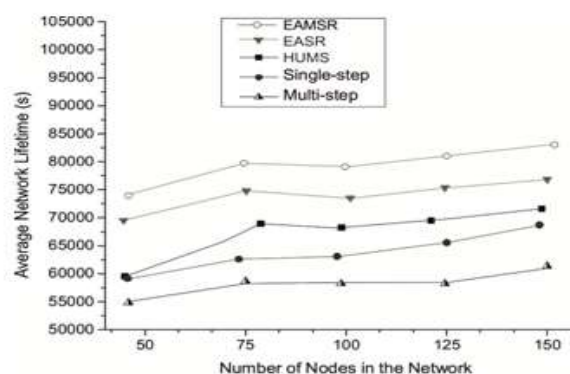


Fig. 3 The network lifetime performance with different node densities (Nodes number:100, initial energy:6.5 J.)

Fig 3 shows some results of the network lifetimes when the number of sensor nodes varies in our experiments. As shown in the figure the EAMSR moving strategy achieves more stable lifetime performance than other moving schemes (EASR, one-step moving scheme, multi-step moving scheme, HUMS). The results are shown in Figure 3, which indicate that the network lifetimes of all the schemes will decrease with an increase in node density. This is because the sensor nodes have to forward more data than before. Nevertheless, EAMSR moving schemes still performed better than the other schemes.

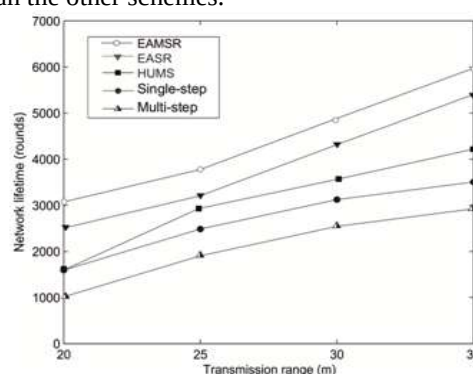


Fig. 4 Network lifetime comparisons with varying transmission range

Fig 4 the network lifetime increased as the transmission range increased for the EAMSR method and the other compared methods. Since a transmission range is setting to be larger, the routing path length will be decreased and the number of neighbors with respect to the sink will also be increased. The amount of residual battery energy in the hot spots for performing the message relaying task to the sink will be increased, which might then increase the network lifetime of a WSN.

VI. CONCLUSION

In wireless sensor networks where nodes operate on limited battery energy and efficient utilization of the energy is very important. In this survey, we have analyzed and compared various moving strategies for sink relocation for enhancing the lifespan of the wireless sensor network. Uneven energy consumption is a significant problem in the sensor networks which is characterized by multihop routing. These techniques are used to reduce the usage of those sensors running low in residual energy to preserve the energy on each sensor node as much as possible. For sink relocation the proposed EAMSR technique uses a new scalable algorithm which regularly moves the sinks towards the distant nodes which have lower load contrary to nodes near the sinks. This approach scales to thousands of nodes and prevents from sending additional information about the energy level of each sensor which is what was done in previous solution.

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