

Data Gathering In Multiple Mobile Sink Environment for WSN

Reshma C. Sonawane, Vijay. S. Bidve

Abstract—Sensor nodes in wireless sensor networks are provided with limited battery power so power conservation is one of the most important issues in WSN. An energy efficient approach can be achieved for data gathering by distributing energy consumption in Wireless Sensor Networks (WSN) by employing sink mobility. Existing data gathering schemes require the sink to periodically update its location to the network to ensure multi-hop connectivity as well as to specify the sinks trajectory in advance which makes it unsuitable for applications consisting of changing field situations such as precision agriculture. The proposed scheme combines approach of Sinktrail with aggregation. Gathering of data is done using Sinktrail i.e., proactive data reporting protocol which is passed further for data aggregation, that is base on slicing and mixing technique, which results into low power consumption for data reporting. Thus proposed work based on a combination of both Sinktrail and aggregation to improve the energy efficiency of data gathering.

Index Terms— Data Aggregation; Data Gathering; Logical Coordinates; Mobile Sink; Multihop Routing; Sensor Nodes; Wireless Sensor Networks.

1 INTRODUCTION

Wireless Sensor Networks (WSNs) have found applications in different areas such as precision agriculture, intrusion detection, forest fire detection, weather monitoring, etc. WSN's main purpose in all these applications is data collection of different parameters such as pressure, temperature, contents of soil, speed, etc. This target data is collected and sensed by the sensor nodes deployed in sensor field. These inch-scale sensor devices have very limited energy budget and are expected to operate over years with limited power supply, so energy saving is very important in designing sensor networks.

Sink nodes are in charge of gathering this sensed data from sensor nodes. This sensed data is then forwarded to the base station where additional assessment is done on the gathered data. This base station serves as the main centre for data processing, data storage and also an access point for the human interface.

Data gathering can be done using either static sink or mobile sink. In static sink data is sent by sensor nodes to the nearest sink. But rather than sending data through long multihop routes to static sink, sink mobility is more promising from the point of view of energy efficiency. So, networks with mobile sink are appropriate either for environmental applications or intelligent space applications with large latency tolerance. In such applications, multi-hop wireless transmission along the network to a fixed sink is not energy efficient. Using a mobile sink is the most effective approach to achieve this goal. But it again has location updating message overhead which can be overcome by location prediction based on logical coordinates rather than geographical coordinates. Again in densely deployed wireless sensor network might be the data sensed by neighbouring nodes can be similar

and transmission of which cannot be considered as energy efficient. These redundancies in sensed data can be removed prior to sending this oversized data to sink node by aggregating data. The following sections describe the existing methodologies their advantages and disadvantages.

The Following sections describes related work on data gathering, survey on different data gathering methods, aggregation methods, their advantages and disadvantages, proposed system with algorithm and conclusion and future scope.

2 RELATED WORK

Power conservation is one of the most important issues in wireless sensor networks, where sensor nodes are provided with limited battery power. Recent study reveals that energy efficient approach can be achieved for data delivery by distributing energy consumption in Wireless Sensor Networks (WSN) by employing sink mobility i.e., mobile sink that gathers data. However, it requires many factors that need to be taken into consideration such as sink mobility, periodically updating location to the network to ensure multi-hop connectivity, traffic overhead, energy consumption etc.

In the early days, inside the observed region static sensor nodes and a static sink were placed inside in WSN. In practice, for sending data from sensor nodes to sink nodes multi-hop communication is preferred. The energy consumption for the multi-hop communication depends on the distance. The communication distance can be reduce by deploying multiple static sinks also each sensor node will route data only to the sink which is closer. This results into reducing the length of the path from source to sink and hence gives good results as compared to the single static sink. Again multiple deployed static sinks partition the WSN into small sub-fields each consisting of single static sink.

Multiple static sinks connect with legacy network and the aggregated data are delivered to the remote users using the legacy networks. A wireless sensor network is divided to the multiple static sinks; then, they distributively gather data from

- Reshma C. Sonawane is currently pursuing masters degree program in Information Technology in Pune University, India, PH-9049091669. E-mail:reshmagold@gmail.com
- Vijay. S. Bidve is currently working as Assistant Professor in Information Technology Department in Pune University,India , E-mail: vjay.bidve@gmail.com.

their own allocated area. The distributively collected data could be aggregated and shared among the multiple static sinks and then the data would be delivered to remote users[1,2].

Problem with multiple static sinks is that to balance the load amongst the nodes one has to decide where to deploy them inside the monitored region. Even then also, the nodes close to the sink will deplete their energy rather rapidly..

In [3] Author discusses two different protocols for a WSN i.e., the SS protocol i.e., a static sink and the MS protocol i.e., mobile sink that moves along a fixed concentric circle. In this paper for configuration of the network two parameters i.e., mobility path of the sink and duty cycling value of the nodes are considered. For the evaluation again two parameters are considered those are Emax i.e., the maximum energy dissipation of any single node in the network, and Ebar i.e., the average energy dissipation over all nodes. A static sink gives an optimal result in terms of both Emax and Ebar for small values of the duty cycle. In case for larger values of the duty cycle, a mobile sink performs better than a static sink, especially in terms of Emax.

In the MS protocol for each new position of the mobile sink at every node in the network routing information has to be updated. So, it is assumed that the sinks time at predetermined locations is greater than the time it spends during its movement that results into infrequent route updates in the WSN; hence increasing energy efficiency as compared to other mobile sink based routing schemes.

Duty cycling parameter of the nodes strongly influence whether the mobile sink has an advantage and to a lesser extent, the radius of the trajectory of the mobile sink. Overall, for short duty cycles the influence of the mobility radius turned out to be stronger, but almost negligible for very long duty cycles. However, If the duty cycle is already too short in order to handle heavy routing load, sensor nodes sometimes extend their active phase beyond the scheduled normal duration. This higher number, of idle time slots increases Emax and results into higher energy dissipation.

Advanced planning of mobile sink's moving path and controlled mobile sink mobility is called as Mobile Element Scheduling (MES) algorithms [4,5]. One or more mobile collectors are deployed in a sensing field, which collects data from sensors at some specific locations via single-hop transmissions. This method effectively reduces data transmission costs, but mobile sink is required to cover every node in the sensor field, which makes it unsuitable for large scale field.

SDMA technique is used in this paper to efficiently schedule data transmissions so the data uploading time can be shorten. SDMA allows multiple senders to simultaneously transmit the data. In [4] subsets of sensors are chosen as the polling points (PPs), which aggregates the data from its assigned sensors. PP temporarily caches the data and relays it to the mobile collector when it arrives. The basic idea is to determine the tour of the mobile collector by visiting each PP in a specific sequence. In [5, 6] instead of using either multihop routing or mobile sink to gather the data sensed by sensors authors have com-

count bounded due to several reasons that affect performance of the network as buffer constraint on sensors. Both method [4,5] uses defined trajectory that is then followed by the mobile sink which makes it mandatory. Unlike, MES algorithms proposed idea has no constraint on the moving trajectory of mobile sinks, achieves much more flexibility to adapt to dynamically changing field situations while still maintains low communication overheads [sink].

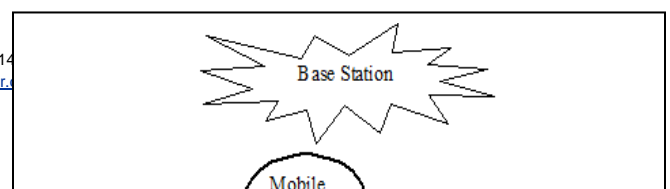
Paper [7] discusses private data aggregation protocol which performs additive data aggregation. It comprises of three phases in first phase cluster is formed, in second phase intermediate aggregation is done within a cluster and in the last phase aggregated result is then forwarded to the query server. Though this scheme is efficient for aggregation but it incurs a high computational overhead. To reduce computational overhead, another scheme is proposed that is SMART Slice-Mix-AggReGate. Again this is also divided into three phases first phase is consisting of slicing where a sensed data from one node is distributed among its k-hop distance neighbour nodes. In the second phase mixing all the gathered slices, are summed up and in the last phase all nodes aggregate the data and that data is then sent to the parent node or sink node. Nonetheless, in this approach communication bandwidth consumption is more so to overcome this [8] proposes a scheme similar to the SMART. The only difference is that the slicing technique is applied only on a leaf node for which prior to data aggregation tree is formed. Slicing is done at a leaf node and the mixing is performed at leaf nodes parent node. In the last then the aggregated data is then forwarded to the either sink or base station directly.

3 PROPOSED SYSTEM

We propose a combined model of the combination of Data reporting and aggregation. The Sinktrail used with aggregation done at sensor nodes. Sinktrail is proactive data reporting protocol used for data reporting. The data aggregation is done at sensor nodes only. The proposed model is shown in figure 1 We consider a uniformly deployed sensor network. Consisting of a densely deployed large number of sensor nodes and they are not mobile. Sensor nodes have limited battery power whereas energy supply of mobile sink can be replaced easily. Periodically two or more mobile sinks are send to gather the data from the network. As the mobile sink enters into the field data gathering process starts and it terminates when within the certain time period there are no more data report. Proactive data reporting technique integrated with data aggregation is put forward.

The operation of proposed method is divided into rounds. Each round begins with a logical coordinate space construction, trail point and greedy forwarding where with respect to each trail point mobile sink waits and broadcasts its trail message to the neighbor sensor nodes, followed by data aggregation phase when data are aggregated and transferred from the sensor nod to the mobile sink and on to base station.

bined both approaches. But, method needs to keep a relay hop



Data gathering process starts as mobile sink enters into the field. Algorithm 1 explains the tasks done by the mobile sink. At some places mobile sink stops for some time, broadcasts a message and simultaneously receive data packets. These places are called as "Trail Points" and the messages are called as "Trail Messages".

A. Algorithm 1

1. /*-----Initialization-----*/
2. Mobile sink send initial trail message and data request sequence message
3. msg.sID=1;
4. msg.trailN = 1;
5. msg.reqN = 0;
6. /*-----Moving Strategies-----*/
7. **while** not timeout **do**
8. *calculate and move to next trail point;*
9. msg.reqN=msg.reqN+1;
10. *broadcast trail message;*
11. *simultaneously gather data packets;*
12. **end while**
13. *End data gathering process and exit;*

The steps given in algorithm 2 summarize the operation to update the sensor nodes trail references. During the data gathering procedure every time as a new trail message is received trail reference is updated. Special variable λ is used to track latest request message. It is also used to eliminate flooding messages in the network.

B. Algorithm 2

1. /*-----Receive trail message-----*/

2. **while** data gathering process is not over **do**
3. *each nearest node to the mobile sink receive message*
4. **if** msg.reqN > λ **then**
5. $\lambda = \text{msg.reqN};$
6. **if** msg.trailN < 2 **then**
7. msg.trailN = msg.trailN+1;
8. *Rebroadcast message;*
9. **else**
10. *stop broadcasting and forward all data to neighbor closet to destination where aggregation is done;*
11. flag=1;
12. **end if**
13. **else if** msg.reqN = λ **then**
14. **if** flag=1 **then**
15. *Discard the message;*
16. **else if** msg.trailN < 2 **then**
17. msg.trailN = msg.trailN+1;
18. *Rebroadcast message;*
19. **else**
20. *stop broadcasting and forward all data to neighbor closet to destination where aggregation is done;*
21. flag=1;
22. **end if**
23. **end if**
24. **else if** msg.reqN < λ **then**
25. *Discard the message;*
26. **end if**
27. **end while**

4 PROPOSED SYSTEM DETAILS

The implementation of the system is divided into three phases.

4.1 Logical Coordinate Space Construction

- While each sensor node in the network consists of its own trail references. During this phase sensor nodes updates their trail references with respect to trail messages broadcasted by mobile sinks.
- Initially the trail message, <msg.sID, msg.trailN, msg.seqN>, is set to <1,1,0> indicating this is the first trail message from first mobile sink's first trail point and also distance to S is 0.
- This trail message is broadcast by mobile sink to all sensor nodes.
- Using these trail messages trail references are updated as presented in the algorithm 2.
- These trail references are in turn used as logical coordinates of all the sensor nodes and the sink node in a given network. So we called it as logical coordinate space is established.

4.2 Trail Point and Greedy Forwarding

- Proposed work facilitates flexible construction of logical coordinate space.
- Location at which mobile sink stops and broadcasts its trail message is called as trail point.
- Moving trajectory of the mobile sink is identified based on its trail points called as footprints using

which location of the mobile sink is traced.

- Once a node updates all its elements in trail reference it starts its own timer.
- As the timer expires the nodes greedily report its data to its neighbour where the aggregation is done.

4.3 Aggregation

- As soon, as the sensor nodes timer expires it forwards its own data to its nearest neighbour.
- This neighbour then performs the data aggregation.
- During this phase, the sensor nodes aggregates i.e., sum up gathered data with its own data. Result is then forwarded to the mobile sink.
- Mobile sinks stop for very short time to broadcast the trail message. Concurrently it listens for data report packets also.
- Mobile sink gets terminated when there are no data report in a certain period i.e., timeout.
- This data is then forwarded to the base station.

5 PERFORMANCE EVALUATION

In this section, performance evaluation of proposed approach is presented. The aim is to compare the performance of the proposed approach with data aggregation with the method of Sink trail.

To demonstrate its feasibility, the proposed method was implemented using the NS2 (Network Simulator version 2). The sensor field for simulation was a square of 1200*1200. In the simulation environment sensor nodes were deployed randomly in the field. The number of sensor nodes in the network i.e., the network size is varied to be 10, 20, 25, 30, 35 and 40 respectively. Three mobile sinks were introduced in the sensing field. Simulated environment for 30 sensor nodes and 20 sensor nodes are illustrated in the figure 2 and figure 3 respectively.

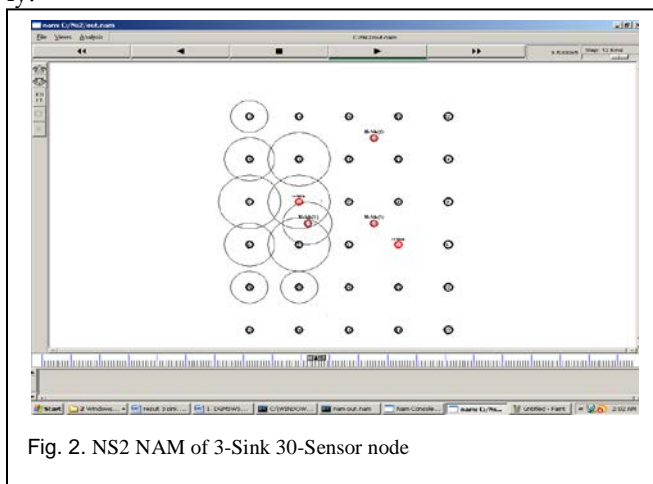


Fig. 2. NS2 NAM of 3-Sink 30-Sensor node

Graph in Figure 4 demonstrates this comparison. In this figure, x-axis represents number of sensor nodes and y-axis represents energy consumption in units. From the graph in Figure 4, we can observe that the proposed method outperforms the sinktrail method where data aggregation is not used. Graph in Figure 5 depicts the number of trail points used by the sinktrail and the proposed system for different experimental network size. Trail points are the points or the positions where mobile sink stop for some time and broadcasts its trail messages.

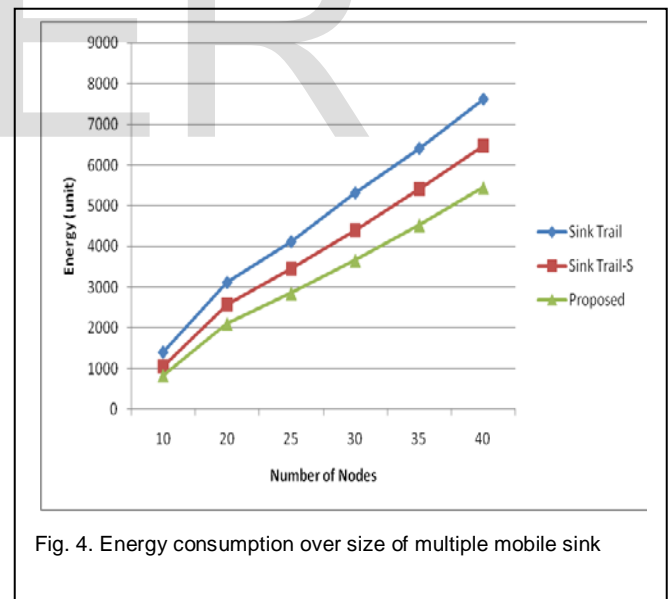
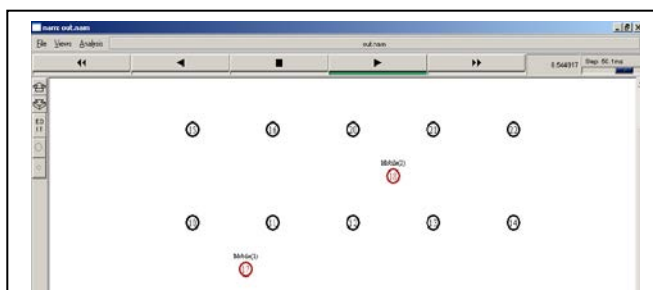


Fig. 4. Energy consumption over size of multiple mobile sink



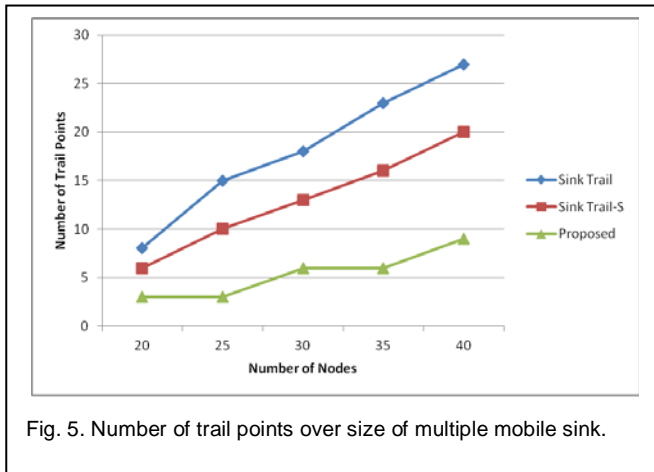


Fig. 5. Number of trail points over size of multiple mobile sink.

The graph in figure 6 shows energy consumption in units for a given sensor network size when the number of mobile sinks are varied within the network. From the figure 6 we observe that as the network size grows energy consumption also increases so to get optimal energy consumption value for given network we have to maintain a ratio 10 : 3 of number of sensor nodes to the number of mobile sink. These results validate the conclusion that energy efficient data gathering is achieved using multiple mobile sink in wireless sensor networks.

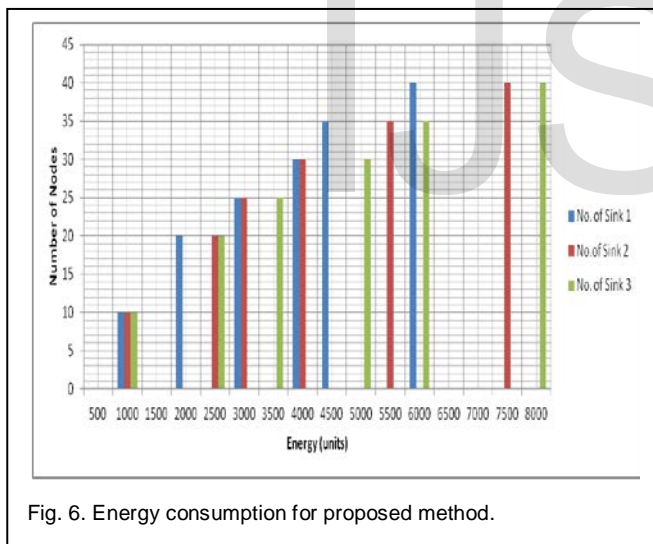


Fig. 6. Energy consumption for proposed method.

REFERENCES

- [1] M. Zhao and Y. Yang, "Bounded Relay Hop Mobile Data Gathering in Wireless Sensor Networks," *IEEE Trans. Computers*, vol. 61, no. 2, pp. 265-277, Feb. 2012.
- [2] E. Lee, S. Park, J. Lee, S. Oh, S. Kim, "Novel service protocol for supporting remote and mobile users in wireless sensor networks with multiple static sinks", *Wireless Networks*, vol. 17, pp. 861-875, 2011.
- [3] Majid I. Khan, Wilfried N. Gansterer, Guenter Haring, "Static vs. mobile sink: The influence of basic parameters on energy efficiency in wireless sensor networks", *Computer Communications* 36 (2013) 965-978.
- [4] M. Di Francesco, S. K. Das, and G. Anastasi, "Data collection in wireless sensor networks with mobile elements: A survey," *ACM Transactions on Sensor Networks*.
- [5] M. Zhao, M. Ma, and Y. Yang, "Efficient Data Gathering with Mobile Collectors and Space-Division Multiple Access Technique in Wireless Sensor Networks," *IEEE Trans. Computers*, vol. 60, no. 3, pp. 400-417, Mar 2011.
- [6] Gen Xu, Gang Lu, "Multipath Routing Protocol for DAG-based WSNs with Mobile Sinks", *2nd International Conference on Computer Science and Electronics Engineering (ICCSEE 2013)*, January 2013.
- [7] Wenbo He, Xue Liu, Hoang Nguyen, Klara Nahrstedt, Tarek Abdelzaher, "PDA: Privacy-preserving Data Aggregation in Wireless Sensor Networks", *IEEE INFOCOM 2007*.
- [8] Hongjuan Li, Kai Lin, Keqiu Li, "Energy-efficient and high-accuracy secure data aggregation in wireless sensor networks", *Computer Communications*[34], 591-597, 2011.

6 CONCLUSION

This work proposes a combination of Sinktrail along with aggregation. An algorithm is used for wireless sensor networks in which many sensor nodes have to communicate their data to a mobile sink node that does data-gathering. The algorithm allows the sensor nodes to aggregate their data before sending it to the mobile sink. This result into reduction in the amount of energy spent on data reporting because the sensor nodes need not all communicate with the mobile sink individually. Further, we presented simulation results demonstrating that our solutions are near optimal and attain significant improvements in energy efficiency, when compared to previous protocols.