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# Maximum network lifetime with load balance and connectivity by clustering process for wireless sensor networks

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**Abstract: -** Wireless sensor networks are formed by a large number of low-power, low-cost and multifunctional wireless sensor nodes. The basic philosophy of wireless sensor network is to provide maximum coverage and connectivity of a sensing environment. Thus the network lifetime must be maximized as long as possible. As the usage of wireless sensor network has grown enormously the need for efficient management of energy has also increased. Wireless sensor networks are applied to a variety of range of applications such as home health care, battlefield surveillance, machine failure diagnosis, biological detection, home security, smart spaces, inventory tracking, machine monitoring, and environmental monitoring. These application tasks require full coverage at any time. Energy is a very scarce resource in case of wireless sensor network and it has to be managed properly to extend the life of the sensors. The nodes must be organized into maximal number of subgroups (clusters) capable of monitoring all discrete points of interest. To guarantee the connectivity of sensor nodes is also important while achieving full coverage. In this paper, thus we develop a novel Fully Clustered Energy-efficient Connected Coverage (FCECC) algorithm. The proposed (FCECC) consists of two components:

1) A clustering process to improve the coverage problem.
2) A load-balancing strategy for determining routing path.

The simulation results show that our solution best performs the existing ones in case of energy consumption and maintenance.

**Keywords:** Wireless sensor networks, Fully Clustered Energy-efficient Connected Coverage, load-balancing strategy, clustering process

## 1. INTRODUCTION

Wireless sensor networks mainly consist of spatially distributed autonomous sensor nodes to monitor environmental conditions such as temperature, sound and pressure. The sensor nodes in wireless sensor network can sense the data and detect events in the region and communicate data and events information back to the Base Station (BS). Thus the Wireless Sensor Networks have become most prominent and interesting area of research. Wireless sensor networks are formed by a large number of connected and multifunctional wireless sensor nodes. All the sensor nodes are connected and have the capability of sensing, processing, communicating and store the information. Each sensor node has processing and wireless communication capabilities, which enable it to gather information from the deployed area and the sensor nodes generate and deliver data and also the events information to the base station (BS). The base station (BS) receives the data, accumulates and analyzes the received information to decide whether there is an unrelated or unconcerned event occurrence in the deployed region.

Each sensor node in the network is battery powered and needs to be charged to complete the desired task. In view of the inadequate capabilities and susceptible nature of an individual sensor node, a wireless sensor network has a large number of sensors deployed in high density range and thus redundancy can be oppressed to enhance data accuracy and system reliability. The sensor nodes are spatially distributed in a wireless sensor network. The main merits of wireless sensor networks are fault-tolerance, strong adaptability and comprehensive sensing coverage. Due to these merits wireless sensor networks are applied to a variety of range of applications including home health care, battlefield surveillance, machine monitoring, and environmental monitoring, smart living, automatic measurement, traffic monitoring, security monitoring, battle damage assessment, nuclear biological and chemical attack detection. The main components of a wireless sensor node are sensing, computation, communication, actuation and power consumption. The basic philosophy behind wireless sensor networks is that though the capability of each individual sensor node is limited, the aggregate power of the entire network is sufficient for the required mission. The energy is a very scarce resource in case of wireless sensor network and it has to be managed properly to extend the life of the sensors. After the initial deployment, sensor nodes arrange themselves to form a network and communicate to the base station (BS). Generally sensors have the data processing and communication capabilities. The sensor node sends the sensed data to the base station through radio transmitter. The base station (BS) can be located in the vicinity of the sensors or it can be mobile. To avoid long communication with the base station (BS) some high energy nodes called gateways are deployed in the network. These high energy nodes (gateways) group sensors to form distinct clusters. Each sensor belongs to only one cluster and communicates with the base station (BS) only through the gateway. The sensor's energy is consumed by the signal processing and communication activities. Basically the wireless sensor networks are categorized into two types. 1. Structured and 2. Unstructured networks.

In case of a structured wireless sensor network all or some of the nodes are deployed in a well-planned manner with low network maintenance and management cost and provides full coverage. In an unstructured wireless sensor network nodes are randomly deployed. The network maintenance such as managing connectivity and detecting failures is difficult since there are so many nodes. The four basic components in a sensor network are 1. An assembly of distributed or localized sensors. 2. An interconnecting network. 3. A central point of information clustering. 4. A set of computing resources at the central point to handle data correlation, event trending, status querying and data mining. The important task is to improve the lifetime of the wireless sensor network because the sensor nodes are constrained by limited energy. To improve the lifetime of a wireless sensor network energy efficient protocol needs to be developed which reduces energy consumption.

The well-known energy efficient methods are clustering based algorithm for homogeneous wireless sensor networks. Sensor nodes must be organized efficiently into clusters to reduce energy consumptions. There are 3 types of constraints in wireless sensor networks: 1. Deployment constraints: Once the sensor nodes are deployed they organize themselves and are ad-hoc in nature. The nodes are left unattended and managed remotely. The deployment may be fixed or random depending on the application. 2. Communication constraints: The wireless sensor network links have limited bandwidths and they are unreliable and prone to attacks. 3. Device constraints: The sensor nodes have limited amount of memory storage, power, and processing capability as they are battery operated. Clustering is one of the most important mechanisms to improve the energy consumption of sensor network and thereby increase the network lifetime. In clustering, whole sensor network is divided into group of clusters. Cluster head is selected based on the battery life of a node. The Cluster head gathers and performs the aggregation of the data and send it back to the BS. Thus to perform data aggregation through efficient network organization, all the nodes in the network can be partitioned into a number of small groups or sets called clusters or clusters sets. As a result, energy efficient network can be designed for improving overall network system lifetime without affecting the system reliability and scalability. This is one of the most essential challenges to be considered in the design of a large wireless sensor network to perform the desired mission. In general, all the sensor nodes share common sensing tasks in the wireless sensor network.

This implies that not all sensor nodes are required to perform the sensing operation throughout the process of the desired task that has to be accomplished during the whole network system lifetime. Thus switching off some nodes does not affect the overall system functionality as long as there are enough working nodes to guarantee it. This means that some of the sensor nodes in the wireless sensor network are turned off or made to enter the sleeping mode and then can be made to become active again by receiving a wake-up beacon from the cluster head at any time when the requirement arises. Therefore, if we can employee the cluster set in the network that holds the cluster head which can schedule and manage the sensor nodes to work alternatively, the system lifetime can be prolonged respectively; i.e. the whole system lifetime is enhanced by exploiting redundancy. The main ambition of this project work is to enhance the network lifetime from two proportions mainly coverage and connectivity by keeping the load balance as the probability issue. The energy utilization of the nodes can be minimized if the amount of data or the events that needs to be transmitted are also minimized. The solution to this difficulty is data aggregation. The most important design target of the wireless sensor networks is to minimize energy consumption and to maximize the system lifetime. In the last few years, researchers are actively exploring advanced power or energy conservation approaches and techniques for wireless sensor networks.

On the one hand, device manufacturers have been striving for introducing low power consumption in their products as the sensor nodes are battery operated. On the other hand, protocol and routing algorithms designers are using an energy efficient communication architecture, which includes all levels from the physical layer to the application layer [4]. For illustration, directed diffusion [11] and LEACH [10] are the two most typical data communication protocols that have been proposed for wireless sensor networks. In directed diffusion, routes (called gradients) are formed that link sensor nodes of interesting data to sinks. When the source node has data of interest, or the event it sends the data or the event information along the gradient paths back to the sinks. LEACH is a clustering-based protocol that utilizes a randomized alternation of a local cluster-head to evenly distribute the energy load among sensors in the network and to concentrate on the load balance issue of the wireless sensor network so as to lessen the burden on the single cluster head.

Thus all the sensor nodes can actively participate in the operation that has been issued to the network by forming the cluster head accordingly. It enables scalability and robustness for dynamic networks by using localized coordination and incorporates data fusion into the routing protocols to achieve energy conservation. In [12], a probing-based density control algorithm is projected to certify long-lived, robust sensing coverage by leveraging unrestrained network scale. In this protocol, only a subset of nodes in the cluster are maintained and organized to be in the working mode to ensure desired sensing coverage, and other redundant nodes are allowed to fall asleep most of the time. Active or the working nodes continue working until they run out of their energy or are destroyed or dead. A sleeping node wakes up after receiving the wake-up beacon and it occasionally probe its local neighbourhood and starts working only if there is no working node within its probing range. It is very difficult to find an association between probing range and desired redundancy, if nodes have different sensing ranges which can be observed in heterogeneous wireless sensor networks. Moreover, the probing-based off-duty eligibility rule cannot ensure the original sensing coverage and blind points may appear after making the nodes to enter the sleeping mode or turning off some nodes.

## 2. RELATED WORK:

In this section, we emphasize the earlier works on the improvement of the lifetime of wireless sensor networks by using a variety of scheduling algorithms and data aggregation techniques for sensors to accomplish the required mission. Routing algorithms in combination with data aggregation techniques are included in the process of exploring the data structure and network topology to reduce energy consumption for data gathering and event management in case of resource limited sensor networks. Theoretically the best approach is to use distributed source coding proposed by Slepian-Wolf coding [3] if the entire knowledge of all sensor nodes in the network correlations is available in advance at each sensor node of the wireless sensor network. In this approach, compression is done at initial sensor nodes in a distributed manner to achieve the minimum entropy and hence the need for data aggregation and event management on the intermediate nodes can be avoided.

In [4], an optimal rate allocation algorithm is projected for sensor nodes in the network and SPT is employed as the best routing scheme. The Routing-driven algorithm illustrates source data compression at each individual sensor node and data aggregation is done when routes overlap. In [5] the directed diffusion scheme was proposed where sensor nodes of the network generate gradients of information in their individual neighbourhoods. If the gradients information of the sensor nodes matches the broadcasted information from the sink node then the data is aggregated at the intersections or at the intermediate nodes. Thus the additional overhead is mandatory. The Energy-aware routing [6] scheme projects the usage of a set of sub-optimal paths sporadically to enhance the lifetime of the network. The selection of the paths is done by means of a probability function, which depends on the energy consumption of each path and the overall sensor nodes energy that are deployed in the network. This approach reveals the fact that the usage of the minimum energy path all the time will reduce the energy of nodes on that path. Instead, selection of one of the multiple paths is done with a certain probability so that the whole network lifetime increases. A class-based addressing protocol is used to address the node in the network and it also includes the location and type of the node. The protocol also gathers the information of the location of the node and describes the mechanism to set up the node. Low-Energy Adaptive Clustering Hierarchy (LEACH) [7] is one of the most popular and proficient hierarchical routing algorithms used for wireless sensor networks. The fundamental scheme behind this algorithm is the formation of clusters of the sensor nodes based on the received signal strength of the deployed network and use local cluster heads as routers to the base station (sink).

Thus the energy can be saved as the transmissions will be done only by such cluster heads rather than all sensor nodes. LEACH uses single-hop routing in which each node can transmit data directly to the cluster-head and the sink. Hence, it cannot be applicable to networks deployed in large regions. In Power Efficient Gathering in Sensors Information Systems (PEGASIS) [8] sensor nodes forms chains through which a node transmits and receives information from a nearby neighbour. In addition it is very risky to maintain the single leader (cluster-head), to perform the whole operation in the network which can cause reduction of energy of the cluster head and also the network lifetime in WSNs. For instance, every sensor node in the cluster needs to be conscious of the significance of its neighbour node so that it can know where to route the data. This means that each node in the cluster must know its responsibility so that the burden of the cluster head can be reduced and the lifetime of the network can be enhanced by making the other nodes as the cluster head after the old cluster head node becomes dead.

The maximum lifetime data aggregation (MLDA) problem's intention is finding a set of data gathering schedules which maximizes the system lifetime. In [13], Chen et al. proposed an algorithm to switch off nodes based on the necessity for neighbouring nodes connectivity. They intend to reduce the system energy consumption without significantly deteriorating the connectivity of the network. In [14], Xu et al. proposed a scheme to conserve energy by making the nodes switch off their communication unit when they are not involved into sending, forwarding or receiving data phase. Also, node density is leveraged to increase the time that communication unit is powered off. In [15], an algorithm, called Geographical Adaptive Fidelity (GAF) was proposed, which uses geographic location information to make the division of the area into fixed square grids. Within each grid, it allows only one node to stay awake to forward packets. These three node-scheduling schemes switch off nodes from communication perception without taking into consideration the system's sensing coverage. In fact, in wireless sensor networks, the main role of each node is sensing of the data or the events. Abnormal or unconcerned event could happen at any time at any place. Therefore, if we only turn off nodes, which are not participating in data forwarding, assured areas in the deploying region may become "blind points". Important events may not be detected and the whole operation or the task for which the network has been deployed may fail [12]. More to the point of diminishing the number of active nodes, there are also other network topology control techniques, which also propose to intensify power efficiency and extend network lifetime [16-18] and thus produces a minimum-energy communication sub network by adjusting transmission power. The sub network is computed and distributed at each node using local neighbour location information [16-17] or directional information [18]. Instead of controlling the transmission power level, node-scheduling schemes power off some redundant nodes in the network and therefore can achieve further energy conservation and the enhancement of the network lifetime.

## 3. PROPOSED ALGORITHM

### Fully Clustered Energy-Efficient Connected Coverage Algorithm (FCECC):

The proposed FCECC algorithm is composed of two sub-strategies: 1. a clustering process to improve the coverage problem using the Energy-efficient LEACH-F protocol. 2. A load-balancing strategy for determining routing paths. LEACH-F is a self-organizing, adaptive clustering protocol which is used for randomization to distribute the energy load evenly among the sensor nodes in the network. The main assumption of LEACH-F is that all sensor nodes can adapt their transmission range and evenly participate in the communication phase of the network. Moreover, energy consumption during communication contest exactly with the distance and every sensor node is able to reach a base station (BS) and the base station maintains the information about the cluster and also the cluster head. Moreover, nodes support several MAC layers and perform signal-processing functions. LEACH-F uses a distributed algorithm to determine the cluster heads in the set-up phase whereas in the steady phase nodes send their data according to the time schedule provided by their cluster heads to the base station (BS).

**Cluster Set-Up :**After each node has decided to which cluster it belongs, it must inform the cluster head node that it will be a member of its cluster. Each node transmits this information back to the cluster head again using CSMA MAC protocol. During this phase, all cluster head nodes must be in the active mode.

**Schedule Creation:** The cluster head receives all the messages from the nodes that would like to join the cluster. Based on the number of nodes in the cluster, the cluster head creates a TDMA schedule telling each node when it can transmit the data. This schedule is broadcasted back to the nodes included in the cluster and also to the base station.

**Data Transmission :**Nodes start to transmit their data after the clusters are created and the TDMA schedule is fixed. Nodes always have data to send, during their allocated transmission time to the cluster head. This transmission uses the minimal amount of energy based on the received strength of the cluster head announcement. The radio of each non-cluster head can be turned off until the node's allocated transmission time, thus minimizing energy dissipation. The cluster head node must keep its receiver on to receive all the data from the nodes in the cluster. Once all the data has been received, the cluster head performs optimization functions such as data aggregation or other signal processing functions to compress the data into a single signal. This composite signal, which is a high-energy transmission since the base station is far away, is then sent to the base station.

The cluster heads send these data packets using a fixed spreading code with CSMA. This is the steady-state operation of LEACH networks. After a certain time, which is determined a priori, the next round begins with each node determining if it will become a cluster head for this round and advertising the decision to the rest of nodes as described in the advertisement phase. The fundamental of the protocol is to develop a cluster based routing where cluster heads should be selected based on maximum coverage and should have sufficient energy to prolong the communication. The following Figure 4.1 shows the proposed algorithm, where we are routing through high energy node for cluster formation, selecting node with high node energy.

**Algorithm:** Modified LEACH-F Algorithm.

[1]. Let W, H is the Network width and Height. Network Area A=WxH where the network is to be deployed.

[2].Let S={s1,s2….sn} denote the set of n sensor nodes.

[3].Let C denote the set of clusters where C= {c1, c2 ….cn}

[4]. Let there be N nodes with E Energy at (X, Y) point in the network region to form the cluster sets.

[5]. Let Node BS be the Base Station located at W/2, H/2 in the network.

[6]. The problem can be summarized as to get a connected graph G={V,E} from S number of sources called the sensor nodes such that V are the Nodes and E are set of all edges or Links, So as to maximize L where L is the Lifetime and is defined as time T when Ei<=0, where i can be any node other than the Sink or the Base Station.

[7]. Initially some nodes are turned into a sleeping mode to conserve energy and then become active when the wake up beacon is received.

[8]. Initially all active nodes broadcast HELLO packets and let the other nodes know their Energy and Position.

[9]. Initially When BS wants to gather data from Sources or the cluster nodes; it selects the nodes with maximum neighbours and sufficient Energy as Cluster Heads.

[10]. Each Cluster head is notified that it is cluster head.

 

[11]. Source node within the cluster generates RREQ packet.
[12]. A node forwards RREQ packet only if it is a cluster head.
[13]. Route is formed between each source node to BS through cluster heads.
[14]. Data is transmitted from source node to BS.
[15]. Nodes looses Energy as
[16]. Eloss= Eidle + Etransmit + Ereceive
[17]. and E=E-Eloss where Eidle=1pJ/s
[18]. Etranmit =5mJ/Packet (considering packet is of
[19]. Length 1024)
[20]. Ereceive = 1mJ/Packet
[21]. During the Transmission if any Ei is less than 0, mark the time as Network Lifetime.
[22]. If cluster head loses its energy below 30% of the Max energy, then it notifies the base station. An alternative cluster head is selected, all the routes through previous cluster head generates RERR and new routes are formed.

The coverage problem aims at finding a maximum number of CLUSTERS of nodes. In each cluster the nodes are able to monitor all the DPOIs together. Thus the coverage problem focuses on the preservation of the coverage issue to improve the overall network lifetime. The load balancing strategy is used to find the appropriate path from each node to the BS after the clusters are initiated. For every possible transmission path from a given node to the candidate parent nodes, the LB strategy will assign different probabilities in order to distribute the load more uniformly. Fig 1 shows the flowchart of the proposed FCECC algorithm. First, the family of the cluster sets (defined as CS), S, P are initialized after a WSN is given to the FCECC (step 1). Then the set of active nodes, Sa, is generated by removing the sleeping nodes without covering any DPOIs from S (step 2). From Sa, the coverage strategy will explore as many cluster sets (Ci) of nodes as possible until the nodes in Sa cannot be selected to group a new independent cluster set (step 3 to step 5). This clustering process for cluster set carried out by the FCECC will divide the set of Sa into several mutual exclusive subsets, i.e., Ci ∩ Cj= {Ø}, and i≠j. Every disjoint set Ci of nodes are able to monitor all the DPOIs together. Full coverage is the main consideration and with this we can get a collection of subset of active nodes.

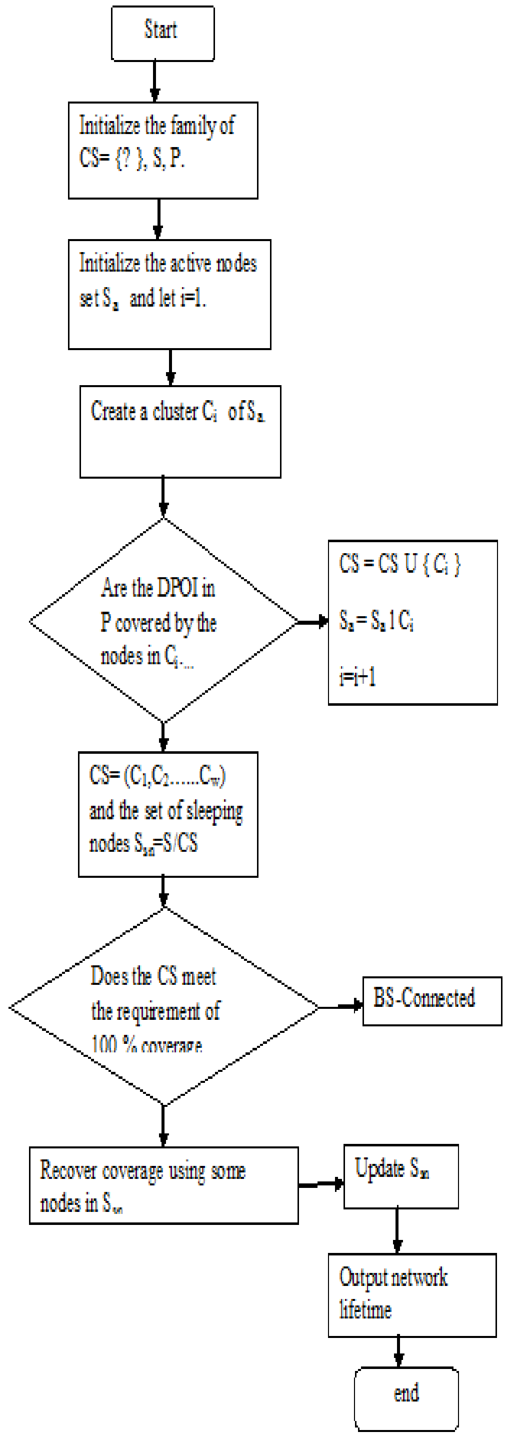


Fig 1: Flow chart of proposed algorithm

## 4. SIMULATION RESULTS

In this section, we implement the FCECC algorithm, 71 sensor nodes are considered. These nodes are placed in a fixed node pattern covering the area of 50 m. The transmission range of each sensor node in discrete point of interests. Here, transmission range is 50 m and frequency is 914MHz.Setting base station and cluster head among the sensor nodes. Here, node 0 is base station, node33 and node 38 is the cluster head. The FCECC algorithm is used to find the maximum number of cluster sets. The nodes in each disjoint set able to monitor all the discrete points of interest. Here, discrete points of interest [DPOIs] sense the data and transmit it to the cluster head. Cluster head further transmit it to the BS. In this, only minimum number of sensor nodes is activated in each DPOI to transmit the data. Other nodes are in idle state. Thus, energy consumption is maintained then load is balanced among the sensor nodes and connectivity is also maintained. From this figure 2, lifetime of the WSN using FCECC with an initial energy of 23 joules is about 16 seconds. Packet loss occurs when one or more packets of data travelling across a sensor network fail to reach their destination. From the figure 3, it is shown that packet loss increases as time increases. Throughput refers to how much data can be transferred from one location to another in given amount of time. From the figure 4, it is shown that time increases as throughput of the network decreases. From the figure 5, it is shown that maximizing the disjoint set, packet loss is reduced.

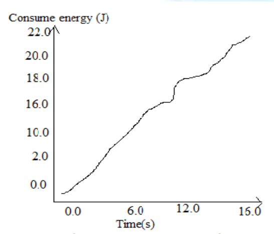

Figure 2 Consume energy vs. time

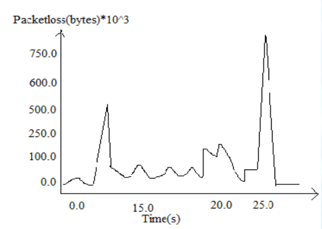

Figure 3 Packet loss vs. time

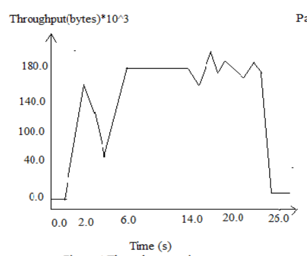

Figure 4 Throughput vs. time

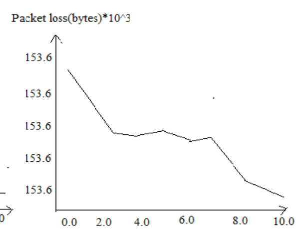

Figure 5 Packet loss vs. number of disjoint set

## 5. CONCLUSION AND FUTURE WORK

In this paper, we have presented an efficient algorithm to deal with the network lifetime and the issues regarding the coverage, connectivity and load-balance problem. The goal of the MCLCT problem is to maintain full sensing coverage and connectivity of WSNs for a long time. In the proposed FCECC, two algorithms are employed, and they are a clustering process to improve the coverage problem using the Energy-efficient LEACH protocol and a load-balancing strategy for determining routing paths. Full coverage is the main consideration and with this we can get a collection of subset of active nodes. Each cluster set is comprised of a small number of sensing nodes. Afterwards, the Load-Balancing strategy dynamically determines the best parent node to relay sensed data using local information among neighbour nodes while achieving even energy consumption of nodes. By doing so, energy-efficient operation can be achieved by the FCECC. Our experimental findings confirm that the combination of the cluster set generation algorithm and the load-balancing algorithm is feasible in maintaining full coverage and connectivity of WSNs to improve the overall network lifetime. According to the experimental results, the proposed FCECC outperforms the existing solutions of OCCH-badness, OCCH-critical, CWGC, Greedy-CSC, and GIECC by 20.5 547.6 % in network lifetime enhancement. Specifically, the

better performance of the proposed FCECC mainly comes from 1) the energy saving method designed for sensing nodes, 2) the coverage recovery strategy, and 3) the load balance mechanism developed for relaying nodes. For the future work, we will extend our study such that the efficient protocol can be designed for the improvement of the lifetime of the network.

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