Mobile Data Gathering with Load Balanced Clustering and Dual Data Uploading in Wireless Sensor Networks

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Abstract—In this paper, a three-layer framework is proposed for mobile data collection in wireless sensor networks, which includes the sensor layer, cluster head layer, and mobile collector (called SenCar) layer. The context employs distributed load balanced clustering and dual data uploading, which is discussed to as LBC-DDU. The neutral is to achieve good scalability, long network lifetime and low data collection latency. At the sensor layer, a distributed load balanced clustering (LBC) algorithm is proposed for sensors to self-organize themselves into clusters. In variance to existing clustering methods, our scheme generates multiple cluster heads in each cluster to balance the work load and facilitate dual data uploading. At the cluster head layer, the inter-cluster transmission range is carefully chosen to security the connectivity among the clusters. Multiple cluster heads within a cluster collaborate with each other to perform energy-saving inter-cluster communications. Complete intercluster transmissions, cluster head information is forwarded to SenCar for its moving course planning. At the mobile collector layer, Sen Car is equipped with two antennas, which allows two cluster heads to concurrently upload data to SenCar in respectively time by applying multi-user multiple-input and multiple-output (MU-MIMO) technique. The course planning for SenCar is enhanced to fully utilize dual data uploading capability by properly selecting polling points in each cluster. By visiting each selected polling point, SenCar can efficiently gather data from cluster heads and transport the data to the static data sink.

KEYWORDS—Wireless sensor networks (WSNs), data collection, load balanced clustering, dual data uploading, multi-user multiple-input and multiple-output (MU-MIMO) mobility control, polling point

I.INTRODUCTION

Mobile computing is a generic term that refers to a variety of devices that allow people to access data and information from wherever they are. Sometimes referred to as "human-computer interaction," mobile computing transports data, voice and video over a network via a mobile device. The spread of the implementation for low-cost, low-power, multifunctional sensors has complete wireless sensornetworks (WSNs) a projecting data collectionparadigm for extracting local events of interests. In such applications, sensors are generally densely deployed and randomly distributed over a detecting field and left unattended after being deployed, which makes it difficult to recharge or replace their batteries. Subsequently sensors form into independent organizations, those sensors nearby the data sink typically reduce their batteries much faster than others due to more relaying traffic. When sensors aroundthe data sink reduces their energy, network connectivity and coverage may not be definite. Due to these constraints, it is critical to design an energy-efficient statistics collection scheme that devours energy consistently across the sensing field to achieve long network lifetime.as sensing data in about applications are time-sensitive, data collection may be required to be performed within a specified time frame. Then, an efficient, large-scale data collection scheme should aim at good scalability, long network lifetime and low data latency.

Some approaches have been proposed for efficient data collection in the works, based on the focus of these works, we can roughly divide them into three types. The first category is the improved relay routing in which data are relayed among sensors. Also relaying, some other factors, such as load balance, schedule pattern and data redundancy, are also considered. The second category organizes sensors into clusters and allow collection heads to take the concern for forwarding data to the data sink. Clustering is particularly useful for applications with scalability requirement and is very current in local data aggregation then it can reduce the collisions and balance load among sensors.we propose a three-layer mobile data collection framework, named Load Balanced Clustering and Dual Data Uploading (LBC-DDU). The main motivation is to apply distributed clustering for scalability, to employ mobility for energy saving and uniform energy consumption, and to exploit Multi-User Multiple-Input and Multiple-Output (MUMIMO) technique for concurrent data uploading to shorten latency.

2.RELATED WORKS

2.1 Relay Directing and Clustering System:

Relay routing visits a simple and effective approach to routing communications to the data sink in a multi-hop mode. Created a coordinated transfer list by choosing alternative routes to avoid blockings. considered the construction of a maximum-lifetime data gathering tree by designing an algorithm that starts from a chance tree and iteratively reduces the load on jam nodes. Considered deployments of relay nodes to extend network lifetime. Evaluated collection tree protocol (CTP). CTP computes wireless routes adaptive to wireless link status and satisfies reliability, robustness, efficiency and hardware independence requirements. When some nodes on the critical path are subject to energy reduction, data collection concert will be depreciated.

The correlation of recognizing data and dynamically partitioned the sensor nodes into clusters. The cluster heads utilize the spatiotemporal correlation to minimize the readings for energy saving. Then, traditional single-head clustering systems may not be compatible with MU-MIMO. Consequently, for generality, we propose a load-balanced multi-head clustering algorithm in this paper.

2.2 Mobile Data Groups:

Compared with data collection via a static sink, introducing mobility for data collection enjoys the benefits of balancing energy consumptions in the network and connecting disconnected regions. considered mobility under random walk where the mobile collector picks up data from nearby sensors, buffers and finally offloads data to the wired access point. But random trajectory cannot guarantee latency constraints. Which is required in many applications. more proposed to control data mules to traverse the sensing field along parallel straight lines and collect data from nearby sensors with multi-hop transmissions. This scheme works well in a uniformly distributed sensor network. To achieve more flexible data gathering tour for mobile collectors, proposed an efficient moving path planning algorithm by determining some uploading to the mobile collector to greatly reduce data collection latency. the locations of the mobile collector are given, we can enable MU-MIMO.

turning points on the straight lines, which is adaptive to the sensor distribution and can effectively avoid problems on the path. They alternatively proposed a single-hop data gathering scheme to track the perfect uniformity of energy consumption among sensors. Where a mobile collector called SenCar is optimized to stop at some locations to gather data from sensors in the proximity via single-hop transmission. The work was more extended in to optimize the data gathering expedition by exploring the balance between the shortest moving expedition of SenCar and the full utilization of concurrent data uploading among sensors. proposed an algorithm to study the scheduling of mobile elements such thatthere is no data loss due to buffer flow. Though these works consider utilizing mobile collectors, latency may be increased due to data transmission and mobile collector’s traveling time. Hence, we exploit MU-MIMO to reduce data transmission time for mobile data group.

2.3 MU-MIMO in WSNs:

The feasibility of employing MIMO techniques in wireless sensor networks is future. Due to difficulties to base multiple antennas on a single sensor node, MIMO is adopted in WSNs to seek cooperation’s from multiple nodes to achieve diversity and reduce bit error rate. An overview of MIMO-based it is not difficult to deploy two antennas on the mobile collector, when a compatible pair of transmitting nodes.

3.SYSTEM OVERVIEWS

The sensor layer is the bottom and basic layer. For generality, we do not make any assumptions on sensor distribution or node capability**.** Such as location-awareness. Each sensor is assumed to be able to communicate only with its neighbor, the nodes within its transmission range. During initialization, sensors are self-organized into clusters. Each sensor decides to be either a cluster head or a cluster member in a distributed manner. In the end, sensors with higher residual energy would become cluster heads and each cluster has at most M cluster heads, where M is a system parameter. For convenience, the multiple cluster heads within a cluster are called a cluster head group (CHG), with each cluster head being the peer of others. The algorithm constructs clusters such that each sensor in a cluster is 1-hop away from at least one cluster head. The benefit of such organization is that the intracluster aggregation is limited to a single hop. In the case that a sensor may be covered by multiple cluster heads in a CHG, it can be optionally affiliated with one cluster head for load balancing. To avoid collisions during data aggregation, the CHG adopts time-division-multiple-access (TDMA) based technique to coordinate communications between sensor nodes. Right after the cluster heads are elected, the nodes synchronize their local clocks via beacon messages.

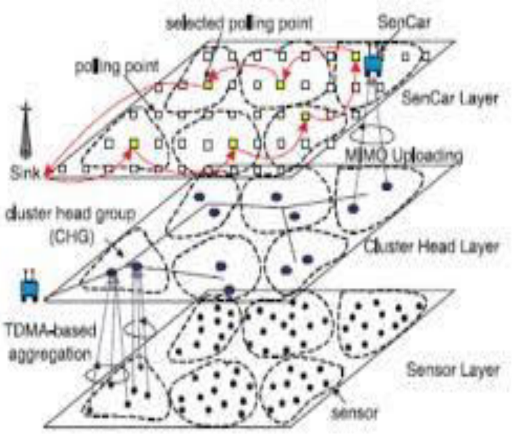

Fig.1.1 LBC-DDU framework

4.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.

4.1 Initialization:

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, is, first sets its status as "tentative" and its initial priority by the percentage of residual energy. Then, is sorts its neighbors by their initial priorities and picks M −1 neighbor 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 is 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. Sets its priority by summing up its initial priority with those of its candidate peers.

4.2 Status Claim

In the second phase, each sensor determines its status by iteratively updating its local information, refraining from prompt claim 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, τh and τm ($\tau h > \tau m$), 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 τh or less than τm compared with its neighbors, it can immediately decide its final status and quit from the iteration.

Algorithm: Cluster Creation

1: if My. Status=cluster head then My. cluster head My.id;

2: else

3: recv_pkt ();

4: My.B Fnl_N (My.B);

5: if My.B $\neq \phi$ then

6: My. status cluster_member;

7: My. cluster_head Rand_one (My. B).id;

8: send_pkt (3, My.id, My.cluster_head, cluster_member, My.init_prio);

9: else

10: My.status cluster_head;

11: My. cluster_head My.id;

12: snd_pkt (2, My.id, ID_List (My.A), cluster_head, My.prio)

4.3 Cluster Forming:

The third phase 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 details are given in Algorithm 3. Fig. 3(d) shows the final result of clusters, where each cluster has two cluster heads and sensors are affiliated with different cluster heads in the two clusters. In case a cluster head is running low on battery energy, clustering is needed. This process can be done by sending out a re-clustering message to all the cluster members. Cluster members that receive this message switch to the initialization phase to perform a new round of clustering.

4.4 Organization among Cluster Heads:

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.

5.CLUSTER HEAD LAYERS

The multiple cluster heads in a CHG coordinate among cluster members and collaborate to communicate with extra CHGs. Hence, the inter-cluster communication in LBC-DDU 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 SenCar. The CHG information will be used to optimize the moving trajectory of SenCar, 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.

5.1 Inter-cluster Communications:

We discuss how cluster heads in a CHG collaborate for energy-efficientinter-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. The self-driven cluster head in a CHG can either coordinate the local information sharing at the transmitting side or act as the destination for the cooperative reception at the receiving side. Each collaborative cluster head as the transmitter encodes the transmission sequence according to a specified space-time block code (STBC) to achieve spatial diversity. Compared to the single-input single-output (SISO) system, that a MIMO system with spatial diversity leads to higher reliability given the same power budget. An alternative view is that for the same receive sensitivity.

6.SENCAR LAYER

We focus on how to optimize the trajectory of SenCar for the data collection tour with the CHG information, which is referred to as the mobility control at the SenCar layer. As mentioned third, SenCar 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 SenCar can be reduced to finding selected polling points for each cluster and determining the sequence to visit them.

6.1 MU-MIMO Uploading:

Where π is a specified schedule, scheduling pair i$\in$ π consists of cluster heads a and b,i and pi are the selected polling point and the set of candidate polling points for scheduling pair i, respectively, and Ci (a,b) is the achieved 2×2 MIMO uplink capacity used for scheduling pair i when SenCar is positioned ati. Once the selected polling points for each cluster are chosen, SenCar can finally determine its trajectory. The moving time on the trajectory can be reduced by a proper visiting sequence of selected polling points. Since SenCar departs from the data sink and also needs to return the collected data to it, the trajectory of SenCar is a route that visits each selected polling point once. This is the well-known traveling salesman problem (TSP). Since SenCar has the knowledge about the locations of polling points, it can utilize an approximate or heuristic algorithm for the TSP problem to find the shortest moving trajectory among selected polling points.

6.2Load Balance and Energy Distributions

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 SenCar. The SenCar selects the cluster with the earliest average deadline and moves to the polling point to collect data via MUMIMO transmissions. After SenCar 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, SenCar would do its best to avoid missing deadlines.

7.PERFORMANCEASSESSMENTS

we evaluate the performance of our framework and compare it with other schemes. Since the main focus of this paper is to explore different choices of data collection schemes, for fair comparison, we assume all the schemes are implemented under the same duty-cycling MAC strategy. The first scheme for comparison is to relay messages to a static data sink in multihops and we call it Relay Routing. Since nodes with higher battery energy provide more robustness and error immunity, sensors select the next hop neighbor with the highest residual energy whileforwarding messages to the sink. Once some nodes on a routing path consume too much energy, an alternative route will be chosen to circumvent these nodes. In this way, the relay routing method can provide load balance among nodes along the routing path.

7.1 Data Collection with Time Constraints:

In this sub section, we demonstrate our proposed framework when data messages have time constraints to be delivered. The percentage of data messages that miss their deadlines and the impact of time constraints on traveling cost of SenCar. To examine the effectiveness of the proposed algorithm in Section 6.3, we set the message deadline to be uniformly randomly distributed over and change from 60 mins to 180 mins. Therefore, the mean of deadline is from 30 mins to 90 mins. The number of nodes n is set to 200 and the side length of sensing field l varies from 100 to 300 with an increment of 50.

8.CONCLUSIONS AND FUTURE WORKS

we have proposed the LBC-DDU framework for mobile data collection in a WSN. It consists of sensor layer, cluster head layer and SenCar layer. It employs distributed load balanced clustering for sensor self-organization, adopts collaborative intercluster communication for energy-efficient transmissions among CHGs, uses dual data uploading for fast data collection, and optimizes SenCar's mobility to fully enjoy the benefits of MUMIMO. Our performance study demonstrates the effectiveness of the proposed framework. 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% less data collection time compared to SISO mobile data gathering and over 60% 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.

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