International Journal of Combined Research & Development (IJCRD)
eISSN:2321-225X;pISSN:2321-2241 Volume: 3; Issue: 2; August - 2014

Energy-Efficient Data Collection and Transmission in Wireless Sensor Networks

[1]Anasuya.N.Jadagerimath, [2]Jeevitha.C,[3] Anirban Basu
[1,2,3] Department of computer science and engineering,
East Point College of Engineering and Technology,
Bangalore,India
1anuprama@rediffmail.com, 2jeevi89@gmail.com, 3abasu@anirbanbasu.in

Abstract : Wireless Sensor Networks(WSNs) enable people to observe details of real-world phenomena in both temporal and spatial dimensions. Data collection and transmission are the functions of WSNs. Due to limited resources of tiny sensor nodes this becomes a challenging task. Data Collection Scheme (DCS) [1] which avoids too much communication overhead yet keeps the data quality is widely used for data collection while Multiple Sink Placement (MSP) [2]which reduces the distance from source to Sink becomes an effective method for data transmission. This paper discusses a method for data collection and transmission which is a modification of standard DCS and MSP algorithms. The performance of the proposed method has been studied by simulation and it was found that sensor nodes in Multi Sink Placement consume less energy than sensor nodes in Single Sink Placement

Keywords: Wireless Sensor Networks, Data Collection, Cluster, Average Sink Degree, Hop Distance, and Particle Swarm Optimization.

1. INTRODUCTION

Sensors are sophisticated devices that are frequently used to detect and monitor a variety of parameters. Nowadays, a lot of attention is being given to Wireless Sensor Networks (WSN) which facilitate monitoring and controlling of physical environments from remote locations with better accuracy [1]. WSNs have applications in a variety of fields such as environmental monitoring, military purposes and gathering sensing information in hospitable locations.

Till recently, research in Wireless Sensor Networks focused on improvement of network performance assuming that there is a single stationary Sink in multi-hop Wireless Sensor Networks. In Wireless Sensor Networks a Sink is defined as a node which has more capabilities than normal sensor node and powered by unlimited energy source. The function of the Sink is to gather the data generated by sensors in the network and transmit via multi-hop relays to the base station.

This traditional Single Sink Network however suffers from two major problems: one is Hotspot and another is Latency.

These problems have been addressed in the literature and Multiple Sink Placement [2] algorithm has been proposed to improve network performance including network lifetime, average data delivery latency, and system throughput. In order to overcome the problems in Single Sink Wireless Sensor Network we propose introduction of the concept of a Leader and Multiple Sinks as shown in Figure 2. While the Sink is responsible for data collection, the Leader is responsible for data transmission. Multiple Sinks are placed in the network with each being used to gather data of the sensors within a certain number of hops from the Sink. This results in decreasing the relay workload of each sensor, lowering the latency.

Energy consumption is an important factor to determine the life of a sensor because usually sensor nodes are driven by battery and have very low energy resources. This makes energy optimization more complicated in sensor networks because it involves not only reduction of energy consumption but also prolonging the life of the network as much as possible. This can be done by incorporating features for reduced energy consumption in every aspect of design and operation.

Major challenge in WSN is the lack of energy efficiency in the network, due to limited resources of sensor nodes. In this paper we propose a Particle Swarm Optimization based Multi Sink Placement algorithm in a cluster based network algorithm to increase the energy efficiency of the Wireless Sensor Network. Performance Analysis done shows the advantages of the proposed method.

2. PRESENT METHODS

2.1 Single Sink Placement

In Single Sink Wireless Sensor Network, nodes closer to the Sink become bottleneck [3] due to heavy traffic load for packet transmission as shown in figure 1. This leads to unbalanced power consumption among the sensor nodes and connectivity between the intermediate nodes may be lost. The power consumed by the sensor nodes can be reduced by developing design methodologies and architectures which help in energy aware design of sensor networks. The lifetime of a sensor network can be increased significantly if the operating system, the application layer and the network protocols are designed to be energy aware. In general the Sink Placement Problem is NP-complete [4], and finding the best position of the Sink is very hard [5].

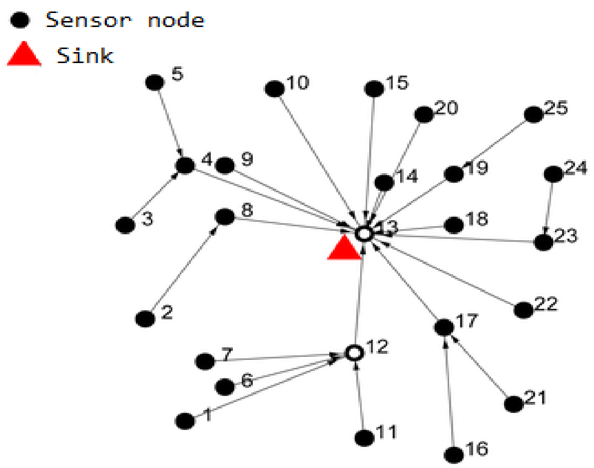

Figure.1 Wireless Sensor Network with Single Sink Placement

2.1 Multi Sink Placement

To overcome the problems in Single Sink Placement, Multi Sink Placement concept has been introduced. Multiple Sinks are deployed in Wireless Sensor Networks (WSNs) to minimize transmission delay and energy consumption and also to extend the network life time [6]. Since the data collected by sensor nodes are forwarded to the Sink, proper placement of Sinks has a great impact on the performance of the WSNs [7]. This paper introduces Sink placement strategy called Particle Swarm Optimization. It has been observed that the proposed strategy exhibit better performance with respect to energy usage and lifetime in comparison with Single Sink Placement.

2. 3 The Data Collection Scheme

A network uses Data Collection Scheme (DCS) described here for clustering of nodes. Nodes with similar properties will gather similar type of data [8]. DCS first groups nodes into clusters based on the similarities in their data. In a network, one node in the cluster is selected as the representative node, which acts as a Leader and sends data to Sink for onward transmission. In general, DCS includes followings phases:

- **Clustering Phase**: With user-defined model clustering parameter c^{th}, node computes similar nodes set Γ for each sensor node. For example, if node S_i and S_j are similar nodes, then S_j is included in the similar nodes set Γ S_i of S_i. Obviously, relation of similar nodes is symmetric, namely S_i is included in set Γ S_j.

Algorithm 1: Centralized Model Clustering For Sensor Nodes

```
Label nodes unclustered : L( Si)=false, i=l→ N;
Compute similar nodes set Γ Si i=l→ N;
Descending sort nodes S according to cardinality [□]
for i=l to N do
         / * Si is the node with the i-th
         Largest cardinality in S */
         if !L( Si) then
             L( Si)=true;
             Csi={Si};
             foreach S j in r Si do
                   if L( Sj) then
                   flag=true;
                   for each Sk in Csi do
                       if  Sj, dissimilar, with k then
                             flag=false;
                             break;
                   if flag then
                             L(Sj)=true;
                             Csi=Csi U{Sj};
Output all m clusters C, U Csi = S
```

- **Data Collection Phase**: Instead of sending readings to Sink by all sensor nodes, one node in each cluster is appointed as Leader to send data periodically to Sink.

The modified data collection scheme is used along with the Particle swarm optimization based Multi Sink Placement in this paper.

3. PROPOSED METHOD

3.1 Multi Sink Placement Algorithm

In this paper, we propose a PSO based approach to deploy Multiple Sinks in Wireless Sensor Network. We overcome the Sink Placement Problem and propose a method for minimization of energy consumption. Initially the steps in Data Collection Scheme are followed.

K-mean clustering and Balance clustering algorithms are used to generate K number of clusters. For each cluster, we use PSO-MSP algorithm to determine coordinates of optimized Sink location. In PSO-MSP [9] algorithm, a Sink is referred to as a particle. An initial set of particles are first randomly generated, with each particle representing the coordinate of a possible Sink location. At the end of iterations, the algorithm stops and returns optimized sink location.

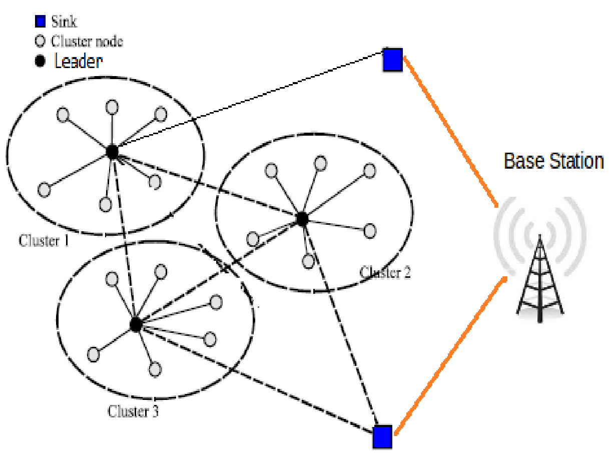

Figure.2 Wireless Network System

Average hop distance**:** The number of nodes traversed by a packet between its Leader and Sink. Given a graph $G = (V, E)$, $V=\{ v1,v2\ldots\ldots ,vN , S1 , S2 \ldots. SM \}$, minimum number of hops of node i from nearest Sink is h and hop distance of graph is

$$\mathrm{dist}_h (vi) = \{vi\ V \mid h(vi , Sj) = h\}$$

Hence minimization of average hop distance of all sensor nodes can be formulated as

$$\textbf{Min} \ {}_{i=1}^{N} \mathrm{dist}_h \ v_i \qquad \text{(I)}$$

Sink's 1-hop connectivity**:** The degree of Sink is the number of its neighbours in the graph. That is,

$deg(Sj) = |\{vi\ V : (vi , Sj)\ E\}|$

And we can then formulate this optimization as

$$\textbf{Max} \ {}_{j=1}^{m} \deg\ S_j \qquad \text{(II)}$$

Algorithm 2: PSO based Multi Sink Placement

Input: A set of N sensors with its location (xj, yj), Integer M,
Output: Locations of Sink nodes.

Step 1: Randomly generate a group of *n* Sink, each representing the coordinate of a possible Sink location.
Step 2: Calculate the hop distance between *ith* sensor positioned at (*xi*,*yi*) with each Sink and 1hop connectivity of particles.
Step 3: Generate the data, based on the similar functionality of sensor nodes group nodes and form clusters. Select Leader node in each cluster.
Step 4: Set *pBesti* as the current *i*th Sink if the value of *fitness(i)* is larger than the current fitness value of *pBesti*.
Step 5: Set *gBest* as the best *pBest* among all the particles.
Step 6: Leader node is responsible to transmit data to the nearest Sink.
Step 7: Update the position of the *i*th sink using equation (II).
Step 8: Repeat Steps 3 to 7 until the iteration reaches to its maximum value.

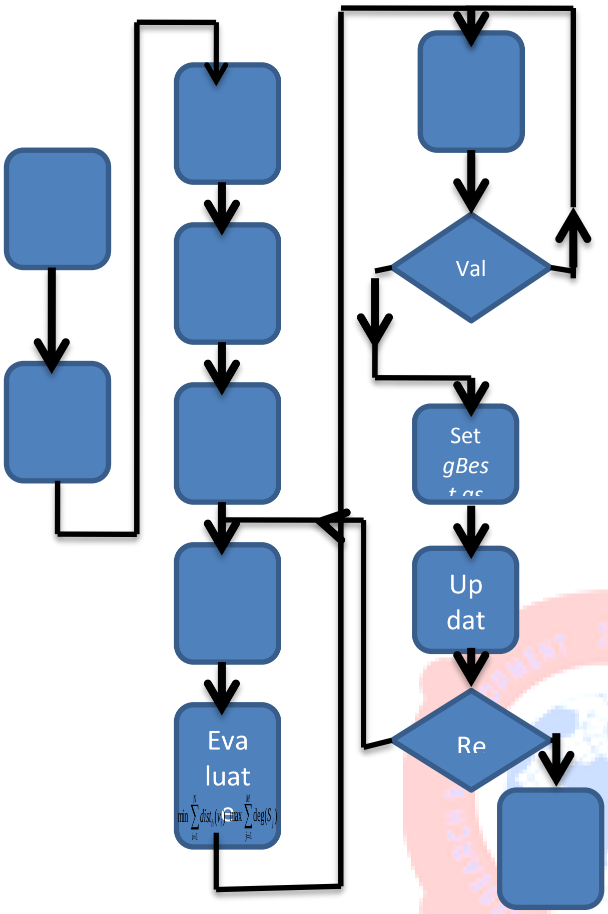

Figure.3 Flow of PSO algorithm

4. PERFORMANCE EVALUATION

The simulations were carried out in NS 2 [11] simulator on Ubuntu Linux operating system. The simulation is done to evaluate the performance in terms of data transmission time and energy consumption of nodes both for Multi Sink placement and Single Sink placement. The performances of these two methods are compared.

The Figure 4 describes the simulation Nam for Creating 40 sensor nodes. Here the 3 solid nodes are selected as Sink nodes and concentric nodes indicates the Leader. Leader is reponsible to forward the packet to the Sink nodes. If queue size is full packets will be dropped. The dropped packets will be resend with differternt sequence number.

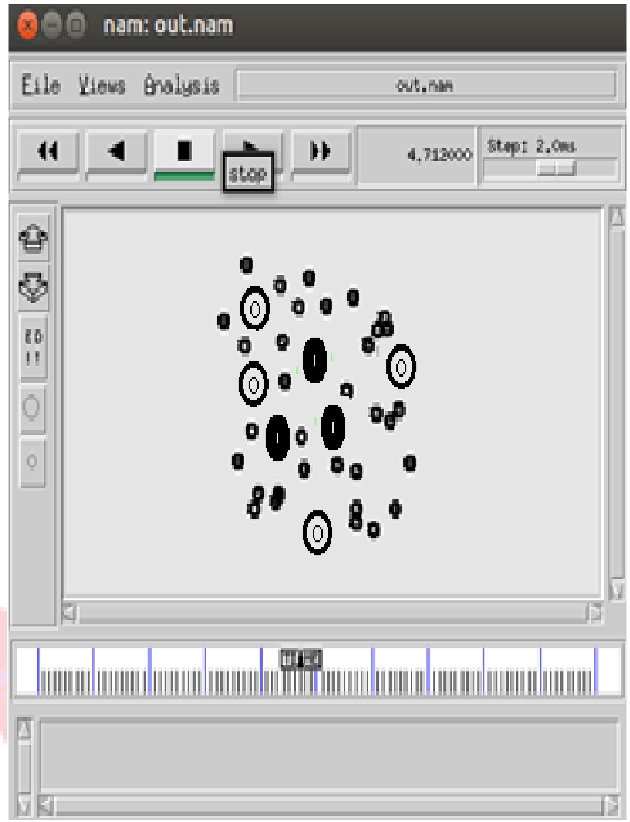

Figure.4 Forming Clusters And Choosing Leader

In this section we have compared Single Sink Deployment with Multi Sink Deployment. In Single Sink Deployment, all sensor nodes with sent data to Sink, energy consumed by the sensor nodes will be increased. In the Multi Sink Deployment algorithm instead of sensor nodes sending data to Sink, Leader is responsible to send data to the nearest Sink so that utilization of energy resources in Wireless Senor Network is minimized when compared to Single Sink Deployment. Summary results are presented in Figure 4.

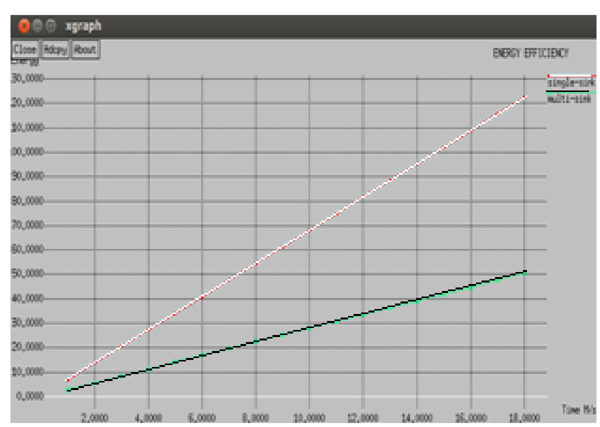

Figure.5 Energy Consumption

Compared to Single Sink, Multi Sink Deployment consumes less energy resources during the transmission. Also it is observed that, increasing the number of Sink nodes beyond a certain threshold value does not show much effect on the average Sink node degree and average hop count. This happens because with the increase in number of Sink nodes, one hop neighbours of Sinks increases which ultimately reduce the average hop count. Hence further increase in the number of Sink nodes may not have any advantage.

5. CONCLUSION

In order to maximize the lifetime of a sensor network, each sensor node must consume its energy resource effectively. In multi-hop Wireless Sensor Networks, to cover large areas, minimize per node energy consumption for data transmission operations and to increase the network lifetime, the network must be divided into smaller sub-networks and optimally deploy multiple sinks in it is always a better solution. An energy-efficient Data Collection Scheme named DCS, for WSNs to reduce communication overhead yet keep data acquisition without too much accuracy loss.

In this paper we have used the Data Collection Scheme and Particle Swarm Optimization based Multi Sink Deployment algorithms for Homogeneous Sensor Networks. Further we can implement the same algorithms for Heterogeneous Sensor Networks.

REFERENCES

[1] Zhidan Liu, Wei Xing , "An Energy-Efficient Data Collection Scheme for Wireless Sensor Networks " Proceedings of the IEEE International Conference on Communications , Jan 2013.

[2] Deepak R Dandekar, P R Deshmukh , "Energy Balancing Multiple Sink Optimal Deployment in Multi-hop Wireless Sensor Networks" *2013 3rd IEEE International Advance Computing Conference (IACC).*

[3] K. Padmanabh, R. Roy, "Bottleneck around Base Station in Wireless Sensor Network and its Solution," pp.1-5, 2006 Third Annual International Conference on Mobile and Ubiquitous Systems: Networking & Services, 2006

[4] A. Bogdanov, E. Maneva, S. Riesenfeld, Power-Aware Base Station positioning for Sensor Networks, in: Proceedings of the 23rd AnnualJoint Conference of the IEEE Computer and Communications Societies(INFOCOM 2004), Hong Kong, March 2004.

[5] W. Y. Poe and J. B. Schmitt, "Minimizing the Maximum Delay in Wireless Sensor Networks by Intelligent Sink Placements," Technical Report 362/07, University of Kaiserslautern, Germany, July 2007.

[6] Debasree Das, Zeenat Rehena and Sarbani Roy, "Multiple-Sink Placement Strategies in Wireless Sensor Networks" in: Proceedings of the 8th IEEE International Conference on Mobile Ad-hoc and Sensor Systems, 2011.

[7] Z. Rehena, S. Roy, N. Mukherjee "Efficient data forwarding techniques in Wireless Sensor Networks",Advance Computing Conference (IACC), 2013 IEEE 3rd International; 01/2013.

[8] P. Corke, T. Wark, R. Jurdak, H. Wen, P. Valencia, and D. Moore, "Environmental Wireless Sensor Networks," P roceedings of the IEEE, vol. 98, no. 11, pp. 1903-1917,2010.

[9] Vincze Zoltan, Vida Rolland, Vidacs Attila,"Deploying Multiple Sinks in Multi-hop Wireless Sensor Networks," IEEE International Conference on Pervasive Services, July 2007.

[10] Dordit S. Hochbaum and Favid B. shmoys,"A best possible heuristic for the k-center problem," Mathematics of Operations Research, Vol. 16, No. 2, May 1985.

[11] www.nsnam.com/2013/10/installing-network-simulator-2-**ns**-235.html.

[12] D. Chu, A. Deshpande, J. Hellerstein, and W. Hong, "Approximate Data Collection in Sensor Networks using Probabilistic Models," in Proceedings of the 22nd International Conference on Data Engineering (ICDE), 2006.

[13] Kennedy, J. and Eberhart, R. C.,"Particle Swarm Optimization," Proc.IEEE international conference on neural networks 1995.