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Sencar Based Load Balanced Clustering With Mobile Data Gathering In Wireless Sensor Networks

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Abstract: **The wireless sensor networks consist of static sensors, which can be deployed in a wide environment for monitoring applications. While transmitting the data from source to static sink, the amount of energy consumption of the sensor node is high. This results in reduced lifetime of the network. Some of the WSN architectures have been proposed based on Mobile Elements such as three-layer framework is for mobile data collection, which includes the sensor layer, cluster head layer, and mobile collector layer (called SenCar layer). This framework employs distributed load balanced clustering and dual data uploading, it is referred to as LBC-DDU. In the sensor layer a distributed load balanced clustering algorithm is used for sensors to self-organize themselves into clusters. The cluster head layer use inter-cluster transmission range it is carefully chosen to guarantee the connectivity among the clusters. Multiple cluster heads within a cluster cooperate with each other to perform energy-saving in the inter-cluster communications. Through this transmissions cluster head information is send to the SenCar for its moving trajectory planning. This is done by utilizing multi-user multiple-input and multiple-output (MU-MIMO) technique. Then the results show each cluster has at most two cluster heads. LBC-DDU achieves higher energy saving per node and energy saving on cluster heads comparing with data collection through multi-hop relay to the static data sinks.**

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

I INTRODUCTION

A wireless sensor network (WSN) consists of a large number of sensors which are densely deployed over a large area. Each sensor monitors a physical environment and communicates via wireless signals with the advancements in hardware miniaturization and wireless communication technologies. WSNs have been used in various applications such as education, warfare, and traffic monitoring. Regardless of the applications, extending the network lifetime is a critical issue in WSNs.

The proliferation of the implementation for low-cost, low-power, multifunctional sensors has made wireless sensor networks (WSNs) a prominent data collection paradigm for extracting local measures of interests. In these applications, sensors are generally densely deployed and randomly scattered over a sensing field and left unattended after being deployed, which make it difficult to recharge or replace their batteries. After sensors form into autonomous organizations, those sensors near the data sink typically deplete their batteries much faster than others due to more relaying traffic. When sensors around the data sink deplete their energy, network connectivity and coverage may not be guaranteed. Due to these constraints, it is crucial to design an energy-efficient data collection scheme that consumes energy uniformly across the sensing field to achieve long network lifetime. Furthermore, as sensing data in some applications are time-sensitive, data collection may be required to be performed within a specified time frame. Therefore, an efficient, large-scale data collection scheme should aim at good scalability, long network lifetime and low data latency.

Several approaches have been proposed for efficient data collection in the literature, see, for example. Based on the focus of these works, we can roughly divide them into three categories. The first category is the enhanced relay routing, in which data are relayed among sensors. Besides relaying, some other factors, such as load balance, schedule pattern and data redundancy, are also considered. The second category organizes sensors into clusters and allows cluster heads to take the responsibility for forwarding data to the data sink. Clustering is particularly useful for applications with scalability requirement and is very effective in local data aggregation since it can reduce the collisions and balance load among sensors. The third category is to make use of mobile collectors to take the burden of data routing from sensors.

In cluster-based schemes, cluster heads will inevitably consume much more energy than other sensors due to handling intra-cluster aggregation and inter-cluster data forwarding. Though using mobile collectors may alleviate non-uniform energy consumption, it may result in unsatisfactory data collection latency. Based on these observations, develop a three layer mobile data collection framework, named Load Balanced Clustering and Dual Data Uploading (LBC-DDU). The main motivation is to utilize distributed clustering for scalability, to employ mobility for energy saving and uniform energy consumption, and to exploit Multi-User 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. First, given a distributed algorithm to organize sensors into clusters, where each cluster has multiple cluster heads. This algorithm balances the load of intra-cluster aggregation and enables dual data uploading between multiple cluster heads and the mobile collector. Second, multiple cluster heads within a cluster can collaborate with each other to perform energy-efficient inter-cluster transmissions. Different from other hierarchical schemes, in this algorithm, cluster heads do not relay the data packets from other clusters, which effectively alleviates the burden of each cluster head. Third, deploy a mobile collector with two antennas (called SenCar) to allow concurrent uploading from two cluster heads by using MU-MIMO communication. The SenCar collects data from the cluster heads by visiting each cluster. It also chooses the stop locations inside each cluster and determines the sequence to visit them, such that data collection can be done in minimum time. The utilization of MU-MIMO technique, which enables dual data uploading to shorten data transmission latency. We coordinate the mobility of SenCar to fully enjoy the benefits of dual data uploading, which ultimately leads to a data collection tour with both short moving trajectory and short data uploading time.

The rest of the paper is organized as follows. Section 2 performs a literature review of previous works. Section 3 presents the system overview of the proposed framework. Section 4 describes the distributed load balanced clustering algorithm on sensor nodes and Section 5 considers the cluster head layer. Section 6 focuses on data collection tour planning of SenCar. Finally, Section 7 provides performance evaluation results and Section 8 concludes the paper.

II. Related Works

A. *Clustering Schemes and Mobile Data Collections*

Relay routing is a simple and effective approach to routing messages to the data sink in a multi-hop fashion.

e heuristic for coverage management and, a probabilistic load-balancing strategy for routing path determination. Jing He [7] suggested a Load-Balanced Data Aggregation Tree for the Load-Balanced Maximal Independent Set, the Connected Maximal Independent Set, and the construction problems. Cong Wang [8] described a two-stage approach for mobile data collection.

Songtao Guo [9] suggested a mobile data gathering has been considered as an efficient alternative to data relaying in WSNs. Haiying Shen [10], described a hybrid RFID and WSN system that synergistically integrates the traditional RFID system and WSN system for efficient data collection. It improve data transmission efficiency and to protect data privacy and avoid malicious data selective forwarding in data transmission. Zhenjiang Li[11],recommended a novel approach for mobile users to collect the network-wide data. The routing structure of data collection is additively updated with the movement of the mobile user. The protocol in a prototype system and test its feasibility and applicability by a 49-node test bed. Ming Ma [12], considered a new data-gathering mechanism for large-scale wireless sensor networks by introducing mobility into the network. An M-collector starts the data-gathering tour periodically from the static data sink, polls each sensor while traversing its transmission range, then directly collects data from the sensor in single-hop communications, and finally transports the data to the static sink. Since data packets are directly gathered without relays and collisions, the lifetime of sensors is expected to be prolonged. Liu Danpu [13], suggested a transmission scheme for energy-constrained WSNs called MIHOP (MIMO and Multi-hop), combines cluster-based virtual MIMO and multi-hop technology. Miao Zhao [14], recommended a polling-based mobile collection approach and formulate it into an optimization problem, named bounded relay hop mobile data collection. Zhao M [1], described an efficient network coverage and to provide a reliable, energy-efficient monitoring depends on selecting minimum number of sensors in active mode to cover all the targets. Multi-user MIMO (MU-MIMO) schemes are used to enable resource allocation to communicate data to two or more MSs It enhances the system throughput. Chuan Zhu [2] suggested a tree-cluster-based data-gathering algorithm for WSNs with a mobile sink. A novel weight-based tree-construction method is introduced. El-Moukaddem F [3] described the key challenges facing wireless sensor networks is extending network lifetime due to sensor nodes having limited power supplies. Chiara Petrioli [4], considered an ALBA-R protocol for converge casting in wireless sensor networks. The cross-layer integration of geographic routing with contention based MAC for relay selection and load balancing, as well as a mechanism to detect and route around connectivity holes. Takaishi D [5], described an energy-efficient big data gathering While this technique can reduce energy consumption of the sensor nodes, the use of mobile sink presents additional challenges such as determining the sink node's trajectory and cluster formation prior to data collection. Chia Pang Chen [6], suggested a novel maximum connected load-balancing cover tree. Each sensing node by dynamically forming load-balanced routing cover trees a coverage optimizing recursiv

Miao Zhao [15] suggested a data gathering scheme and provide distributed algorithms to achieve its optimal performance. A load balanced multi-head clustering algorithm in this paper.

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. This scheme works well in a uniformly distributed sensor network. To achieve more flexible data gathering tour for mobile collectors, 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. Although these works consider utilizing mobile collectors, latency may be increased due to data transmission and mobile collector's traveling time. Thus exploit MU-MIMO to reduce data transmission time for mobile data collection.

B. *MU-MIMO in WSNs*

The feasibility of employing MIMO techniques in wireless sensor networks. Due to difficulties to mount multiple antennas on a single sensor node, it is adopted in WSNs to seek cooperation's from multiple nodes to achieve diversity and reduce bit error rate. An overview of MIMO-based scheduling algorithms to coordinate transmissions. Another challenge is that the energy consumption in circuits could be higher than a traditional Single-Input-Single-Output (SISO) approach that with proper designs of system parameters, It is significant energy saving can be achieved with MIMO techniques. To compensate energy consumptions in the circuit, optimization of transmission time and modulation parameters was presented. In our framework, since it is not difficult to deploy two antennas on the mobile collector, when a compatible pair of transmitting nodes and the locations of the mobile collector are given, we can enable MU-MIMO uploading to the mobile collector to greatly reduce data collection latency.

III. System Overview

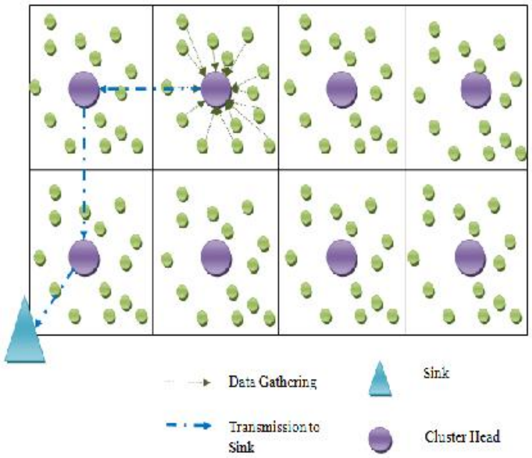

Figure 1: Overview of system architecture

A. Description

The overview of LBC-DDU based mobile data collection technique is shown in figure 1.

B. Sensor Layer

In the sensor layer, a distributed load balanced clustering (LBC) algorithm is proposed for sensors to self-organize themselves into clusters. 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 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 neighbors, i.e., 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. To avoid collisions during data aggregation, the CHG adopts time-division-multiple-access based technique to co-ordinate communications between sensor nodes. Note that only intra-cluster synchronization is needed here because data are collected via SenCar. In the case of imperfect synchronization, some hybrid techniques to combine time division multiple access with contention-based access protocols (Carrier Sense Multiple Access) that listen to the medium before transmitting are required

C. Cluster Head Layer

At the cluster head layer, the inter-cluster transmission range is carefully chosen to guarantee the connectivity among the clusters. Multiple cluster heads within a cluster cooperate with each other to perform energy saving intercluster communications. Through intercluster transmissions, cluster head information is forwarded to SenCar for its moving trajectory planning. The cluster head layer consists of all the cluster heads. As a fore mentioned, intercluster forwarding is only used to send the CHG information of each cluster to SenCar, which contains an identification list of multiple cluster heads in a CHG. Such information must be sent before SenCar departs for its data collection tour. Upon receiving this information, SenCar utilizes it to determine where to stop within each cluster to collect data from its CHG. To guarantee the connectivity for intercluster communication, the cluster heads in a CHG can cooperatively send out duplicated information to achieve spatial diversity, which provides reliable transmissions and energy saving.

D. Mobile Collector Layer

The mobile collector layer is SenCar it is equipped with two antennas, which enables two cluster heads to simultaneously upload data to SenCar in each time by utilizing multi-user multiple-input and multiple-output (MU-MIMO) technique. The top layer is the SenCar layer, which mainly manages mobility of SenCar. There are two issues to be addressed at this layer. First, we need to determine the positions where SenCar would stop to communicate with cluster heads when it arrives at a cluster. In LBC-DDU, SenCar communicates with cluster heads via single-hop transmissions. It is equipped with two antennas while each sensor has a single antenna and is kept as simple as possible. The traffic pattern of data uploading in a cluster is many-to-one, where data from multiple cluster heads converge to SenCar. To mitigate the impact from dynamic channel conditions, SenCar measures channel state information before each data collection tour to select candidate locations for data collection. We call these possible locations SenCar can stop to perform concurrent data collections polling points. In fact, SenCar does not have to visit all the polling points. Instead, it calculates some polling points which are accessible and we call them selected polling points. In addition, we need to determine the sequence for SenCar to visit these selected polling points such that data collection latency is minimized. Since SenCar has preknowledge about the locations of polling points, it can find a good trajectory by seeking the shortest route that visits each selected polling point exactly once and then returns to the data sink. The proposed framework aims to achieve great energy saving and shortened data collection latency, which has the potential for different types of data services. Using MU-MIMO can greatly speed up data collection time and reduce the overall latency

IV. LBC-DDU Algorithm

The distributed load balanced clustering dual data uploading algorithm (LBC-DDU) 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. The LBC algorithm is comprised of four phases: (1) Initialization (2) Status claim (3) Cluster forming and (4) Cluster head synchronization.

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 it claims itself to be a cluster head and the cluster only contains itself. Otherwise, a sensor s_i, first sets its status as "tentative" and its initial priority by the percentage of residual energy. Then, s_i sorts its neighbors by their initial priorities and picks M − 1 neighbors with the highest initial priorities, which are temporarily treated as its candidate peers.

B. 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.

C. 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 case a cluster head is running low on battery energy, re-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.

D. Cluster head synchronization

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.

V. Connectivity Among CHGs

We now consider the cluster head layer. As 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-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.

VI. Sencar Layer

The sencar is equipped with two antennas, as it is not difficult to mount two antennas on sencar, while it likely becomes difficult 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 SenCar, which act as the receiving antennas in data uploading, make it possible for multiple cluster heads in a CHG to transmit distinct data simultaneously. In other words, since SenCar is equipped with two receiving antennas, at most two cluster heads in a CHG can simultaneously send data to SenCar.

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. The SenCar selects the cluster with the earliest average deadline and moves to the polling point to collect data via MU-MIMO 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.

VII. Performance Evaluations

In this section, we evaluate the performance of our framework and compare it with other schemes. The first scheme for comparison is to relay messages to a static data sink in multi-hops 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 forwarding 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. The next scheme to compare is based on Collection Tree Protocol (CTP). In this protocol the expected number of transmission (ETX) is used as a routing metric and the route with a lower precedence over routes with higher ETX. This assumption is reasonable since using fixed power for longer transmission distance would cause attenuated receiving power and potentially increase error probability and expected number of transmissions. Any broken links caused by nodes depleted battery energy would lead to large ETX and are avoided in routings.

Furthermore, we introduce two schemes that organize nodes into clusters and relay to the static data sink by multi-hop transmissions. The third scheme to compare is clustered SISO in which sensors form into clusters with a single cluster head. The last scheme is our proposed LBC-DDU framework (denoted by mobile MIMO for clarity) that elects multiple cluster heads to enable MU-MIMO uploading to SenCar in each cluster.

The program written in Tcl scripting language was executed using the network simulator 2(NS2) software. Fig a. shows deploying mobile nodes in the network. It is consist of nodes for data transmission. These nodes are randomly distributed in the network. Select the data receiving node in the given mobile nobes named as sink node. Fig b. shows the cluster forming from the given number of nodes. It provides 8 clusters with cluster head node. Finding neighbors of each node (i.e) nodes found within range to that node and forming neighbor table.

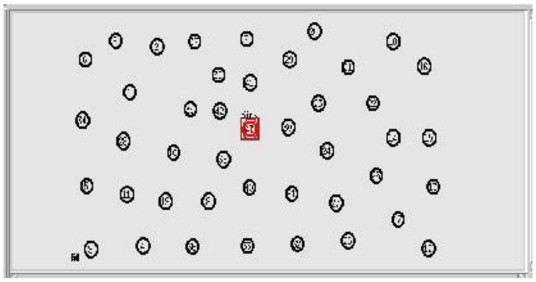

Figure: (a). Node construction in the network

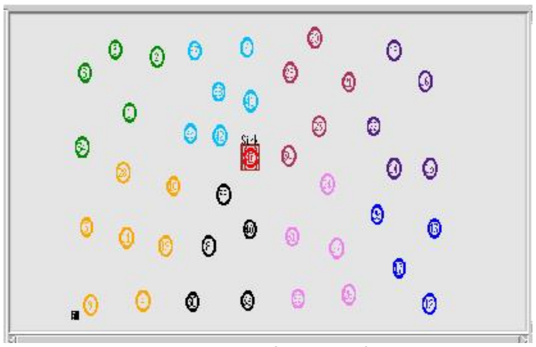

Figure: (b). Cluster formation of nodes

Fig(c) & Fig (d) shows the status and data transmission of each node to the desired cluster head. Each cluster having two cluster heads. In route discovery status of a node send to custer head then the data can be send to cluster head. Select source and destination node, source node sends route discovery packets to all nodes for choosing efficient path between source and destination.

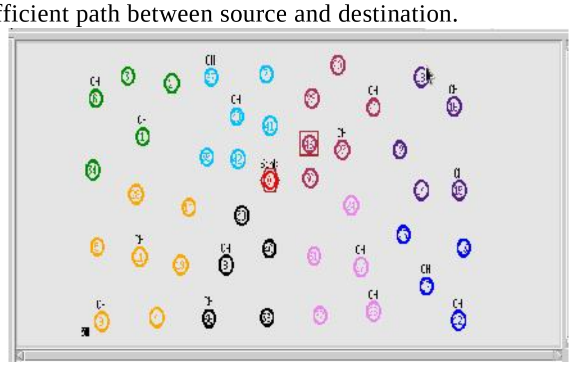

Figure: (c) Selection of cluster head(CH)

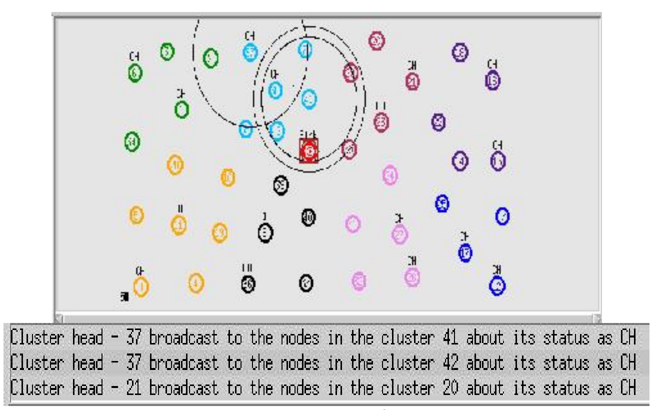

Figure: (d) Status transmission of nodes in network

Fig (e), Fig (f) shows the data transmission of each node to their respective cluster heads based on the status of node in the cluster.

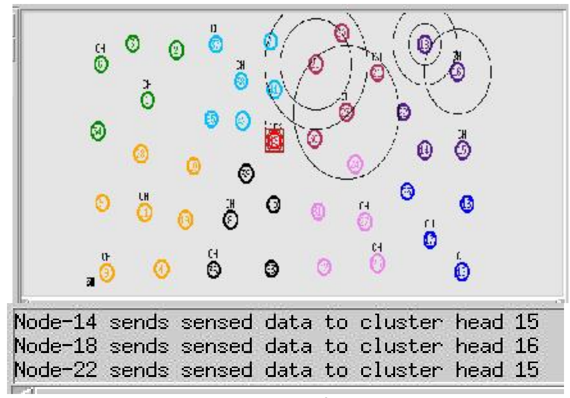

Figure: (e) Data transmission of nodes to cluster heads

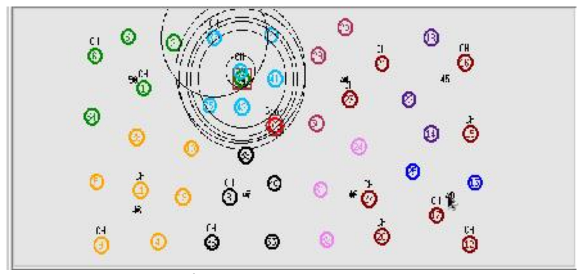

Figure: (f) Data transmission through Sencar

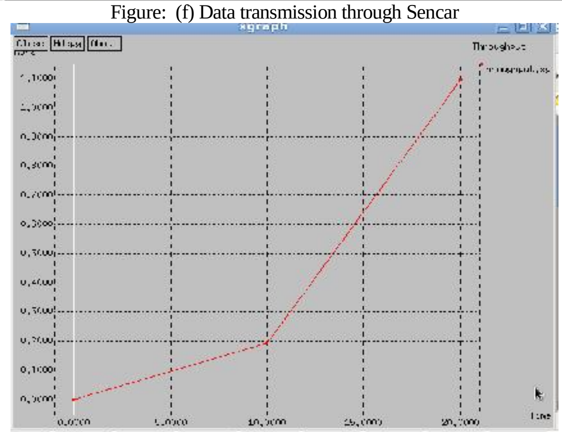

Figure: (g) Throughput vs Time

VIII. CONCLUSIONS

The LBC-DDU framework for mobile data collection in a WSN. It consists of three layers such as sensor, cluster head and SenCar layers. It employs distributed load balanced clustering for sensor self-organization, and adopts collaborative intercluster communication for energy-efficient transmissions among CHGs, and uses dual data uploading for fast data collection, then it optimizes SenCar's mobility to fully enjoy the benefits of MU-MIMO.The results show that LBC-DDU can greatly reduce energy consumptions. It is done by alleviating routing burdens on nodes, balancing workload among cluster heads which achieves less data collection time compared to SISO mobile data gathering.

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REFERENCES

[1]. M. Zhao, M. Ma and Y. Yang, "Efficient data gathering with mobile collectors and space-division multiple access technique in wireless sensor networks," IEEE Trans. Computers, vol. 60, no. 3, pp. 400-417, 2011.

[2]. Chuan Zhu, Shuai Wu, Guangjie Han; Lei Shu; Hongyi Wu, "A Tree-Cluster-Based Data-Gathering Algorithm for Industrial WSNs With a Mobile Sink," in Access, IEEE , vol.3, no., pp.381-396,2015.

[3]. El-Moukaddem, F. Torng, E. Guoliang Xing, "Maximizing Network Topology Lifetime Using Mobile Node Rotation," in IEEE Transactions on Parallel and Distributed Systems, vol.26, no.7, pp.1958-1970, 2015.

[4]. Chiara Petrioli, Michele Nati, Paolo Casari, Michele Zorzi, and Stefano Basagni, "ALBA-R: Load-Balancing Geographic Routing Around Connectivity Holes in Wireless Sensor Networks". IEEE Transactions On Parallel And Distributed Systems, Vol. 25, No. 3, March 2014.

[5]. Takaishi, D.Nishiyama, H.;Kato, N.;Miura,R.,"Toward Energy Efficient Big Data Gathering in Densely Distributed Sensor Networks,". IEEE Transactions on Emerging Topics in Computing, Vol.2, No.3, pp.388-397,Sept. 2014.

[6]. Chia-Pang Chen, "Efficient Coverage and Connectivity Preservation with Load Balance for Wireless Sensor Networks". IEEE Sensors Journal. 2014.

[7]. Jing (Selena) He, Shouling Ji, Yi Pan, Yingshu. Li, "Constructing Load-Balanced Data Aggregation Trees in Probabilistic Wireless Sensor Networks" IEEE Transactions on Parallel And Distributed Systems ©1045-9219/14, 2014.

[8]. Cong Wang, Songtao Guo and Yuanyuan Yang "Energy-Efficient Mobile Data Collection in Energy-Harvesting Wireless Sensor Networks" IEEE 978-1-4799-7615-7/14 ©2014 IEEE.

[9]. Songtao Guo; Cong Wang; Yuanyuan Yang, "Joint Mobile Data Gathering and Energy Provisioning in Wireless Rechargeable Sensor Networks," , IEEE Transactions on, Mobile Computing, vol.13, no.12, pp.2836-2852, Dec. 2014.

[10]. Haiying Shen; Ze Li; Lei Yu; Chenxi Qiu, "Efficient Data Collection for Large-Scale Mobile Monitoring Applications, "IEEE Transactions on Parallel and Distributed Systems,, vol.25, no.6, pp.1424-1436,2014.

[11]. Zhenjiang Li, Yunhao Liu, Mo Li, Jiliang Wang, and Zhichao Cao, "Exploiting Ubiquitous Data Collection for Mobile Users in Wireless Sensor Networks" IEEE Transactions On Parallel And Distributed Systems, Vol. 24, No. 2, 2014.

[12]. Ming Ma, Yuanyuan Yang, Miao Zhao," Tour Planning for Mobile Data-Gathering Mechanisms in Wireless Sensor Networks "IEEE Transactions On Vehicular Technology, Vol. 62, No. 4, May 2013.

[13]. Liu Danpu; Zhang Kailin; Ding Jie, "Energy-efficient transmission scheme for mobile data gathering in Wireless Sensor Networks," in Communications, vol.10, no.3, pp.114-123, March 2013.

[14]. Miao Zhao, Yuanyuan Yang, "Bounded Relay Hop Mobile Data Gathering in Wireless Sensor Networks", IEEE TRANSACTIONS ON COMPUTERS, Vol. 61, No. 2, February 2012.

[15]. MiaoZhao; Yuanyuan Yang," Optimization-Based Distributed Algorithms for Mobile Data Gathering in Wireless Sensor Networks," IEEE Transactions on Mobile Computing, vol.11, no.10, pp.1464-1477, Oct. 2012.