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A Survey on Various Methods Based On Analysis of Energy Hole and Energy Efficiency Problems in Wireless Sensor Networks

Manopriya.P.C*, Sugashini.S
Pg Scholar, SNS College Of Technology, Coimbatore, India
Assistant Professor, SNS College Of Technology, Coimbatore, India

Abstract

Wireless sensor network (WSN) is fashioned by a huge amount of distributed sensors jointly with an information collector, denoted as the sink node. Each distributed sensor node has the potential to gather and forward any sensed data back to more than one sink nodes through their wireless transceiver in a multihop mode. However the significance of using mobile sinks is to prevent the energy hole formation and reduction of energy consumption in WSN. The critical issue occurs in WSN is to prevent energy holes by means of balancing energy consumption in each sensor nodes. These constraints have directed and made exhaustive research attempts on designing various energy-efficient protocols. In this paper several methods and protocols has been surveyed for the analysis of energy hole problem and design of energy efficient. Finally comparative measures of each method are presented which provides the significance and limitations of each method or protocol in terms of performance measures in Wireless sensor network (WSN).

Keywords: Data collection, mobile sink, wireless sensor networks (WSNs).d.

Introduction

Wireless sensor networks (WSNs) are possessed by a various number of sensor nodes organized in a field. Some of the applications used by WSN comprise smart transportation, health, home automation, environment monitoring, military and agriculture. Each sensor node has the potential to gather and route and forward any sensed data back to more than one sink nodes through their wireless transceiver in a multihop mode. Additionally, it is furnished with a battery that might be impractical or difficult to put back which is given the different sensor nodes and environment. This challenge of constraints brings exhaustive efforts of research on energy-efficient protocols designs.

In multihop communications, nodes which are close to a sink be subject to become congested since they are accountable for data forwarding from nodes which are farther away. Therefore, these nodes maintains initial energy of more than 90% whose nodes are near to a sensor node are sink and its battery runs out faster the faster its battery runs out. This tends to non uniform depletion of energy that gives out partition in network by reason of the energy holes formation in WSN. Consequently, the sink turns out to be disconnected from other nodes, by means of damaging the WSN. For this reason, energy consumption of sensor nodes are needed to be balanced to avoid energy holes which is considered as a significant issue in WSNs.

Several works uses more than one mobile sinks in which it gathers sensed data straightly from the sensor nodes and whereas guides the nodes of sensor to save energy else these energies are consumed by multihop communications.

The following figure 1 shows the collection of data by the mobile sinks in Wireless sensor network.

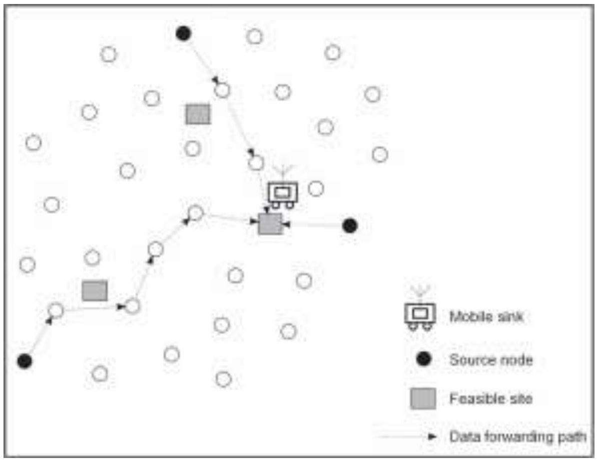

Figure 1: Convention data collection model by mobile sinks in WSN

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The above Figure 1 demonstrates the possible sites of a mobile sink in a WSN model. Particularly, the squares indicate the possible sites that the mobile sink will meet and stop for collection of data. Based on the existing position of the sink's the dependency path is established for data forwarding form the sensor nodes to the sink node. This necessitates sensor nodes to dynamically plan more than one data forwarding paths to each possible site when the sink node varies its position with time. In general, the lifetime of sensor nodes are maximized when a mobile sink that goes at the margin of a sensor field. Spontaneously, the forwarding tree will engage a diverse set of sensor nodes by altering the sink position with time and, thus, this help to equalize the consumption of energy.

One fundamental problem in WSN is to find how the mobile sink goes about gathering sensed data. The solution found for this issue is to visit each sensor node to obtain sensed data directly. This direction collection of sensed data can be done by means of familiar method known as travelling salesman problem (TSP). The main objective of TSP is to determine the shortest tour that visits every sensor nodes. Still, with a growing quantity of nodes, this problem turn out to be impractical and intractable as the obtained length of tour is likely to abuse the delay bound of applications. At last, researchers have presented rendezvous points (RPs) to bind the length of the tour. This means a division of sensor nodes are chosen as rendezvous points RPs, and non- rendezvous points nodes by just forwarding their data to RPs. After that, estimation of tour has been done based on the set of RPs. This estimation results that most suitable RPs are selected which minimizes consumption of energy in multihop communications when visiting a assumed packet delivery bound. The secondary problem occurs here is the efficiency of choosing the appropriate RPs which providing the uniform energy expenditure of sensor nodes in order to increase the lifetime of network.
The following literature, surveys various methods for analysis of energy hole problem and energy efficient design related issues in WSN. In addition merits and demerits of each method is represented in the following comparative table.

Analysis of energy hole problem and energy efficient design in wsn

1. Non uniform node distribution strategy

In [1] Xiaobing et.al presented non uniform node distribution strategy in which its theoretical characteristics addresses the energy hole problem in Wireless sensor networks. Even though it is impracticable to attain balanced energy depletion along with all the nodes by means of WSNs traffic pattern, the possibility of network can be attained by the depletion of subbalanced energy in the network. Because of this the presented method attains very high energy efficiency. With this strategy, the ratio among the adjacent $(i+1)^{th}$coronas node density and i^{th} node density has been formulated. After that an algorithm of q-Switch Routing has been used for the presented non uniform node distribution strategy. Extensive results by means of simulations demonstrate that once the network lifetime ends, the nodes in every inner corona nearly exploit their energy at the same time, even if nodes in the outermost corona include sufficient residual energy.

2. Distributed algorithm based on the subgradient method

In [2] Marios et.al presented distributed algorithm based on the subgradient method for single mobile sink sensor network by providing a choice to the centralized solution for maximizing the lifetime of network. The presented distribution algorithm estimates the sensor network's maximum lifetime by routing data to a mobile sink. By removing some constraints from the dual problem and including flow conservation to every locations of sink, the quantity of Lagrange multipliers was condensed as well as dual problem attains special structure which has been employed for obtaining the efficient solution by using the minimum cost flow ∈-relaxation algorithm and the standard subgradient method. At last the efficiency of the presented method has been evaluated by means of numerical simulations.

3. Rendezvous-based Data Collection protocol

In [3] Guoliang et.al presented Rendezvous-based technique for gathering sensor data under temporal constraints. The presented approach initially devises the minimum-energy rendezvous planning (MERP) problem in which its objective is to determine a set of RPs that can be visited by mobile elements (MEs) within a considerable delay whereas the network energy devoted in transmitting data from sources to rendezvous points (RPs) is reduced. The presented approach developed two rendezvous planning algorithms namely RP-UG and RP-CP. RP-UG is a utility-based greedy heuristic which determines RPs with fine ratios of saving network energy to mobile elements travel distance whereas RP-CP determines the best RPs at the time MEs move with the data routing tree. At last,Rendezvous-based Data Collection (RDC) protocol has been presented and employed which facilitates consistent data transfers at RPs by means of efficiently organizing movement of

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MEs' and transmission of data transmission in the network. With the extensive simulation result, the presented approach outperforms with other traditional schemes in high-bandwidth collection of data under temporal constraints.

4.Delay tolerant mobile sink model (DT-MSM)

In [4] YoungSang et.al presented Delay tolerant mobile sink model (DT-MSM) for maximizing the lifetime of a Wireless sensor network by taking benefit of sink mobility when the existing applications tolerate delayed information delivery to the sink node.

Within a presumed level of delay tolerance, each node does not necessitate to forward the data at once when it becomes presented. Instead, the node might temporarily accumulate the data t and broadcast it once the mobile sink is at the most desirable location for attaining the maximized lifetime of WSN. In order to find the optimal solution within the underlying structure, optimization problems has been formulated which exploit and increases the lifetime of the WSN dependent on the node energy constraints ,delay bound constraints and flow conservation constraints. At last with the obtained simulation result on optimization problem the presented method maximizes the lifetime of network significantly.

4. Data mule scheduling

In [5] Ryo et.al presented Data mule scheduling approach for improving the data delivery latency in the data mule approach.Data mule characterizes a mobile device that gathers data in a field of sensor by actually meeting the nodes in a sensor network. Data are gathered in data mule once these data are in the proximity of a sensor node. Hence this can act as option to multihop forwarding of data once it may be employed by the mobility of node in a sensor network. In general these data mule approach necessitates reducing the data delivery latency. The presented approach efficiently deals this problem and minimizes the data delivery latency.The presented work formulated the data mule's optimal motion control problem to reduce the latency as the DMS problem. After that the 1D case of DMS problem has been studied and then devised an efficient heuristic algorithm. By means of analysing the numerical experiments and lower bound, it has been illustrated that the presented algorithm runs faster and determines near optimal solutions those are within 10 percent of the existing optimal solution.

5. Maximum Amount Shortest Path (MASP)

In [6] Shuai et.al presented Maximum Amount Shortest Path (MASP) for reducing and energy consumption and improving the number of collected data. In this approach, the members contained by the multihop communication area (MCA) are allocated to the equivalent sub sinks within the direct communication area (DCA) in accordance with the span of the communication time among the subsinks and the mobile sink, therefore network throughput has been improved. The presented MASP is considered as a 0-1 integer linear programming problem (ILP).The main objective of this problem is determine the optimized mapping between subsinks and members to reduce the consumption of energy. The MASP problem has been solved by employing the genetic algorithm solution with two-dimensional binary chromosomes. After that two-phase communication protocol has been designed based on partition of zone by without relying on the idea of geographical information. At last, the presented approach is validated by means of simulation experiments using OMNET++ which results that the performance has been improved in terms of energy efficiency and system throughput.

6. MobiCluster

In [7] Charalampos et.al presented MobiCluster protocol for minimizing the overall network overhead and expenditure of energy connected with the data retrieval method by agreeing balanced consumption of energy between sensor Nodes (SNs) and long-lasting network lifetime. This is accomplished by constructing the cluster structures comprising of member nodes that direct their calculated data to their assigned cluster head (CH). The cluster head (CHs) execute data filtering ahead of the unrefined data developing possible spatial-temporal data redundancy and forward the sorted information to their allotted rendezvous nodes RNs, usually positioned in closeness to the MS's trajectory. In addition to that a sophisticated method is introduced for registering suitable nodes as RNs taking into consideration for the density of sensor nodes and deployment model. Finally by means of extensive simulation tests, performance gain has been validated over other alternative approaches.

7. Neighbor coverage-based probabilistic rebroadcast protocol

In [8] Xin et.al presented probabilistic rebroadcast protocol based on neighbor coverage to minimize the routing overheads. The idea of neighbor coverage comprises connectivity factor and supplementary coverage ratio. After that a new method is presented to estimate the rebroadcast delay dynamically in which it is utilized to find the forwarding order and exploits the

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idea of neighbor coverage efficiently. Extensive Simulation results demonstrate that the presented protocol produces less rebroadcast traffic rather than the flooding schemes. The presented protocol mitigates the collision of network and contention in order to increase the packet delivery ratio as well as decrease the average end-to-end delay by means of less redundant rebroadcast. In addition, the simulation results also demonstrate that the presented protocol has good performance once the traffic is in heavy load or the network is in high density.

Comparitive table

The following comparative table shows the points of merits and demerits of each surveyed method in WSN energy hole problem analysis and energy efficient design

Table1:ComparativeTable

S.No	Author &Year	Technique/Concept	Merits	De-Merits
1	Xiaobing Wu, Guihai Chen and Sajal K. Das-2008	Non uniform node distribution strategy	Achieve very high energy efficiency in term of network lifetime, the residual energy ratio, and the data delivery ratio.	Difficult arises in the initialization of networks.
2	MariosGatzianas and Leonidas Georgiadis-2008	Distributed algorithm based on the subgradient method	Obtain better solutions with acceptable constraint violations. Adapt to small network perturbations.	Mobile sink has not received as much attention as the single mobile sink.
3	Guoliang Xing, Tian Wang, ZhihuiXie, and Weijia Jia-2008	Rendezvous-based Data Collection protocol	Reduces network energy consumption and scale well with network density, ME speed, and the number of different deadlines.	It is not applicable in heterogeneousWSNs . Misses fewer deadlines with the dropping of fewer data packets on lossy links.
4	Young Sang Yun, and Ye Xia-2010	Delay tolerant mobile sink model (DT-MSM)	Improved lifetime of network is achieved, It is applicable for studying energy-efficient network designs.	Stop of sink is not considered. Optimization simplification is not done.
5	Ryo Sugihara and Rajesh K. Gupta-2010	Data mule scheduling	Runs faster and gives out good optimal solution.	No precise mobility model is used for consideration of acceleration constraint.
6	ShuaiGao, Hongke Zhang, and Sajal K. Das-2011	Maximum Amount Shortest Path (MASP)	Better trade off is achieved between computational complexity and energy efficiency. Improved system throughput is obtained.	Various movement trajectories of mobile sinks are not validated.
7	CharalamposKonstantopoulos, GrammatiPantziou, DamianosGavalas,	MobiCluster protocol	Balanced energy consumption across WSN has been enabled. Ensures increased data throughput.	Same aggregation level is not maintained over other protocols.

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	Aristides Mpitziopoulos, and Basilis Mamalis-2012			
8	Xin Ming Zhang, En Bo Wang, Jing Jing Xia, and Dan Keun Sung-2013	Neighbor coverage-based probabilistic rebroadcast protocol	Decreases the transmission rate ,reduces the routing overhead and improves the routing performance.	High Computational complexity is resulted.

Conclusion

The present work surveys various methods or protocols for the analysis of energy hole problem and energy efficiency design in Wireless sensor networks (WSN). The presented methods in the above literature demonstrate their inspiration and characteristics of the WSN routing problem primarily for selecting optimal path within time constraint. With this work, the challenges and issues that exist in WSN for the last few years were investigated and described. In addition to each surveyed methods, comparison between each method is shown in comparison table which summarized result of the merits and de-merits of each methods. Therefore the various methods described in the presented survey deals with related issues in WSN whose open issues and research challenges are examined and characterized, as such effective effort on research must have be taken to address these issues.

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