International Journal of Emerging Technology in Computer Science & Electronics (IJETCSE)
ISSN: 0976-1353 Volume 24 Issue 4 – MARCH 2017.

Agent Based Efficient Data Gathering Scheme for Wireless Sensor Networks with a Mobile Sink

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***Abstract*— Configuring a WSN with multiple transmitters and receivers consumes very less amount of power during long term data transmission, but, it increases the number of sensor nodes for in-built circuitry power. Thus, the energy optimization models are required to be considered. The energy-efficient data gathering problem in sensor networks has been extensively investigated using the traditional communication scheme. For many monitoring applications with a periodic reporting pattern, a tree-based topology was adopted due to its simplicity and energy efficiency, which were two important factors to consider in resource-constrained networks. In this paper, we intend to study about the novel data gathering techniques for energy constrained sensor networks. We introduce multiple mobile units to gather the neighboring node's details under different scenarios. The variants mobile units contain two phases, namely, Path –length based data gathering module and Agent –based routing selection. The main objective of first phase is to improve life time of the WSN network by finding the most efficient Mobile Units (MU) path. Similarly, the second phase is to select the best routes from the specified Mobile Units. These two schemes are evaluated in terms of Packet delay, Packet Delivery Ratio and Packet Dropping Ratio. The outcomes from the two modules will encourage on how to maintain the energy without compromising the network model i.e. static or dynamic Wireless Sensor Networks.**

Index Terms*— Wireless sensor network; mobile sink; data gathering; logical coordinate system; routing; data aggregation.

I. Introduction

The wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure etc. and to cooperatively pass their data through the network to a base station. Each node is made up of many things a radio transceiver with an internal antenna or connection to an external antenna, a battery or some form of energy harvesting device and an electronic circuit that interfaces the sensor with the energy source. Since each node has limited energy resource, we need efficient methods to minimize the energy loss due to data gathering to maximize the lifetime of the network [1].

Many research works have been carried out in Wireless Sensor Network (WSN), and many models and algorithms have been designed. Some new strategies have been developed afterwards by creating Wireless Sensor Networks (DWSN) to balance the energy consumption among the sensors. WSN may have either movable collector with static sensor nodes or movable sensor nodes with one fixed static base station or may have both movable sensor nodes and movable base station. In case of movable collector, number of it may be one or more [2].

WSN is employed for data collection. The uses of WSNs are smart agriculture, smart environment and smart cities. Several sensors are positioned within network for gathering info. Sink collects info from the network. After getting the information, mobile sink process over it. It's not possible to recharge the node after deploying in the network. It simply indicates nodes aren't reversible. Because of that energy saving is necessary task coming up with WSNs. If the sink is static then the nodes near to the sink die first as they are used every time while forwarding data and it concrete difficulty of "Energy Hole". Owing to that sink is unable to get further data. Therefore researchers include sink mobility to reduce the power consumption [3].

Sinks are moving to gather the data of the network and method over it. Hence sensors don't use energy for transferring info to the device. The moving sink could also be an automobile, animals or automaton that has broadcasting instruments and it directly communicates with nodes that cause optimum information transmission pathway and scale back energy ingestion. We have to plan sink's mobility in advance to reduce the energy consumption. Predefined trajectory is not appropriate for many applications. Thus we use ST protocol by which device travels within the network and accumulate the information while not predefined trajectory [4].

The sink broadcasts the control message at certain point after interval of same time. It uses lower frequency than required for other data gathering protocols. A sink stops at certain point for some time and broadcast control message is called as 'footprints'. This footprint is used to identify node's hope count distance. The logical coordinate system is used in sink-trail protocol which represents the coordinates of the hop count distances from every trail-point. By measuring distance between neighbor nodes and sink node, the next hop is selected [5].

Numerous data collecting schemes based on mobile sink are proposed to avoid the 'hot spot' problem and balance energy consumption, thereby extending network lifetime. However, collecting data with a mobile sink brings a series of problems, such as the trajectory of mobile sink, the transmission delay, the way of senor nodes uploading data to the sink correctly when the latter changes location, etc. Therefore, it has become a research hotspot in WSN. Traditional wireless sensor networks generally use static sinks to collect data of the whole network. It is a simple and direct method, however it may cause the 'hot spot' problem as the nodes surrounding sinks deplete their energy much earlier compared to the remote nodes due to higher data relaying load. One of the effective ways to solve this problem is introducing mobility into WSN [6].

According to the scope of data collection region, data gathering schemes with mobile sinks can be divided into two categories: local data collection with one hop or constraint hops, and the full data collection with multi-hops. In most existing local data collection schemes, sensor nodes upload data to a mobile sink when the latter moves into their communication ranges. It is one of the most energy efficient and reliable ways, but the mobile sink needs to traverse the whole network in order to collect all data. Obviously, it will result in a long delay. What's more, if the mobile sink doesn't move into a sensor node's communication range in time, it may get out of memory and lose sensed data [7].

The full data collection schemes can avoid these problems effectively. In the full data collection schemes, the primary goal is to collect data from the whole network effectively and correctly. However, as the location of the mobile sink changes, how to obtain the location of the sink and upload messages to it correctly are difficult for sensor nodes. Most existing solutions need the mobile sink or source nodes flood their location information or data messages periodically. However, frequent location updating can increase transmission traffic and energy consumption [8].

In WSN there can be two types of transmissions. One is single-hop data transmission and the other is multi-hop data transmission. Single hop transmission technique provides less delay and less energy loss than the multiple mobile sink. In this paper we have proposed an algorithm where we have clustered the nodes on the basis of the transmitting-receiving range of the mobile collector in hexagonal gridding and then have designed a path of traversal for a single mobile data collector [9].

In order to minimize the overhead of location updates, we present a novel data-gathering scheme for WSNs with a single mobile sink. It is based on the following two conclusions. One is that the energy consumption of data collecting is more balanced when adopting a mobile sink. In terms of network lifetime, the best moving trajectory of a mobile sink is along the periphery of the deployment area, while the load near the center is greater. The other is that with the increase of sink's moving trajectory length l, a circular mobility pattern is better than a straight line [10].

The remainder of this paper is organized as in the following sections. Section 2 will describe the related works on data gathering in WSN. Section 3 will present the proposed agent based data gathering method. In Section 4, we will analyze the results of proposed method and compare it with standard data gathering methods. Finally, a brief conclusion will be given in Section 5.

II. RELATED WORK

Cheng et al. considered the problem of collecting a large amount of data from several different hosts to a single destination in a wide-area network. This problem is important since improvements in data collection times in many applications such as wide-area upload applications, high-performance computing applications, and data mining applications are crucial to performance of those applications. Often, due to congestion conditions, the paths chosen by the network may have poor throughput. By choosing an alternate route at the application level, we may be able to obtain substantially faster completion time. This data collection problem is a nontrivial one because the issue is not only to avoid congested link(s), but to devise a coordinated transfer schedule which would afford maximum possible utilization of available network resources. Our approach for computing coordinated data collection schedules makes no assumptions about knowledge of the topology of the network or the capacity available on individual links of the network. This approach provides significant performance improvements under various degrees and types of network congestions. To show this, we give a comprehensive comparison study of the various approaches to the data collection problem which considers performance, robustness, and adaptation characteristics of the different data collection methods. The adaptation to network conditions characteristics are important as the above applications are long lasting, i.e., it is likely changes in network conditions will occur during the data transfer process. In general, our approach can be used for solving arbitrary data movement problems over the Internet. We use the Bistro platform to illustrate one application of our techniques [11].

Hassanein et al. stated that in heterogeneous wireless sensor network (WSN), relay nodes (RNs) are adopted to relay data packets from sensor nodes (SNs) to the base station (BS). The deployment of the RNs can have a significant impact on connectivity and lifetime of a WSN system. This paper studies the effects of random deployment strategies. We first discuss the biased energy consumption rate problem associated with uniform random deployment. This problem leads to insufficient energy utilization and shortened network lifetime. To overcome this problem, we propose two new random deployment strategies, namely, the lifetime-oriented deployment and hybrid deployment. The former solely aims at balancing the energy consumption rates of RNs across the network, thus extending the system lifetime. However, this deployment scheme may not provide sufficient connectivity to SNs when the given number of RNs is relatively small. The latter reconciles the concerns of connectivity and lifetime extension. Both single-hop and multihop communication models are considered in this paper. With a combination of theoretical analysis and simulated evaluation, this study explores the trade-off between connectivity and lifetime extension in the problem of RN deployment. It also provides a guideline for efficient deployment of RNs in a large-scale heterogeneous WSN [12].

Gnawali et al. presented that most sensor networks are used to collect information from the physical world. Examples include sensor networks deployed to monitor micro-climates in agriculture farms and deployments that measure energy consumption in office or residential buildings. The nodes in these networks collect information about the physical world using their sensors and relay the sensor readings to a central base station or server using multi-hop wireless communication. Collecting information reliably and efficiently from the nodes in a sensor network is a challenging problem, particularly due to the wireless dynamics. Multihop routing in a dynamic wireless environment requires that a protocol can adapt quickly to the changes in the network (agility) while the energy-constrains of sensor networks dictate that such mechanisms not require too much communication among the nodes (efficiency). CTP is a collection routing protocol that achieves both agility and efficiency, while offering highly reliable data delivery in sensor networks CTP has been used in research, teaching, and in commercial products. Experiences with CTP have also informed the design of the IPv6 Routing Protocol for Low power and Lossy Networks (RPL) [13].

Lee et al. analyzed most existing geographic routing protocols on sensor networks concentrates on finding ways to guarantee data forwarding from the source to the destination, and not many protocols have been done on gathering and aggregating data of sources in a local and adjacent region. However, data generated from the sources in the region are often redundant and highly correlated. Accordingly, gathering and aggregating data from the region in the sensor networks is important and necessary to save the energy and wireless resources of sensor nodes. We introduce the concept of a local sink to address this issue in geographic routing. The local sink is a sensor node in the region, in which the sensor node is temporarily selected by a global sink for gathering and aggregating data from sources in the region and delivering the aggregated data to the global sink. We next design a Single Local Sink Model for determining optimal location of single local sink. Because the buffer size of a local sink is limited and the deadline of data is constrained, single local sink is capable of carrying out many sources in a large-scale local and adjacent region. Hence, we also extend the Single Local Sink Model to a Multiple Local Sinks Model. We next propose a data gathering mechanism that gathers data in the region through the local sink and delivers the aggregated data to the global sink. Simulation results show that the proposed mechanism is more efficient in terms of the energy consumption, the data delivery ratio, and the deadline miss ratio than the existing mechanisms [14].

Fahmy et al. stated that energy efficiency is critical for wireless sensor networks. The data-gathering process must be carefully designed to conserve energy and extend network lifetime. For applications where each sensor continuously monitors the environment and periodically reports to a base station, a tree-based topology is often used to collect data from sensor nodes. In this work, we first study the construction of a data-gathering tree when there is a single base station in the network. The objective is to maximize the network lifetime, which is defined as the time until the first node depletes its energy. The problem is shown to be NP-complete. We design an algorithm that starts from an arbitrary tree and iteratively reduces the load on bottleneck nodes (nodes likely to soon deplete their energy due to high degree or low remaining energy). We then extend our work to the case when there are multiple base stations and study the construction of a maximum-lifetime data-gathering forest. We show that both the tree and forest construction algorithms terminate in polynomial time and are provably near optimal. We then verify the efficacy of our algorithms via numerical comparisons [15].

III. PROPOSED WORK

The proposed method consists of four modules namely initialization, agent generation, cluster formation and data gathering. The energy-efficient data gathering problem in sensor networks has been extensively investigated using the traditional communication scheme. In Our Proposed System, we intend to study about the novel data gathering techniques for energy constrained sensor networks. We introduce multiple mobile units to gather the neighboring node's details under different scenarios. The variants mobile units contain two phases, namely, Path length based data gathering module and Agent based routing selection. It minimizes the Packet delay and Packet Dropping ratio and maximizes the Packet Delivery Ratio. Also it maintains the energy without compromising the network model.

The architecture of the proposed work is given in the figure 1.

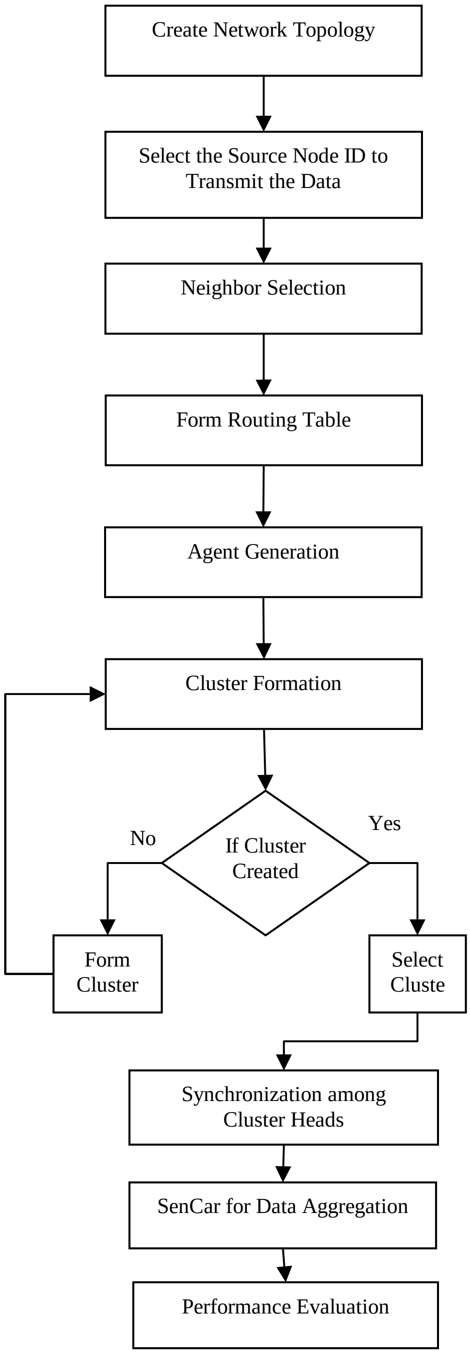

Figure 1. Proposed System Architecture

A. *Initialization Phase*

In the initialization phase, each sensor acquaints itself with all the neighbors in its proximity. If a sensor is an isolated node (i.e., no neighbor exists), it claims itself to be a cluster head and the cluster only contains itself. Otherwise, a sensor, say, si, first sets its status as “tentative” and its initial priority by the percentage of residual energy. Then, si sorts its neighbors by their initial priorities and picks neighbors with the highest initial priorities, which are temporarily treated as its candidate peers. We denote the set of all the candidate peers of a sensor by A. It implies that once si successfully claims to be a cluster head, its up-to-date candidate peers would also automatically become the cluster heads, and all of them form the CHG of their cluster. si sets its priority by summing up its initial priority with those of its candidate peers. In this way, a sensor can choose its favorable peers along with its status decision.

B. *Agent Generation*

In the second module, each sensor determines its status by iteratively updating its local information, refraining from promptly claiming to be a cluster head. We use the node degree to control the maximum number of iterations for each sensor. Whether a sensor can finally become a cluster head primarily depends on its priority. Specifically, we partition the priority into three zones by two thresholds, th and tm (th > tm), which enable a sensor to declare itself to be a cluster head or member, respectively, before reaching its maximum number of iterations. During the iterations, in some cases, if the priority of a sensor is greater than th or less than tm compared with its neighbors, it can immediately decide its final status and quit from the iteration.

We denote the potential cluster heads in the neighborhood of a sensor by a set B. In each iteration, a sensor, say, si, first tries to probabilistically include itself into si:B as a tentative cluster head if it is not in already. Once successful, a packet includes its node ID and priority will be sent out and the sensors in the proximity will add si as their potential cluster heads upon receiving the packet. Then, si checks its current potential cluster heads. If they do exist, there are two cases for si to make the final status decision; otherwise, si would stay in the tentative status for the next round of iteration.

C. *Cluster Formation*

The third module is cluster forming that decides which cluster head a sensor should be associated with. The criteria can be described as follows: for a sensor with tentative status or being a cluster member, it would randomly affiliate itself with a cluster head among its candidate peers for load balance purpose. In the rare case that there is no cluster head among the candidate peers of a sensor with tentative status, the sensor would claim itself and its current candidate peers as the cluster heads. The following is cluster formation algorithm.

```
Input : grid, number_of_column

temp A (number_of_column) % 4
noc Å number_of_column
  if (temp = 0)
    two_col Å noc
    two_col_zigzag(grid,two_col)
  else if(temp = 1)
    two_col Å noc-3
    two_col_zigzag(grid,two_col)
    three_col_path(grid)
  else if(temp = 2)
    two_col Å noc-2
    two_col_zigzag(grid,two_col)
    straight_up(grid,noc-1)
    straight_down(grid,noc)
  else if(temp = 3)
    two_col Å noc-1
    two_col_zigzag(grid,two_col)
    straight_down(grid,noc)
  end
 horizontal_path(grid)
```

D. *Data Gathering*

To perform data collection by TDMA techniques, intra-cluster time synchronization among established cluster heads should be considered. The fourth phase is to synchronize local clocks among cluster heads in a CHG by beacon messages. First, each cluster head will send out a beacon message with its initial priority and local clock information to other nodes in the CHG. Then it examines the received beacon messages to see if the priority of a beacon message is higher. If yes, it adjusts its local clock according to the timestamp of the beacon message.

In our framework, such synchronization among cluster heads is only performed while SenCar is collecting data. Because data collection is not very frequent in most mobile data gathering applications, message overhead is certainly manageable within a cluster. The nearest n is the primary individuals to listen to this message broadcasted via the sink. By matching the message sequence number with the further latest message sequence-number we can find that the message is new or not. When a new message has been received the vector components are going to be modernized with fresh message order number. The node's v is restructured as below. All the elements of v are shifted by one position in left. Once shifting left the hop-count is inflated via one and swaps with the proper most part of path-reference. Currently new trail message is retransmitted with identical M and raised H. This process is repeated for other n_1.

IV. EXPERIMENTAL ANALYSIS

Beacon signal is used in localization of a sensor node and for invoking MDC. For localization sensors can be used as beacon device. Localization algorithms like TPSS algorithm or algorithm depending on multi angulations or tri-lateration can be used. As per the proposed work MDC does not visit every sensor. MDC will visit cluster head only in case cluster head invokes it. In some situation sensors do not have anything to deliver, so MDC doesn't waste its energy visiting every sensor.

Clustering is used. Sensors are arranged in clusters. Cluster head is responsible for collecting data from sensors by polling method in small size cluster .It then perform aggregation of the data and invokes the MDC with its transmission signal. In case of large cluster internal MDC for the respective cluster can be used. Sensors continuously collect data and send data to cluster head which are also equipped with limited memory space, so waiting for MDC to collect data for long time may cause obsolete data and also causes missing of data due to erase process by the sensors.

In static sink and mobile sensor data gathering mechanism, energy requirement is high. Data collection through mobile sink is efficient and energy consumption is less than the earlier method. For sparse network mobile mules works efficiently in sensor visiting and power consumption. Opportunistic data collection is used where a mobile device performs other tasks as well as data collection. This method is mainly used in delay tolerant applications.

MDC visits each and every sensor to collect data by making spanning tree. It maintains spanning tree covering algorithm so that no sensor is left uncovered even if the sensor have not sensed any data. There are many data collecting ways i.e. pull mechanism and push mechanism. In pull mechanism data are transmitted to the sink only when sink requests for it. And in push mechanism data are sent by sensors. The proposed mechanism is combination of the two strategies where both pull and push is used according to the situation.

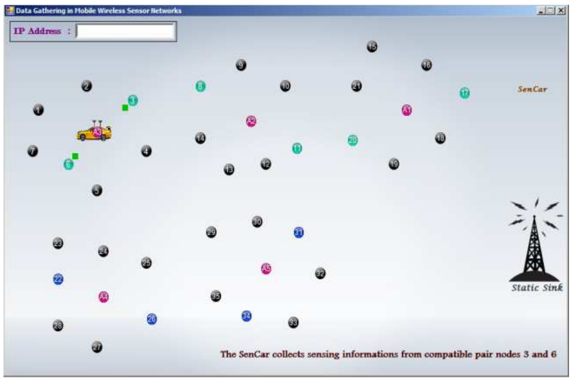

Figure 2. Data Gathering (SenCar) simulation

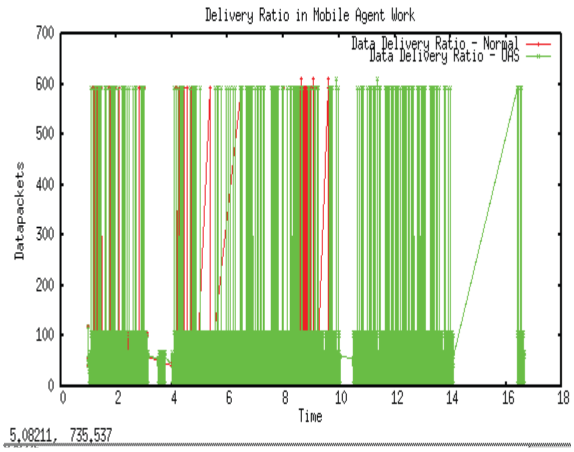

Figure 3. Packet Delivery Ratio

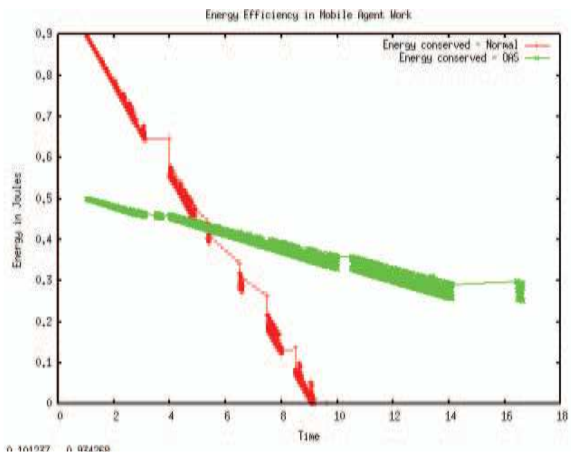

Figure 4. Energy efficiency

The network loss probabilities for both the standard random walk strategy and network coding strategy tend to increase with a larger number of sensor nodes (n = 200), since the number of sensor nodes to be covered by a mobile collector itself increases. The amount of reduction in the network loss probability that we achieve from network coding strategy is much greater than the existing one. For each arrival pattern, the data points are obtained by taking the average of the results under 30 different heterogeneous and spatially-correlated data arrival patterns.

We expect that our reasoning behind the Network coding strategy can be applicable for the design of Markovian random walk-based applications sample topologies of each sensor nodes. In all these simulations, we observe that the network loss probability under our Network coding Algorithm is about 2 times smaller than that of the Distributed optimal Movement Strategy model. In all cases, our coding strategy is consistently better than the standard random walk strategy, and the ratio tends to decrease implying that our strategy is increasingly more advantageous as the buffer size.

V. CONCLUSION

In this paper, we present a novel data gathering scheme for WSNs with a single mobile sink called, virtual binary-tree infrastructure based data gathering scheme, which constructs a virtual binary-tree infrastructure for sensor nodes to inquiry the sink location. The sink moves along the peripheral leaf-areas in a clockwise manner and stops in each leaf-area to collect data. The sojourn time in different areas is based on the total amount of data collected after the sink enters each area. The main contribution of our virtual binary-tree infrastructure based data gathering scheme is to collect the whole network data with less broadcast overhead efficiently.

We also investigate the impact of different structures on the average energy consumption, the maintenance cost, the packet loss rate and the number of packets collected, respectively. And compare the proposed scheme with standard data collection schemes in the simulation. Results show that the agent based data gathering scheme is energy efficient and prolongs the network lifetime significantly with tolerable packet loss rate, especially in large-scale intensive networks.

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