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A Hybrid Sink Positioning Technique for Data Gathering in Wireless Sensor Networks

Prerana Shrivastava, Dr. S. B. Pokle

***Abstract*— In Wireless Sensor Networks (WSN), nodes around the sink would deplete their energy faster, leading to what is called as energy hole around the sink. Multi-hop relaying is the main reason for the energy hole problem which can be avoided by sink repositioning technique. Although sink deployment can provide optimal solution, they are not always feasible since they require precise knowledge of the monitored area. In this paper, we develop a hybrid sink repositioning technique to avoid the energy hole problem. Our technique uses both stationary and moving sinks to gather the data from the sensor nodes. The nodes are categorized into two different groups depending upon the data generation rate and their residual energy.**

Index Terms— **Energy Efficiency, Hybrid, Sink Relocation, Wireless sensor Networks.**

I. INTRODUCTION

A large number of small electromechanical devices with sensing, computing and communication capabilities are included in the wireless sensor networks (WSN). From an extended geographic area, they can be used for collecting sensory information such as temperature information [1]. An emerging technology which has received attention from the research community is comprised in the wireless sensor networks. Normally, sensor networks are self-organizing adhoc systems which consist of several small and low cost devices. They gather and relay information to one or more sink nodes by monitoring the physical environment. Normally, the radio transmission range of the sensor nodes are the orders of magnitude smaller than the geographical extent of the entire network. Therefore, the data needs to be transmitted towards the sink node hop-by-hop in a multi-hop manner. If the amount of data which needs to be transmitted is reduced, then the energy consumption of the network can also be reduced [2]. The factors which affect the performance and reduce the efficiency of the WSN are the computational power, data storage, battery lifetime and the communication bandwidth. It is necessary to consider in the WSN architecture, the network topology, power consumption, data rate and fault tolerance for avoiding the energy consumption and for improving the bandwidth utilization [3].

Energy efficiency is vital in the wireless sensor networks. The sensor nodes act as both data originator and data router. The data traffic follows a many-to-one communication pattern. The nodes which are nearer to the sink have to take heavier traffic load and thus the nodes which are around the sink may deplete their energy quickly which gives rise to energy hole around the sink. If the energy hole arises, then the data transmission to the sink is stopped. Therefore, the lifetime of the network is reduced and much energy of the nodes would be wasted [4]. Some nodes have to transmit more traffic for other nodes in multi-hop transmissions, which is the main reason for the energy hole problem [5].

By sink repositioning, the multi-hop relaying can be avoided. The sink repositioning includes a moving node which has the ability to move around to collect data from sensor nodes [5]. Sink repositioning can be performed in the following ways.

(i) Multiple Sink Deployment

Since the data will always be sent to the closest sink, deploying multiple sinks may decrease the average number of hops a message has to pass through.

(ii) Sink Mobility

WSNs may take the advantage of the mobile capacity, if a sink moves fast enough to deliver data with a tolerable delay.

Hence with the mechanical movements, the mobile sink picks up data from nodes and transports the data. Therefore for the reduction of energy consumption of nodes, this approach trades data delivery latency [8].

(iii) Deploying Multiple Mobile Sinks

In this case, without delay and without causing buffer overflow, the multiple sinks are deployed so that the sensor data can be acquired.

During the regular network operation, relocating the sink is very challenging. During the sink's movement, the fundamental issues are where the sink should go and how the data traffic will be handled. In a multi-hop network, finding an optimal location for the sink is very difficult problem. The following are the two factors which results in the difficulty [9] Firstly the sink can be moved to the potentially infinite possible positions and secondly in order to qualify that interim solution in comparison to the current or previously picked location in the search, a new multi-hop network topology needs to be established for every interim solution considered during the search for an optimal location.

Since employing the sink requires the precise knowledge of the monitored area, they are not always possible even though the sink deployment can provide optimal solution. When accurate position of sensor is available and when nodes have motion capabilities, controlled deployment or online deployment is possible. The developing graph may have different properties during the online deployment. The basic issue in the sensor deployment is controlling the dynamic graph of mobile sensor networks [10].

The energy unbalanced problem is another big challenge in sink deployment. Here the sensors which are closer to the sink are likely to consume their energy much faster than other nodes [11]. When a network consists of multiple clusters, the

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relocation problem is significantly compounded. Without considering the potential impact, a sink cannot choose to wander randomly around its cluster to enhance the intra-cluster network operation [12]. Using the odd pattern of energy depletion or data route setup, first the relocation of the sink has to be motivated even if it is considered as the most efficient network operation for a given traffic distribution and network state at that time. The sink must make sure that no data is lost, when it moves [13]. Using mobile sinks for data gathering has the drawback of buffer overflow problem. The sink has to visit each sensor nodes before its buffer overflow, which depends on the speed of the mobile sink. But it will be difficult to set the optimum speed for the mobile sink to overcome the buffer overflow problem since each sensor node has different buffer sizes and data generation rate. Apart from this problem, the residual energy of the node should also be considered since nodes with low residual energy may deplete their energy before the mobile sink visits.

II. Related Work

Jun Luo et al [8] have investigated the problem of maximum lifetime data collection in WSNs by jointly considering sink mobility and routing. They considered a type of continuously monitoring WSNs whose data generation rates of sensors can be estimated accurately. They also focused on the slow mobility approach and build a unified framework to cover most of the joint sink mobility and routing strategies.

Kemal Akkaya et al. [9] have investigated the potential of sink repositioning for enhanced network performance in terms of energy, delay and throughput. They addressed the issues related to when should the sink be relocated, where it would be moved to and how to handle its motion without negative effect on data traffic. Further they presented two approaches that factor in the traffic pattern for determining a new location of the sink for optimized communication energy and timeliness, respectively. Jesse English et al [12] have argued that changing the position of a sink cannot be pursued without the consideration of the impact on inter-sink connectivity. They presented an efficient algorithm for Coordinated Relocation of sinks (CORE). CORE strives to maintain communication paths among sinks while repositioning individual sinks to better manage the sensors in their vicinity. Mohamed Younis et al [13] have investigated the potential of base-station repositioning for enhanced network performance. They addressed the issues related to when should the base-station be relocated, where it would be moved to and how to handle its motion without any effect on the data traffic. Their approach tracks the distance from the closest hops to the base-station and the traffic density through these hops. When a hop that forward high traffic is further than a threshold, the base-station qualifies the impact of the relocation on the network performance and moves if the overhead is justified. Waleed Alsalih et al [14] have proposed a mobile base station placement scheme for extending the lifetime of the network. In their scheme the life of the network is divided into rounds and base stations are moved to new locations at the beginning of each round. Also they defined and solved a more general problem in which a base station can be placed anywhere in the sensing field. They formulated the problem as an Integer Linear Program (ILP) and used an ILP solver to find a near-optimal placement of the base stations and to find routing patterns to deliver collected data to base stations.

III. Proposed Solution

In this paper, we have developed a hybrid sink positioning technique to achieve the above goals. The following are features of the proposed technique. It uses both stationary and moving sinks to gather the data from the sensor nodes. Initially the sensor nodes are categorized into two groups based on their residual energy and data generation rate. In order to collect the data from urgent sensor nodes, we deploy a stationary sink. Then we determine a set of "relay" nodes such that each urgent node has one relay node. The urgent nodes send their data to the static sink through these relay nodes. In order to collect the data from the "non-urgent" sensor nodes, we deploy a mobile sink which periodically collects the data from the nodes.

A. Sensor Node Classification

The nodes are classified into two different categories based on the following two conditions.

Urgent - If $REi < RE_{th}$ and $GRi > GR_{th}$

Non-Urgent - If $REi > RE_{th}$ and $GRi < GR_{th}$

B. Positioning Relay Nodes near Sink

We have considered a two-tier network in a sensing field V with a static sink N, set of urgent sensors S = {s1, s2…….sn}, and set of relay nodes R = {r1, r2……re}. Every node has a short-range antenna and each sink and relay nodes has a long-range antenna with a transmission distance TD. Short-range antennas can only communicate with short range antennas, and so are long-range antennas. Our objective is to utilize the resource efficient relay nodes with high residual energy in order to relay the sensory data from urgent sensors to N. Initially, the set of urgent sensors S and the set of relay nodes R are randomly deployed in V such that S is densely deployed and R is sparsely deployed. A relay node that is connected to N in the high-tier network is called connected and it is un-connected otherwise. The location of any node in S and R is not known.

C. Mobile Sink Deployment Algorithm

We propose a multiple mobile sink deployment algorithm in order to collect the data from the "non-urgent" sensor nodes. The mobile sinks periodically collect the data from the nodes. Let {v1, v2…….vn}, be set of non-urgent sensors. The sinks identify only the locations of the vi, i=1,2…n, which communicate directly with them and the locations of the other sinks by using the locally available information. Except the neighboring nodes, the sinks do not know the positions of all the sensors in the network. It also knows how many routes are passing through these sensors. Thus at the end of the period, it can determine how many sensors are sending the messages through sensor k, k ∈ Q j.Sink j assumes that there are Zk sensors in the direction of sensor k.

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The unit vector pointing from the sink to sensor i is denoted by Ui. If |RVj| is below a threshold then sink j remains at its present position sj, otherwise moves to sj + RVj.Stmax,

IV. Simulation Results

A. Simulation model and parameters

We have evaluated our Hybrid Sink Repositioning Technique (HSPT) through NS2 simulation [15]. We have used a bounded region of 1000 x 1000 sqm, in which we have placed nodes using a uniform distribution. We assign the power levels to the nodes such that the transmission range and the sensing range of the nodes are all 250 meters. In our simulation, the channel capacity of mobile hosts is set to the same value: 2 Mbps. We have used the distributed coordination function (DCF) of IEEE 802.11 for wireless LANs as the MAC layer protocol. The simulated traffic is Constant Bit Rate (CBR).

B. Performance Metrics

We have compared the performance of the proposed HSPT with mobile base station placement scheme (MBSP) [14]. We evaluate mainly the performance according to the following metrics:

Average end-to-end delay: The end-to-end-delay is averaged over all surviving data packets from the sources to the destinations.

Average Packet Delivery Ratio: It is the ratio of the number of packets received successfully and the total number of packets sent.

C. Results

In this experiment, we vary the number of nodes as 20, 40, 60, 80 and 100.

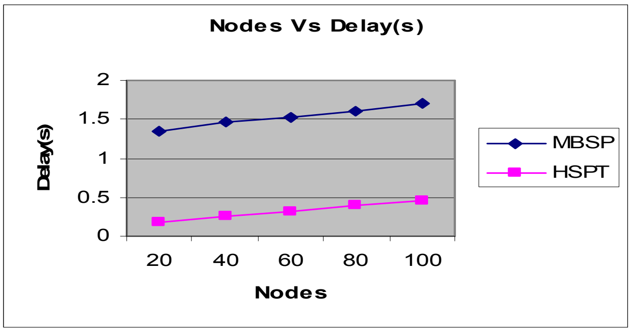

Fig: 1.Node Vs Delay

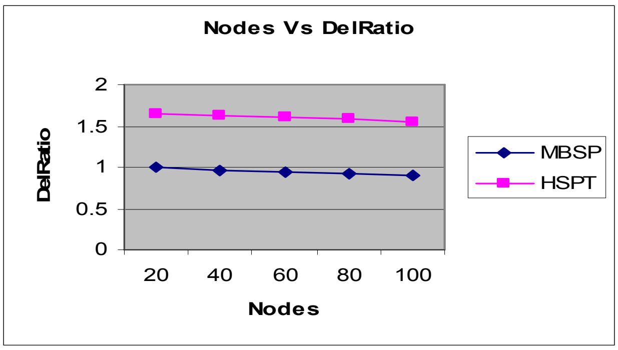

Fig: 2. Node Vs Del Ratio

Fig.1 shows the results of the average end-to-end delay when the number of nodes is varied. It is clear that our HSPT technique achieves less delay than the MBSP scheme. Fig. 2 presents the packet delivery ratio when the nodes are increased. It is clear that HSPT achieves good delivery ratio when compared with the MBSP scheme.

V. Conclusion

In this paper, we have developed a hybrid sink repositioning technique to avoid the energy hole problem. Our technique uses both static as well as mobile sinks to gather the data from the sensor nodes. The nodes are categorized into two different groups based upon their residual energy and data generation rate. In order to collect the data from the depleting sensor nodes, we deploy a static sink within the centre of the network. The relay nodes are selected based on their residual energy and can be changed in each interval. The depleting nodes send their data to the static sink through these relay nodes. In order to collect the data from the other sensor nodes, we use a mobile sink deployment algorithm which collects the data from the nodes.

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AUTHOR BIOGRAPHY

Mrs. Prerana Shrivastava obtained her Bachelor's degree in Electronics Engineering from University of Nagpur, India. Then she obtained her Master's degree in Electronics Engineering and currently pursuing her PhD in Wireless Sensor Networks from Nagpur University, India. She is working as Assistant Professor in Electronics Department at Lokmanya Tilak College of Engineering, University of Mumbai, India. Her specializations include Electromagnetic Wave Theory, Image Processing and Computer Networks. Her current research interests are Wireless Adhoc Networks, Wireless Sensor Networks and Network Security. She has presented papers in the reputed national and international conferences. She is member of ISTE.

Dr. Sanjay. B. Pokle obtained his Bachelor's degree in Electronics and Telecommunication Engineering from Govt. College of Engineering, Pune University, India in 1993.He then obtained his Masters degree in Electronics Engineering and also Ph. D. in Electronics from Visvesvaraya National Institute of Technology Nagpur, India. His research area includes designing aspects of MIMO-OFDM Wireless Communication Systems and Wireless channel Estimation Algorithms. He has published research papers in the reputed national and international Journals and also has presented papers in the reputed national and international conferences. He has guided several projects in the area of signal processing, Digital image processing, Artificial intelligence etc. at post graduation level. He is member of technical societies like ISTE and IEEE. He has total 18 years of experience which includes 3 years industry and 15 years of teaching experience. Presently he is working as Professor and Head of Electronics & Communication Engineering Department, Shri Ramdeobaba College of Engineering and management, Nagpur, India.