Multiple Mobile Sink Weighted Rendezvous Planning and Interference-Aware Path Selection in Wireless Sensor Networks

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Abstract

Wireless sensor networks consist of many sensor nodes installed in an area. One of the major problems in WSN is energy efficiency. Many studies have revealed that mobile sink can be used to reduce the energy consumption in nodes and to prevent the formation of energy holes in Wireless Sensor Networks. The existing uses a hybrid moving pattern where the mobile sink visits only the rendezvous points (RP). In order to choose an optimal route to visit the RPs Weighted Rendezvous Planning is used where a weight is calculated and assigned to every node based on the hop distance from tour and the amount of data packets that gets transmitted to the closest RP. In the proposed method, an innovative technique is introduced which is called Multiple Mobile Sink Weighted Rendezvous Planning and Interference-Aware Path Selection (MMSWRP-IPS) for placing multiple mobile sinks and reducing interference. In this technique the network is divided into smaller regions and for each region a mobile sing will be assigned.

Keywords: wireless sensor networks (WSN), mobile sink, Rendezvous points (RP).

1. Introduction

A wireless sensor network consists of a large number of nodes that are miniature sensors that are used to collect data from the targeted area. The collected data is then transmitted to a base station where the collected data is used to generate useful information. The combination of sensing, processing and communication in a miniature device translates to the possibility for limitless applications [1]. Some of the applications of WSN are monitoring the environment, health care, military etc. since the nodes are primarily battery powered it was essential that the power consumption was kept to the minimum to get the maximum life time. Many studies have been carried out to develop protocols that are energy efficient. Sinks are used to collect the data from the nodes in the networks. So in a multihop wireless network, the sensor nodes that close to the sinks run out of battery fast and the nodes that are distant from the sinks have a longer life time. This non uniform consumption of energy results in the formation of energy holes that causes the other nodes to get disconnected from the sink. For efficient energy consumption and to prevent the formation of energy holes, mobile sinks are used. The mobile sinks as the name suggests has the ability to move around the field of sensors and collect the data. Many researches have been done on implementing a single or multiple mobile sinks. The mobile sink acts as a bus that goes through a route to collect the passengers and drop the passengers at their destination.

The basic problem with a mobile sink is to decide how the mobile sink should collect the data from the nodes. The travelling salesman problem provided a method to collect the data from all the nodes directly. It helps in finding the shortest route to traverse all the nodes with minimum cost. But this method is not practical where a large number of nodes are used. To overcome this problem the concept of rendezvous point was proposed, where a set of nodes are assigned as RP’s. The nodes that are not RP simply deliver the collected data to the RP, and the mobile sink collects the data from the RP’s. To overcome the problem of selecting RPs, Weighted Rendezvous Planning (WRP) was proposed. In this method for every node weight is computed based on the hop distance to the tour and the number of data packets that the node transmits to the closest RP. But since only a single mobile sink is use, the deadline for receiving the packet is often missed.

So, in the proposed method an innovative technique is introduced which is called Multiple Mobile
Sink Weighted Rendezvous Planning and Interference-Aware Path Selection (MMSWRP-IPS) for placing multiple mobile sinks and reducing interference.

2. Literature Review

The use of mobile sinks can be mainly classified into two. First one is Direct and the second one is Rendezvous. In the direct method the mobile sink travel to each and every node to collect the data whereas in the Rendezvous method the sink visits only the RPs [2].

2.1 MULEs

In the year 2006 Sushant Jain, Rahul C. Shah and Sumit Roy proposed a new scheme called MULE. In this work the concept called MULEs (Mobile Ubiquitous LAN Extension) because they “carry” data from sensor to the access point. MULES pick up the data from the nodes, buffers it and then it drops off the data at the access point. This paper suggests the advantages of the MULE architecture over the Ad-hoc networks. The benefits of using MULE are low energy consumption and high network lifetime is achieved [3].

2.2 Mobi Route

In this paper a routing protocol name “Mobi Route” is proposed in order to support WSN with a mobile sink. This work is the continuation of the work that proved that mobile sinks can increase network lifetime without affecting the data delivery latency. The proposed method showed improved network lifetime. Also the traffic load in the network was also balanced. The problem with the proposed method was that high interference was observed [4].

2.3 Rendezvous Planning

In the year 2008 Guoling Xing, Tian Wang, Hihui Xie and Weijia proposed a rendezvous based approach. This work presented a rendezvous based approach to collect data with delay requirements. The idea was that some of the nodes in the network will be assigned as rendezvous point, and the non RP nodes will transmit the collected data to the RP. The mobile sink during the tour will collect the data from the RPs. The advantage was, the mobile sink didn’t have to collect the data from all the nodes individually which resulted in minimum energy consumption. Two algorithms called RP-CP and RP-UG were introduced. RP-CP finds the optimal RPs when mobile sink move along the route. RP-UG was used to assign RPs in a network [5].

2.4 DDRP

In the year 2011 Lei Shi, Baoxian Zhang, Kui Huang, Jian Ma proposes DDRP (Data-driven routing protocol) to be used with mobile sink in WSN. The DDRP lowers the protocol overhead for data gathering in networks. DDRP uses the broadcast feature in sensor nodes for route learning. The paper goes explains that continuous route learning will provide more route information for the sensor nodes in the network [6].

2.5 HUMS

In this paper, an autonomous moving strategy is suggested, in which the energy mower can make moving decisions without the global topology of the network or energy status of all sensor nodes. The aim of this research is to design a strategy for the energy mower to react to the energy distribution of the sensors. If the sensors report their data by multihop, the closer to the energy mower the sensors are, the heavier their traffic burdens are, and the more energy they have to consume. Thus, drive the energy mower to approach the sensor with the highest residual energy in the network and avoid passing by the sensors with low residual energy. In each data gathering period, the sensors pack their residual energy information into data packets, so that the energy mower can calculate a new position to move after it collects all the packets. During the sojourn of the energy mower in each position, the sensors report their data packets by multihop.

Furthermore, considering the limited speed of moving the energy mower in a real scenario, it is not possible for the energy mower to reach anywhere in the network field by one move. As a whole, the proposed strategy makes the energy mower move autonomously to collect data packets in the monitoring area, along with balancing the energy consumption among all the sensors, alleviating the hotspot problem and extending the network lifetime [7].

2.6 REDM

In the year 2010 S.Y. Choi, J.S. Kim, J.H Lee and K.W Rim proposed a Robust and energy efficient dynamic routing for a mobile sink (REDM). This algorithm makes use of controlled sink mobility. For the initial advertisement Global flooding is utilized. Hop count and
average residual energy of the paths are considered to establish the routes. In case the battery in a node fails, the routes are updated taking it to account. The proposed method is suitable for nomadic sinks. The algorithm proposes mechanism for uniform energy consumption [8].

3. Problem Identified

Energy efficiency and extending the network lifetime are two of the most important considerations in the WSN. Since the nodes are mostly equipped with battery it is impossible to replace battery for all the nodes if the network is implemented for a vast area with a several sensor nodes. In the existing method Weighted Rendezvous point is proposed that is used to control the mobile sinks movement. Existing method only considers only one mobile sink to gather data from the sensor nodes. Furthermore, if interference around the node is very high, then nodes need more transmission energy for successful transfer of packet.

4. Proposed method

In WRP, the sensor nodes with more connections to other nodes and placed farther from the computed tour in terms of hop count are given a higher priority. But there is high delay if the single mobile sink is used. So, we propose a Multiple Mobile Sink Weighted Rendezvous Planning and Interference-Aware Path Selection (MMSWRP-IPS) method.

In this technique the network is divided into smaller areas and each region the mobile sink is placed. In each region, the mobile sinks collect the sensed data from the sensor nodes and send the data to the base station. So, by using the multiple mobile sinks all data are collected within a given deadline. In addition to that, the path is selected the interference of the link is computed and link with low interference is selected for routing path.

In order to increase the network lifetime the proposed method takes interference as a major parameter for estimating a robust and suitable routing path. In the proposed system, the weighted clustering algorithm is used. It evaluates a weight for each node and the cluster heads are chosen among the best suitable nodes in terms of node degree, distance from neighbors, mobility and energy available. In terms of energy consumption, the algorithm tries to achieve the most stable cluster architecture, meaning after the first iteration the algorithm is executed only when there is a demand. This reduces system updates and hence computation and communication costs. Another important feature of this scheme is that the cluster heads are chosen among the nodes that have enough energy available. This leads to a fair cluster head distribution amongst nodes; avoiding the problem of power drainage for nodes that serve as cluster heads for long periods of time.

5. Overall Architecture

![Architecture for the proposed system.](Image)
5.1 Creation of Network module

An undirected graph $G (V, E)$ where the set of vertices $V$ represent the mobile nodes in the network and $E$ represents set of edges in the graph which represents the physical or logical links between the mobile nodes.

Let $N$ denote a network of $m$ mobile nodes, $N_1, N_2, \ldots, N_m$ and let $D$ denote a collection of $n$ data items $d_1, d_2, \ldots, d_n$ distributed in the network. For each pair of mobile nodes $N_i$ and $N_j$, let $t_{ij}$ denote the delay of transmitting a data item of unit-size between these two nodes.

5.2 Cluster formation

In the proposed system, the weighted clustering algorithm is used. It evaluates a weight for each node and the cluster heads are chosen among the best suitable nodes in terms of node degree, distance from neighbors, mobility and energy available. In terms of energy consumption, the algorithm tries to achieve the most stable cluster architecture, meaning after the first iteration the algorithm is executed only when there is a demand.

5.3 Computation of hop count

After the cluster is formed the mobile sink is placed at each cluster. In every cluster select the rendezvous points for data gathering. For this the hop count is computed for every node. The mobile-sink node moves with a constant speed $v$.

A mobile-sink node starts its movement from a node $m_{0} \in V$ and before time $D$ returns to its starting point. Each sensor node sends its generated data packets to the closest RP through multihop transmissions. We define a function called $H(i,M)$ that returns the closest RP in terms of hop count to the sensor node $i$, where $M$ is the set of RPs.

5.4 Computation of number of forwarded data packets

The number of data packets $NFD(i)$ that sensor node $i$ forwards to the closest RP $m_{i}$ in each time interval $D$ is equal to its own generated data packet plus the number of its children in the data forwarding tree $T_{m_{i}}$.

5.5 Compute the weight of the sensor node

WRP preferentially designates sensor nodes with the highest weight as a RP. The weight of a sensor node is calculated by multiplying the number of packets that it forwards by its hop distance to the closest RP on the tour.

5.6 Optimal route identification.

The optimal route is identified based on the factors like interference in the network and WRP. Based on these computations we can choose the optimal route for the mobile sink.

6. Conclusion

In this paper Multiple Mobile Sink Weighted Rendezvous Planning and Interference-Aware Path Selection (MMSWRP-IPS) for placing multiple mobile sinks and reducing interference is proposed. In this technique the network is divided into smaller regions and in each region the mobile sink is placed. In addition to that, interference-aware path selection method is used that considers interference for cost effective routing path determination. Thus, the quality of wireless communication is improved, because the effects of wireless interference are reduced.

References


