Sink site determination scheme for enhancing energy efficiency in wireless sensor networks

Nasrin Mansouri
Department of Computer and Information Technology engineering Qazvin branch, Islamic Azad University
Qazvin, Iran
mansoori@qiau.ac.ir

Mohammad Reza Meybodi
Faculty of Computer and Information Technology engineering, Amirkabir University
Tehran, Iran
mmeybodi@aut.ac.ir

***Abstract*—Energy efficiency is one of important issues in Wireless Sensor Networks (WSNs). In the WSN energy, memory and processor of the nodes are limit. The nodes send their data to the sink by passing to nodes near the sink for further processing. Sensors near the sinks called hotspot. The hotspots relay other sensors' data and will lose their energy quickly. To avoid energy holes, Sink mobility is used to balance load on network. To determine appropriate sink site, different methods are developed. In this paper we propose a method to find optimal sink location based on convex hull. Simulation results show this proposed improves lifetime.**

Keywords-wireless sensor network; sink; convex hull.

I. INTRODUCTION

A WSN is a combination of a large number of sensor nodes to monitor and sense their surroundings. Sensor nodes send their data to a sink for further processing because of their limited computation and memory capacity. Due to the large scale of the network, battery of sensor nodes is not rechargeable. In this view, energy efficiency is essential in WSN to prolong network lifetime. Load balancing and energy conservation is necessary to obtain more lifetime uniform energy dissipation or equal energy consumption of nodes. Clustering, routing and mobility are some solutions for load balancing. Energy Consumption of data transmission is very high. Regardless of their location and/or distance from the sink, radio range of all nodes is set. Applying the multiple sinks lead to balance the network traffic load, shorten communication path, and prolong the lifetime. However, it's so costly and has some limitations. In order to send data to the sink, the long distance from sink results more energy consumption. Multi-hop routing is one of the solutions for energy efficiency. But Sensors near a sink deplete their battery power faster than other sensor nodes because of their heavy overhead of relaying messages. This problem is known as the energy hole problem and the sink's one-hop neighbors is called the 'hot-spot' nodes [1]. There are some different methods which are provided by researches to handle this problem, but the best solution is sink mobility.

II. RELATED WORKS

Sink mobility by moving among nodes virtually increases sensor nodes neighbors and will balance load among them. Among three methods of sink mobility which are random, predictable, and controlled, we choose the last one. The controlled sink mobility moves sink due to an algorithm. A centralized method is Mixed Integer Linear Programming (MILP) analytical model determines those sink routes which maximize network lifetime. It's a NP-Hard problem and not scalable for large-scale networks [2]. Distributed schemes such as Greedy Maximum Residual Energy (GMRE) [3], in which the MS selects the location surrounded by nodes with the higher residual energy; all nodes around sink will have enough energy to relay data to the sink. However, this solution may choose sink sites that are far from together, cause a delay, and find a far place from the event place. In event-based strategy sink moves towards the event site [4]. In this way load isn't balanced in the network because sink has been located in the special places. Some solutions select the node with more neighbors for next sink site [5]. So most of the nodes around new position of sink have less distance to the sink and consume less energy for data transmission but sink always rotate in this area and it's a static solution. Some strategies use hybrid solutions [6]. In wireless sensor networks, nodes are clustered to increase energy efficiency. Clustering can be done using different methods, of which hierarchal clustering is more suitable for this study [7]. After the cluster heads are determined, the network partitions into several clusters. The cluster heads send data from their cluster nodes toward the sink. The neighbor nodes sense quall data and hand nodes send data to the sink. It is possible for data not to change during this period of time. Data aggregation uses the redundant data that the cluster heads do not send toward the sink [8]. The nodes consume less energy, so resources usage and bandwidth decrease. Data aggregation is not suitable for all cases because some applications cause data loss. The best solution for balancing energy among the nodes and extending its lifetime is sink mobility. The main drawback to sink mobility is choosing a method for sink site determination.

III. MAIN CONSEPTS

A. Clustering

Sensor nodes in a network have some roles such as simple sensing; data storage; routing; and data processing. Network is broken down into clusters to simplify communication and energy efficient routing. Cluster heads organize activities such as data-aggregation and organizations the communication in the cluster as the leader of a cluster. There are some methods for clustering. In this paper we use heretical methods. Low-Energy Adaptive Clustering Hierarchy (LEACH) is one of the heretical clustering approaches in wireless sensor networks. It provides load balancing by random rotation of cluster heads and reduces the amount of data transmission. The sensors' energy consumption for transmitting/receiving data in WSN has shown as following:

For transmitting a message,

$$E_{TX}(K,D) = E_{elec} * k + E_{amp} * k * d^2 \tag{1}$$

and for receiving a message,

$$E_{TR}(k) = E_{elec} * k \tag{2}$$

Where k is the size of the transmitted/received message,

And d is the transmission distance. The distance between sender and receiver of message, have direct impact on energy consumption.

B. Convex Hull

Convex hull is employed in various applications such as mathematics and computer science. Convex hull computation is a computational geometry method [9]. In this paper convex hull is used for sink site determination Convex hull is made of a finite set of points. Assume s is number of input points on the plane and p is number of points construct convex hull. P is the least subset of S. all points usually aren't on the same line so convex hull of S is the smallest convex polygon that contains all the points of S. A polygon P is said to be convex if P is non-intersecting and for any two points p and q on the boundary of P, segment pq lies entirely inside P. The convex hull CH (*P*) of a set *P* is the intersection of all convex sets that contain *P* and smallest convex set that contains *P*.

Several algorithms are proposed to construct convex hull such as Graham's Algorithm, Jarvis's Algorithm, Divide and Conquer, Chan's Algorithm and so on. These algorithms receive a set of points and return a counter-clockwise ordered subset of those points. Graham's Algorithm is employed in this paper.

C. Graham's algorithm

It starts with the lowest point (anchor point), forms a closed simple path traversing the points by increasing angle with respect to the anchor point. The anchor point and the next point on the path must be on the hull.

keeps the path and the hull points in two sequences elements are removed from the beginning of the path sequence and are inserted and deleted from the end of the hull sequence, orientation is used to decide whether to accept or reject the next point. Graham pseudo code has shown as follows:

```
Input: a set of points S = {P = (P.x,P.y)}
  Select the rightmost lowest point P0 in S
  Sort S radially (ccw) about P0 as a center {
    Use isLeft() comparisons
    For ties, discard the closer points
  }
  Let P[N] be the sorted array of points with P[0]=P0
  Push P[0] and P[1] onto a stack Ω
  while i < N
  {
    Let PT1 = the top point on Ω
    If (PT1 == P[0]) {
      Push P[i] onto Ω
      i++
    }
    Let PT2 = the second top point on Ω
    If (P[i] is strictly left of the line  PT2 to PT1) {
      Push P[i] onto Ω
      i++
    }
    else
      Pop the top point PT1 off the stack
  }
  Output: Ω = the convex hull of S.
```

Figure 1. GRAHAM PSEUDE CODE

IV. PROPOSED METHOD

Cluster heads aggregate data received from sensor nodes and send them toward the sink. The lower the distance from the sink to the cluster heads, the less energy is consumed to send the data. One solution to increasing the network lifetime is to use sink mobility for clustering. In order to reach energy efficiency, the sink site should be positioned close to all cluster heads. Our solution is based on finding a convex hull of cluster heads and moving the sink into this convex hull. A convex hull of cluster heads directs the sink toward the nodes contained in the convex hull. In this way cluster heads will consume less energy for sending aggregated data of its cluster toward the sink. The node with the most neighbors having residual energy is selected as the sink site. Different algorithms exist for finding the convex hull. The present paper employs the Graham algorithm because of its decreased run time.

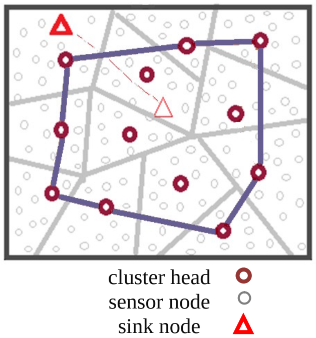

Figure 2. NETWORK SCHEME

V. SIMULATION RESULTS

Proposed scheme is simulated using omnet++. The experiments are performed with diverse number of nodes placed in an area by varying the number of sensor nodes. Table I describes the simulation environment.

TABLE I. SIMULATION PARAMETERS

parameters	values
Number of nodes	200,300,400,500,600
Number of sinks	1
Network area	1000*1000 m^2
Initial energy of nodes	1j
Initial energy of sinks	1000j
E_{elec}	100 $j/bit/m^2$
e_{amps}	50 nj/bit

In this section, we analyze and compare the performance of proposed scheme versus GMRE and random walk schemes. The GMRE (Greedy Maximum Residual Energy) scheme conducts sink toward the sensor with more residual energy of its neighbors. In random walk scheme, the sink moves randomly among sensors. The evaluation metric is lifetime that indicates the time until the first node dies. In order to compare the three schemes, we have used the energy model described in section III. We call proposed method CHSSD (Convex Hull Sink Site Determination) figure 2 plots the network lifetime against the number of sensor nodes. Network size varies from 200 to 600.

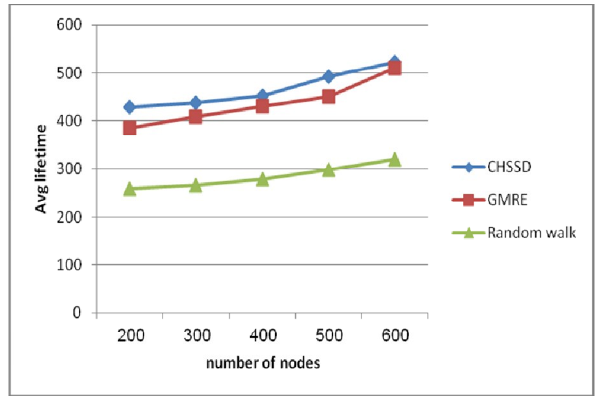

Figure 3. NETWORK LIFETIME VS. NUMBER OF SENSOR NODES

It can be seen that the network lifetime in CHSSD is the largest among three schemes.

VI. CONCLUSION

Determination of the sink site effects energy consumption. The proposed method establishes a convex hull for cluster heads and guides the sink toward it. This decreases the distance required to send data from the cluster head to the sink and increases the energy consumption of the cluster heads.

REFERENCES

[1] Viplavi, D., Mohamed, Y., Bartino, E., and Joshi J., "Sink Mobility to Extend the Lifetime of Wireless Sensor Networks", Collaborative Computing: networking, Application and Worksharing, Vol. 10, Social Informatics and Telecommunications Engineering, pp. 355-369, 2009.

[2] W. Liang, J. Luo, X. Xu, "Prolonging Network Lifetime via Controlled Mobile Sink in Wireless Sensor Networks,"In IEEE Globecom, pp. 1-6, 2010.

[3] Akkaya, K., Younis, M., and Bangad, M., "A Sink Moving Scheme Based on Local Residual Energy of Nodes in Wireless Sensor Networks", Journal of Central South University of Technology, Vol. 16, pp. 265-268, 2009.

[4] Vincze, Z., Vass D., Vida, R., and Telcs, A., "Adaptive Sink Mobility in Event-driven Multi-hop Wireless Sensor Networks," In Proc. of 6th Int. Network Conference, pp. 315-322, 2006 .

[5] Viplavi, D., Mohamed, Y., Bartino, E., and Joshi J., "Sink Mobility to Extend the Lifetime of Wireless Sensor Networks", Collaborative Computing: networking, Application and Worksharing, Vol. 10, Social Informatics and Telecommunications Engineering, pp. 355-369, 2009.

[6] Koc, M., Korpeoglu, I., Gelenbe, E., Lent, R., and Sakellari, G., "Algorithms for Sink Mobility in Wireless Sensor Network to Improve Network Lifetime", 26th Int. Symposium on Computer and Information Sciences, pp. 173-177, 2012.

[7] A. A. Abbasi, M. Younis, "A Survey on Clustering Algorithms for Wireless Sensor Networks," Journal of Computer Communications, vol. 30, pp. 2827-2840, 2007.

[8] X. Jianbo, G.., Jian, L. Jing, Z. Xinalian,"Mobile Sink –based Data Gathering Protocol," Hunan University of Science and Technology, International Forum on Information Technology and Applications, pp. 427-429, 2010.

[9] R. Jacob, "Dynamic Planner Convex Hull," PhD. Thesis, 2002.