SUFFICIENT DATA GATHERING WITH BALANCED CLUSTERING AND CAPABLE ROUTING FOR WIRELESS SENSOR NETWORK

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Abstract— *Data gathering is a common but critical operation in many applications of wireless sensor networks. Innovative techniques that improve energy efficiency to prolong the network lifetime are highly required. Clustering is an effective topology control approach in wireless sensor networks, which can increase network scalability and lifetime. The framework employs distributed load balanced Clustering and dual data uploading, which is referred to as BC. A distributed balanced clustering (BC) algorithm is proposed for sensors to self-organize themselves into clusters. We used mobile divider for split the data about cluster and cluster head calculation. In contrast to existing clustering methods, our scheme generates multiple cluster heads in each cluster to balance the work load and facilitate dual data uploading. The trajectory planning for Mobile collector is optimized to fully utilize dual data uploading capability by properly selecting polling points in each cluster. By visiting each selected polling point, Mobile collector can efficiently gather data from cluster heads and transport the data to the static data sink. Extensive simulations are conducted to evaluate the effectiveness of the proposed BC schemes.*

Keywords— Clustering; Dual Data Uploading; MIMO; Balanced Clustering

1. Introduction

A wireless sensor network (WSN) 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 main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.

The WSN is built of "nodes" from a few to several hundreds or even thousands, where each node is connected to one sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding. In computer science and telecommunications, wireless sensor networks are an active research area with numerous workshops and conferences arranged each year, for example IPSN, SenSys, and EWSN.

2. RELATED WORKS

2.1 Relay node deployment strategies in heterogeneous WSN

In a 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 and performance evaluation. Both the single-hop and multi hop models represent practical system scenarios. To solve the BECR problem associated with uniform random deployment, we propose two novel random deployment strategies for RNs in both communication models, namely, lifetime-oriented deployment and hybrid deployment. We then analyze and compare the three deployment strategies (uniform, lifetime-oriented, and hybrid). Both theoretical analysis and simulated evaluation show that the new deployment strategies can effectively alleviate the BECR problem and extend the system lifetime. To the best of our knowledge, this is the first effort to optimize the random device deployment (by the density function) in order to extend the lifetime of a large-scale heterogeneous WSN. When the number of RNs is large, the hybrid deployment is the same as the lifetime deployment, and they both significantly outperform the connectivity-oriented deployment. This paper provides a guideline for random deployment of typical large-scale heterogeneous WSNs

2.2 Energy-efficient clustering in lossy wireless sensor networks

The clustering scheme for WSNs with mobile collectors, with the objective to maximizing network lifetime (number of rounds of data collection until the first node dies), by taking the lossy nature of wireless links into consideration. We first give a network model for lossy WSNs, formulate the one-hop clustering problem under lossy links into an integer program, and prove that the problem is NP-hard. We then present a heuristic algorithm to construct one-hop clusters in a distributed manner. We further extend the clustering algorithm to form k-hop clusters, such that a sensor node selects the cluster head to which it has the most reliable path in its k-hop neighborhood. As will be seen, for small WSNs, the clusters derived by the proposed algorithms are very close to the optimal results obtained by solving the integer program. To evaluate the performance of the proposed algorithms in large WSNs, we have conducted extensive simulations based on a realistic link model that captures the lossy characteristic of WSNs. The results show that the network lifetime can be extended by up to 89% via employing the proposed algorithms, compared with the results given by classical HEED clustering algorithm. We formulated the problem into an integer program and proved its NP-hardness. We formulated the problem into an integer program and proved its NP- hardness. We then introduced a cluster head selection metric that accounts for both residual energy of a node and the link qualities in its neighborhood. Based on this metric, we proposed two distributed algorithms to construct one hop and k-hop clusters, respectively. We have conducted extensive simulations and the results show that the proposed algorithms can significantly improve the packet reception ratio, reduce overall energy consumption and extend network lifetime compared to HEED algorithms, and at the same time maintain good scalability.

2.3 Data gathering mechanism with local sink in geographic routing for wireless sensor networks

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. 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 large-scale local and adjacent region. Hence, we also extend the Single Local Sink Model to a Multiple Local Sinks Model. To address this issue, we first introduce the concept of a local sink in geographic routing. The Local sink is an entity which collects locally data in a local and adjacent region and delivers the aggregated data to a global sink. This local sink is one sensor node selected by the global sink, based on location information of general sensor nodes in the region. Because the buffer size of a local sink is limited and the deadline of data is constrained, a local sink is capable of carrying out many sources in a large-scale local and adjacent region. We next propose an efficient mechanism that gathers data in the region through the local sink and delivers the aggregated data to the global sink.

2.4 Distributed clustering in ad-hoc sensor networks

Prolonged network lifetime, scalability, and load balancing are important requirement5 for many ad- hoc sensor network applications. Clustering sensor nodes is an effective technique for achieving these goals. In this work, we propose B new energy-efficient approach for clustering nodes in adhoc sensor networks. Based on this approach, we present a protocol, HEED (Hybrid Energy- Efficient Distributed clustering), that periodically selects cluster heads according to a hybrid of their residual energy, such as nude proximity to its neighbors or node degree. HEED does not make any assumptions about the distribution or density of nudes, or about node capabilities, e.g., location-awareness. The clustering process terminates in O(1) iterations. And not depend on the network topology or sue. The protocol incurs low overhead in terms of processing cycles and messages exchanged. It also achieves fairly uniform cluster head distribution across the network. A careful selection of the secondary clustering parameter can balance load among cluster heads. Our simulation results demonstrate that HEED outperforms weight-based clustering protocols in terms of several cluster. We also apply our approach to a simple application to demonstrate its effectiveness in prolonging the network lifetime and supporting data aggregation. We are currently investigating cluster size constraints in HEED. We are also incorporating HEED in a multi-hop power-aware routing model for sensor networks with multiple external mobile observers.

2.5 TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks

Wireless sensor networks are expected to find wide applicability and increasing deployment in the near future. In this paper, we propose a formal classification of sensor networks, based on their mode of functioning, as proactive and reactive networks. Reactive networks, as opposed to passive data collecting proactive networks, respond immediately to changes in the relevant parameters of interest. We also introduce a new energy efficient protocol, TEEN (Threshold sensitive Energy Efficient sensor Network protocol) for reactive networks. We evaluate the performance of our protocol for a simple temperature sensing application. In terms of energy efficiency, our protocol has been observed to outperform existing conventional sensor network protocols. Time critical data reaches the user almost instantaneously. So, this scheme is eminently suited for time critical data sensing applications.

Message transmission consumes much more energy than data sensing. So, even though the nodes sense continuously, the energy consumption in this scheme can potentially be much less than in the proactive network, because data transmission is done less frequently. The soft threshold can be varied, depending on the criticality of the sensed attribute and the target application. A smaller value of the soft threshold gives a more accurate picture of the network, at the expense of increased energy consumption. Thus, the user can control the trade-off between energy efficiency and accuracy. In this paper, we present a formal classification of sensor networks. We also introduce a new network protocol, TEEN for reactive networks. TEEN is well suited for time critical applications and is also quite efficient in terms of energy consumption and response time. It also allows the user to control the energy consumption and accuracy to suit the application.

In previous work, we used a new clustering algorithm and event-driven cluster head rotation mechanism are also proposed based on this topology.

The clustering information announcement message and clustering acknowledgment message were designed according to RFC and original RPL message structure. An Energy-Efficient Heterogeneous Ring Clustering (E2HRC) routing protocol for wireless sensor networks is then proposed and corresponding routing algorithms and maintenance methods are established.

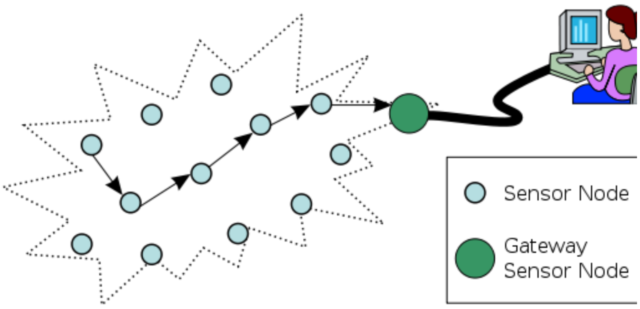
To overcome the difficulties in finding routes in case of topology defects many protocols that extend geographic routing have been proposed. Here we have limited wireless communication range. Therefore, limited communication range may pose a challenge for data collection from all sensor nodes.

Ring routing algorithm is the worst routing algorithm when node density is low. This algorithm has less energy consumption .Here we want to achieve High energy consumption. And more energy efficiency. The main motivation is to utilize distributed clustering for scalability, to employ mobility for energy saving and uniform energy consumption, and to exploit Multiple- Input and Multiple-Output (MU-MIMO) technique for concurrent data uploading to shorten latency. The main contributions of this work can be summarized as follows.

We propose a mobile data collection framework, named Balanced Clustering (BC).
The main motivation is to utilize distributed clustering for scalability, to employ mobility for energy saving and uniform energy consumption.
We propose a distributed algorithm to organize sensors into clusters, where each cluster has multiple cluster heads.

Second, multiple cluster heads within a cluster can collaborate with each other to perform energy efficient inter-cluster transmissions.
Third, we deploy a mobile collector with two antennas to allow concurrent uploading from two cluster heads by using MIMO communication.

We used mobile divider for split the data about cluster and cluster head calculation



2.6 Constructing maximum- lifetime data- gathering forests in sensor networks

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. We prove that this problem is NP-complete, and hence too computationally expensive to solve exactly. By exploiting the unique structure of the problem, we obtain an algorithm that starts from an arbitrary tree and iteratively reduces the load on bottleneck nodes, i.e., nodes likely to soon deplete their energy due to either high degree or low remaining energy. We show that the algorithm terminates in polynomial time and is provably "near optimal" (i.e., close to optimal; the precise definition will be given in Section IV-A). In many sensor network applications, there may be multiple base stations to which the sensor nodes report. Each base station selects a group of sensors to construct a "local" data- gathering tree. We assume that the base stations have no energy constraint. We thus extend the tree construction problem to construct a data gathering forest for a network with multiple base stations. Each base station should construct a tree that does not intersect with trees constructed by other base stations, and the subset of nodes a base station chooses to construct a tree is not fixed. Hence, it is infeasible to run the tree construction algorithm independently at each base station. This is analogous to network clustering, which cannot be executed independently at each cluster head. Moreover,

as will be shown in the paper, running the original tree construction algorithm iteratively could result in poor overall performance. Thus, we need to intelligently extend our framework to construct a maximum-lifetime data-gathering forest.

2.7 Adaptive data collection strategies for lifetime-constrained wireless sensor networks

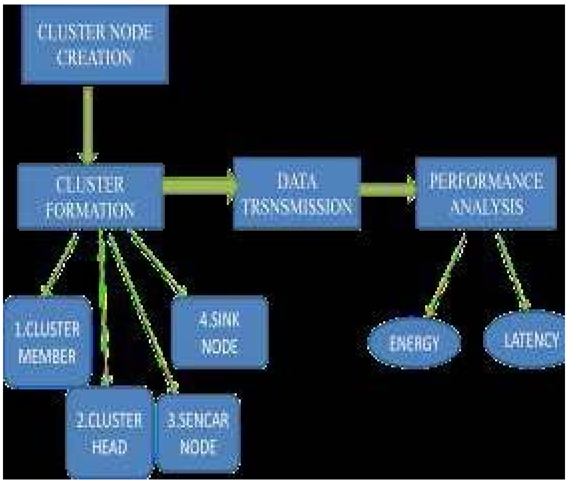
The investigate data collection strategies in lifetime-constrained wireless sensor networks. Given a network lifetime requirement, we are interested in determining which sensor readings to send to the base station with an objective of minimizing the deviations of the readings observed by the base station over the network lifetime. Our contributions are as follows: . We formulate the lifetime-constrained data collection problem in sensor networks. An offline algorithm is developed to compute the optimal data update strategy. . We propose an adaptive strategy that makes data update decisions on the fly based on sensor readings to meet network lifetime requirements. The basic strategy applies directly to individual data collection where the application monitors the reading of an individual sensor node. It is also extended to deal with aggregate data collection where the application continuously requests an aggregate form of sensor data (e.g., the average reading of all sensor nodes). We develop two methods, History and Expected, for the adaptive strategy to cope with message losses in wireless transmission. The key idea is to take into consideration the possibility of update losses in estimating the importance of sensor readings. In connection with the adaptive strategy for aggregate data collection, we develop an algorithm to allocate the numbers of updates allowed to be sent by the sensor nodes based on their topological relations. The goal is to make full use of the energy budgets of the sensor nodes to improve the quality of collected data. We conduct an experimental evaluation using a wide range of real data traces for both individual and aggregate data collections. The results show that, compared to the periodic strategy, the proposed adaptive strategies significantly improve the accuracy of data collected by the base station over the network lifetime.

3. Layer Load Balanced Clustering Algorithm

The distributed load balanced clustering algorithm at the sensor layer. The essential operation of clustering is the selection of cluster heads. To prolong network lifetime, we naturally expect the selected cluster heads are the ones with higher residual energy. Hence, we use the percentage of residual energy of each sensor as the initial clustering priority.
Assume that a set of sensors, denoted by S={ s1;s2;...;sn}, are homogeneous and each of them independently makes the decision on its status based on local information. After running the LBC algorithm, each cluster will have at most M (1) cluster heads, which means that the size of CHG of each cluster is no more than M. Each sensor is covered by at least one cluster

head inside a cluster. The LBC algorithm is comprised of four phases:

(1) Initialization; (2) Status claim; (3) Cluster forming and (4) Cluster head synchronization. Next, we describe the operation through an example in Fig. 3, where a total of 10 sensors (plotted as numbered circles in are labelled with their initial priorities and the connectivity among them is shown by the links between neighbouring nodes. 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.



3.1Initialization

Each sensor acquaints itself with all the neighbors in its proximity. If a sensor is an isolated node 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. The neighbors with the highest initial priorities, which are temporarily treated as its candidate peers.

3.2 Status Claim

Each sensor determines its status by iteratively updating its local information, refraining from promptly claiming to be a cluster head. The node degree use to control the maximum number of iterations for each sensor. Whether a sensor can finally become a cluster head primarily depends on its priority. The priority is partitioned 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.

3.3Cluster Forming

A sensor with tentative status or being a cluster member, it would randomly affiliate itself with a cluster head among its candidate peer.
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.
Each cluster has multiple cluster heads and sensors are affiliated with different cluster heads in the two clusters.

4. Cluster Head Selection

The cluster head layer, aforementioned the multiple cluster heads in a CHG coordinate among cluster members and collaborate to communicate with other CHGs. Hence, the inter-cluster communication in LBC is essentially the communication among CHGs. By employing the mobile collector, cluster heads in a CHG need not to forward data packets from other clusters. Instead, the inter-cluster transmissions are only used to forward the information of each CHG to Mobile collector. The CHG information will be used to optimize the moving trajectory of Mobile collector, which will be discussed in the next section. For CHG information forwarding, the main issue at the cluster head layer is the inter-cluster organization to ensure the connectivity among CHGs.

The inter-cluster organization is determined by the relationship between the inter-cluster transmission range Rt and the sensor transmission range Rs. Clearly, Rt is much larger than Rs. It implies that in a traditional single- head cluster, each cluster head must greatly enhance its output power to reach other cluster heads. However, in LBC the multiple cluster heads of a CHG can mitigate this rigid demand since they can cooperate for inter- cluster transmission and relax the requirement on the individual output power. In the following, we first find the condition on Rt that ensures inter-cluster connectivity, and then discuss how the cooperation in a CHG achieves energy saving in output power.

cluster heads in a CHG collaborate for energy-efficient inter-cluster communication. We treat cluster heads in a CHG as multiple antennas both in the transmitting and receiving sides such that an equivalent MIMO system can be constructed.

5. Trajectory Planning

How to optimize the trajectory of Mobile collector for the data collection tour with the CHG information, which is referred to as the mobility control at the Mobile collector layer. As mentioned, Mobile collector would stop at some selected polling points within each cluster to collect data from multiple cluster heads via single-hop transmissions. Thus, finding the optimal trajectory for Mobile collector can be reduced to

finding selected polling points for each cluster and determining the sequence to visit them.

The case that Mobile collector is equipped with two antennas, as it is not difficult to mount two antennas on Mobile collector, while it likely becomes difficult and even infeasible to mount more antennas due to the constraint on the distances between antennas to ensure independent fading. Note that each cluster head has only one antenna.

The multiple antennas of Mobile collector, which act as the receiving antennas in data uploading, make it possible for multiple cluster heads in a CHG to transmit distinct data simultaneously. To guarantee successful decoding when Mobile collector receives the mixed streams, we need to limit the number of simultaneous data streams to no more than the number of receiving antennas. In other words, since Mobile collector is equipped with two receiving antennas, at most two cluster heads in a CHG can simultaneously send data to Mobile collector in a time slot.

Hence, an equivalent 2*2 MIMO system for an uplink transmission is formed, which achieves spatial multiplexing gain for higher data rate. With such concurrent transmissions, data uploading time can be greatly reduced.

If there are always two cluster heads that simultaneously upload their data to Mobile collector in each time slot, data uploading time can be cut into half in the ideal case.

6. Data Collection

When there are time constraints on data messages. In practice, it is common for some emergent data messages to be delivered within a specified deadline. If the deadline has expired and the message is yet to arrive at the destination, it would carry less value and cause performance degradation. In mobile data collection with dynamic deadline was considered and an earliest deadline first algorithm was proposed. In their solution, the mobile collector would visit the nodes with messages of the earliest deadline. Here, we extend and adapt their solutions to the clustered network. Our method is described in the following. First, the cluster heads collect data messages and calculate a deadline by averaging all the deadlines from messages in the cluster. All the clusters then forward their deadline information to Mobile collector. The Mobile collector selects the cluster with the earliest average deadline and moves to the polling point to collect data via MU-MIMO transmissions. After Mobile collector finishes data gathering, it checks to see whether collecting data from the next polling point would cause any violations of deadline in its buffer. If yes, it immediately moves back to the data sink to upload buffered data and resumes data collection in the same way. By prioritizing messages with earlier deadlines, Mobile collector would do its best to avoid missing deadlines.The results show that LBC-DDU can greatly reduce energy consumptions by alleviating routing burdens on nodes and balancing workload among cluster heads, which achieves 20 percent less data collection time compared to SISO mobile data gathering and over 60 percent energy saving on cluster heads. We have also justified the energy overhead and explored the results with different numbers of cluster heads in the framework.

7. CONCLUSION

We established a heterogeneous ring communication topology proposed a related clustering algorithm for this topology, and built the E2HRC routing protocol to improve original RPL performance in this study. The proposed method yield better average energy consumption and overall performance than RPL while balancing the energy consumption of the whole wireless sensor network. We also designed a messaging structure for clustering and routing and verified that both protocols are efficient and effective.The load balanced clustering- dual data uploading framework for data gathering in WSN is proposed in this paper. It consist of sensor layer, cluster head layer and Sensor layer. It employs distributer load balanced clustering for sensor self-organization, adopts collaborative inter-cluster communication for energy-efficient Transmission among cluster Head Groups, uses, dual data uploading for fast data collection, andoptimizes sensors mobility to fully enjoy the benefits of MIMO. Our performance study demonstrates the effectiveness of the proposed framework. The result shows that LBC-DDU cangreatly reduce energy consumptions by alleviating routing burdens on nodes and balancing workload among cluster heads.

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