International Journal of Engineering and Techniques - Volume 4 Issue 2, Mar-Apr 2018

RESEARCH ARTICLE OPEN ACCESS

Energy Efficient Schemes for Exploiting Dual Mobile Sinks in Wireless Sensor Networks

A.Jenifer Ebinezer/PG Student
Computer Science and Engineering
Francis Xavier Engineering College
Tirunelveli

P. Brundha/Assistant Professor
Computer Science and Engineering
Francis Xavier Engineering College
Tirunelveli

Abstract —

Wireless Sensor Network (WSN) is a collection of small sensor nodes in a geographically distributed region to keep track of physical or environmental conditions. If each node in the network transmits the sensed data to the Base Station (BS), the energy consumption is very high which directly affects the network lifetime. By using clustering techniques, network lifetime can be extended by making Cluster Head (CH) to interconnect with BS on behalf of other cluster members. Clustering is done and CHs are selected based on the Residual Energy (RE) parameter. A Dual Mobile Sink scheme is proposed where the sink nodes have more energy and resources compared to other sensor nodes. The sink nodes moves near the clusters and gathers the sensed data from the CH. Simulation results and analysis shows that there is an improvement in throughput, delay, packet delivery ratio with reduction in energy consumption compared to schemes that use static sink or BS, where all the CHs communicate the gathered data from the clusters members to the static sink node. Thus mobile sink scheme increases the network lifetime by reducing energy consumption.

Keywords — **dual mobile sink, residual energy, cluster head, network lifetime**

I. INTRODUCTION

Wireless sensor networks have the potentiality to innovate the manner in which we sense the real physical world. The envisioned applications of wireless sensor networks range widely, such as environment monitoring, disaster surveillance, and military target tracking, among others. In wireless sensor networks for data-gathering applications, sensed data packets always congregate towards one or more powerful sink nodes. In a network with a single stationary sink, the nodes closer to the sink have heavier workloads due to relaying data for farther nodes as well as delivering local data. Therefore, they become hotspots and consume their energy quickly. The hotspot problem causes an early rupture of the network because the hotspot nodes no longer relay data for the farther nodes when they run out of their energy. Although optimizing energy efficiency in local areas of a network can prolong network lifetime to a certain extent, the energy balance of the whole network cannot be achieved.

There are several possible ways to handle the hotspot problem. The first one is to move some workloads from the hotspots to light-hearted ones, which is the main method of many existing energy- aware routing protocols. The workloads may include data delivery, heavy computation, frequent access of memory, and so forth. The second way is to deploy multiple sinks. Multiple sinks can cooperate with each other to lighten the workloads of hotspots and enhance the energy efficiency of sensor networks. The third way is to make sinks move.

A mobile sink can redirect traffic flows and help to equilibrate the energy consumption among sensor nodes. Since sink mobility can reduce hotspots and balance energy consumption among sensor nodes, the kind of sensor network with a single mobile sink is focused, which is in charge of gathering the sensed data of all sensor nodes periodically, and investigate the moving schemes of the sink. In the applications that gather data periodically, the purpose of employing a mobile sink is usually to improve flexibility and prolong network lifetime while gathering sensed data timely, reliably and efficiently. Thus, not all moving manners are appropriate for the sinks in these applications.

First, the sink cannot move in a random way, which is energy-unconscious and only a little beneficial to balancing energy consumption. Second, a mobile sink that moves along fixed tracks lacks flexibility and scalability because its moving path has to be redesigned for different networks. In contrast, autonomous moving schemes, in which a sink makes moving decisions according to the circumstances at that time, can provide reasonable adaptability to various types of network conditions.

The two simple moving schemes are proposed to alleviate the hotspot problem and prolong network lifetime. In moving schemes, at the beginning of each data gathering period, the mobile sink makes a moving decision according to the distribution of the residual energy of a small number of sensor nodes. In the first scheme, the sink directly moves to the sides of the node with the highest residual energy in the network. In the second scheme, the sink directly moves to the sides of the node with the least residual energy in the network. Both the moving schemes can help sensor nodes consume their energy more evenly, which results in extending network lifetime.

II. LITERATURE SURVEY

In [1], the author proposes a robust and energy efficient single mobile sink based WSN data gathering protocol is proposed. Unlike other approaches, an enhanced centralized clustering model is developed on the basis of expectation-maximization (EEM) concept. Further, it is supported by using an optimal cluster amount estimation technique that guarantees that the number of clusters in the network area doesn't presentundesirable energy exhaustion. For the meantime, the relative distance between sensor node and cluster head as well as mobile sink is used to make transmission (path) decision. Results show that the proposed EEM based clustering with optimal cluster selection and optimal dynamic transmission decision enables higher throughput, fast data gathering, minimal delay and energy consumption, and higher efficiency.

Advantages

- Higher impact on reliable and delay sensitive data gathering.
- Higher efficiency than other distributed clustering based approaches.

Drawbacks

- Data drops due to unavailability of sink nodes.
- Lower packet delivery ratio.

In [2], the author proposes an Energy Adaptive Clustering Hierarchy, which uses a multipurpose sink, has been projected for WSNs with non-uniform centre point allotment. The entertainment occurs exhibit that: differentiated and standard data addition plots, the strategy shortens the moving partition of the adaptable base station, improves the network life cycle reduces the essentialness use, and has the shorter delay of the data.

Advantages

- Gives better soundness period and framework lifetime.
- Provide high packet data delivery ratio.

Drawbacks

- Suffers from the high overhead of constructing a separate cluster.
- Construction of the cluster is static.

In [3], the author proposes energy consumption of nodes, before clustering, is considered to determine the optimal cluster size. A two-stage Genetic Algorithm (GA) is engaged to determine the optimal interval of cluster size and derive the exact value from the interval. Furthermore, the energy hole is an essential problem which leads to a notable decrease in the network's lifetime. This problem stems from the asynchronous energy depletion of nodes placed in dissimilar layers of the network. And so, the author suggested Circular Motion of Mobile-Sink with Varied Velocity Algorithm to equilibrium the energy depletion ratio of cluster heads (CH).

Advantages

- Can attain better performance in terms of network lifetime
- Could balance the energy consumption ratio of CHs in dissimilar time periods

Drawbacks

- Fixed movement paths
- Higher node counts in cluster leads to communication overhead

In [4], the author proposes a new scheme (CRSSI), which gives the efficient CH selection scheme with the help of the residual energy of the node, the position of sensor node and the transmission and reception count of the node and all these metrics values are received through Cluster Received Signal Strength Indicator (CRSSI).

Advantages

- Achieves high energy efficiency.
- High packet delivery ratio.

Drawbacks

- Assumes that CHs are static.
- It is not efficient in terms of energy consumption and data delivery rate.

In [5], the author propose an attempt to give a wide comparison of the routing protocols in WSNs focusing on the hierarchical or clustering based routing protocols. Moreover, extracting the strengths and weaknesses of each protocol, providing a comparison among them, including some metrics like scalability, mobility, power usage, robustness etc. to make it understandable and simple to select the most suitable one as per the requirement of the network.

Advantages

- Helps in improving the dynamic updating of the routing table which may overcome the problem of the dead node sensing and cluster head value updating
- Improves the efficiency of the energy consumption along with the improvement of the node lifetime values.

Drawbacks

- It does not guarantee that all CHs in the network can communicate with sink during a round.
- Requires more overheads for registration of CHs with a sink in each round.

III. SYSTEM MODEL

The proposed system designed to minimize energy consumption by reducing multi hop transmissions from sensor nodes to Cluster Heads. The energy consumption of sensor nodes is reduced by forming clusters using LEACH. The controlled mobility pattern of mobile sink is used for data collection from Cluster Heads. The mobile sink checks the workload of CHs and traverses the CH in the optimal path. The delay is consistently reduced as the mobile sink traverses the CH in a controlled pattern and it leads to no unwanted movement of mobile sink. Multiple mobile sinks are used to collect data. To avoid collision and interference, primary mobile sink sense the nodes and collects data while the other is recharging.

The sink and the sensor nodes know their own topographical locations, by either GPS services or self-configuring localization techniques. Before gathering sensed data, the network carries out a neighbor discovery process first to help sensor nodes set up their neighbor lists. In the neighbor discovery process, sensor nodes can obtain the location information of their one-hop neighbors by exchanging notification messages. After the neighbor discovery process, the network starts gathering sensed data periodically. In each data-gathering period, the sensor nodes will send their data to the sink through multi-hop communication paths. This will guarantee the fresh- ness of the sensed data in each period because the data will not suffer from great latency before arriving at the sink.

The sink determines the direction and distance based on analyzing the energy distribution information carried by the data packets it received, and then it moves to the new position before the next period begins. The two moving schemes proposed in this paper are designed to help the sink calculate the new position to move to.

- Provides dual mobile sink system which will provide higher data delivery ratio.
- The proposed system will also provide higher data aggregation ratio than any other existing works.
- The system uses Residual Energy system which might increase the accuracy of the communication rate in the clusters.

Modules

- Node Formation
- Node Clustering
- Residual Energy Calculation
- Movement Selection

1. Node Formation

In this module, sensor nodes are formed in Wireless Sensor Network (WSN) and capable of sensing the environment, processing the information locally and sending it to the point of collection through wireless links in a particular geographical area. WSNs are scalable and smart. The sensors can communicate directly among themselves or to some base station deployed externally in the area. But being autonomous nodes, they have limited battery, processing power and bandwidth. Of all the resources constraints, limited energy is most concerning one. One of the main design goals of this module is to carry out energy efficient data communication while trying to prolong the lifetime of the network.

2. Node Clustering

In this module, node clustering adopted the member nodes sense the data and forward to the CH and CH aggregates and process the data to deliver it to the Base Station in dynamic manner. The CH node looses more energy as compared to the Mobile Nodes and Sink Nodes because it performs the fusion on the entire collected data and sends that aggregated report to the BS located far from the cluster location. In a cluster organization both the Intra-cluster and the Inter-cluster communication takes place.

3. Residual Energy Calculation

In this module, a parametric model which can be used to find out the current residual energy in any part of the network at any time. The information regarding the residual energy of the network should be available in centralized manner in one dedicated monitoring node, making it easily accessible for other applications. The other main target of this module is to make the gathering of information regarding the amount of energy left in each node of the network less costly in terms of energy.

4. Movement Selection

In this module, there are two functions of sinks which one can be act as mobile element and other one act as Base Station. Travelling Salesman problem (TSP) used to find a shortest path for visiting all Rendezvous points by a Mobile-Sink node. A mobile sink that preferentially visits extents of RP will prevent energy holes from forming in a WSN. In clustering purpose only all the sensor nodes send its data's to cluster head and cluster head sends the data's to appropriate rendezvous point and mobile sink node travel along the network and collect the data's from rendezvous point. This process is to effectively save the energy of network.

Algorithm

1. Let N_i or N_j denote a common node
2. $S(N_i) = (N_1, N_2 \ldots\ldots N_n)$ denote the set of n nodes
3. $E(N_i)$ denote energy in a node
4. N_{xyz} denote node location
5. d_{ij} denote distance measured from node N_i to N_j
6. thresh (N_i) denote the threshold value of node N_i Initialization
7. Create node N_i
8. Set node position N_{xyz} Clusters formation
9. Divide the sensor field into equal sub-region R_i
10. Select ResidualEnergy E from the each sub-region R_i based on threshold value.
11. if $N_i \in R_i$ && thresh(N_i) < Threshold && has not been E yet then
12. $N_i = E(N_i)$ for sub-region R_i
13. else $N_i = N_j$ (normal node)
14. end if Send Data to Base station
15. $CH(N_i)$ sends data to Base station Repeat the steps 12 to 15 for different rounds

IV. RESULT

i. Packet Delivery Ratio

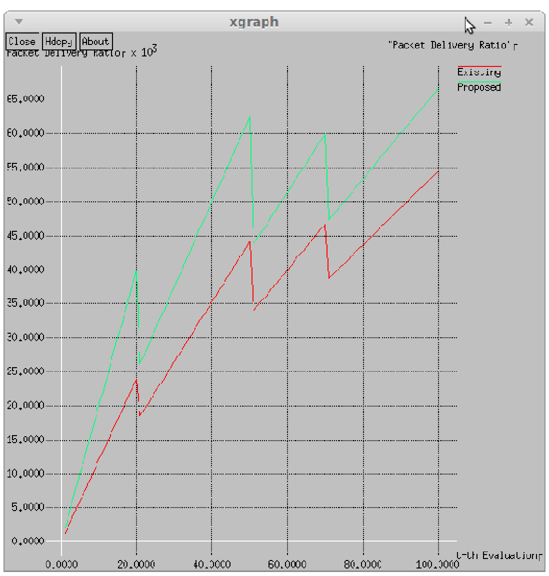

Figure: Packet Delivery Ratio

The more packets are delivered to the destination as compared to the existing techniques.

ii. Energy Consumption

Energy consumption occurs because of packet transmission, packet reception, and processing and sensing by each node during network operation. The packet transmission consumes more energy than reception which is less than sensing. The less energy is consumed as LEACH model is used and controlled sink mobility based on heavy and least residual energy of cluster heads.

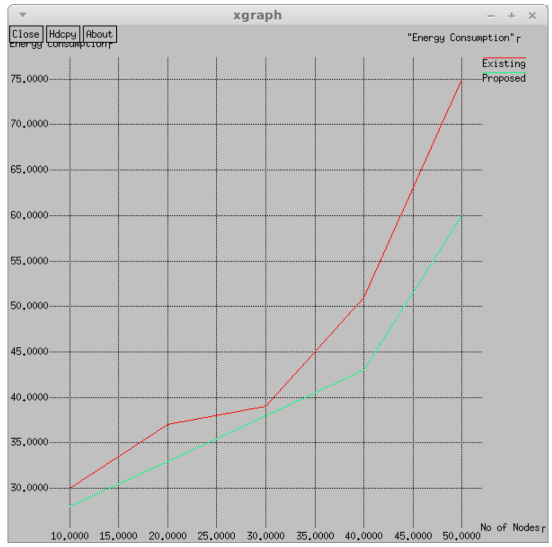

Figure: Energy Consumption

iii.End-to-End Delay

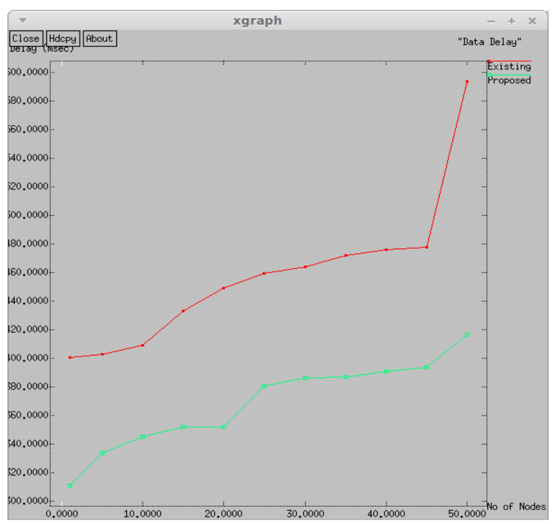

Figure: End-to-End Delay

The proposed system acquires less data delivery delay compared to previous techniques.

VI. CONCLUSION

The problem of exploiting the lifetime in a wireless sensor network is addressed where the information generated by the monitoring sensors needs to be routed efficiently to a mobile sink. The proposed model determines the optimal sink sojourn times at different locations, and the optimal rates at which the sensed data must be transmitted from one sensor to another in order to be routed to the sink. However, implementing this model implies that the information obtained by solving the linear programming problem must be flooded to the network, so that every sensor is aware of the sink sojourn times and of the rate at which it has to transmit data to its neighbouring nodes. The simulation experiments are performed to evaluate the network lifetime performance of the two schemes and studied the effects of different network settings on node deployment, nodes density, and trans- mission power of sensor nodes. The results show these schemes can prolong the network lifetime and achieve stable performance under different topologies; however, if the network has few hops, the advantage of sink mobility may be overwhelmed by the overhead of maintaining valid data-forwarding paths to the mobile sink.

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