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Implementation of EECS Protocol for Reliable and Efficient Data Collection in Large - Scale Wireless Sensor Networks

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Abstract **- In large-scale Wireless Sensor Networks (WSN), the main constraint is to have a reliable and energy efficient data collection. Dynamic clustering and selection of Cluster Head (CH) based on residual energy, provides a scalable and efficient solution. However the existing works, have a static way of CH selection, which is not an optimal solution for an energy efficient data collection, and there exists a problem of disconnection and inefficient cluster topology. In this paper, a method of combining the Energy Efficient Cluster head Selection (EECS) protocol and Artificial Bee Colony (ABC) algorithm, which selects the CH in a dynamic manner, based on the residual energy have been proposed. EECS protocol provides the means for dynamic clustering, after which the residual energy of the nodes is considered for the CH selection. Then ABC, a hierarchical based algorithm provides an optimum way of transferring data to the sink node from the CH, by means of using the Employee, Onlooker and the Scout bees. In which the Employee and the Onlooker bee acts as CH, which collects the information and the Scout bees passes it to the sink node. The simulation result shows high energy efficiency with reduced packet loss and increased through put compared to the existing system.**

Index terms - EECS protocol, ABC algorithm, residual energy, dynamic clustering, energyefficiency.

I. INTRODUCTION

Wireless sensor networks (WSNs) play important roles in collecting large-scale physical data that can be implemented in various security system such as environment monitoring [1], intelligent transportation system [2], [3], and industrial control [4], [5]. In WSN, a great number of sensor nodes with limited energy are self-organized in a vast region; thus, the data collection in large scale network meets the challenges of scalability and energy efficiency [6], [7]. Dynamic clustering provides a promising solution for data collection in large-scale WSNs [8]. Sensor nodes are grouped into clusters which have a leader called cluster head (CH) and a number of cluster members (CMs). In this process , the data are first collected by each CH from its cluster, and then forwarded to the sink through multi hops routing. Moreover, the cluster-based topology is reorganized periodically in order to balance the heavy traffic load of CHs. However, most previous works deal with the dynamic clustering without in-depth consideration on the impact of inter cluster routing. It is observed that there are tight relations between clustering and routing that may influence the performance of data collection in large-scale WSN.

1) Energy efficiency of inter cluster communication: The inter cluster communication is built among CHs; therefore, the efficiency of inter cluster communication depends not only on the position of the node but also the CHs selection.

2) Network connectivity with limited transmission range: Most dynamic clustering protocols assume that the nodes have enough transmission power to keep the network connected [9], [10]. For example, in LEACH [9], it is assumed that every node should have enough power to communicate with sink directly. In HEED [10], which has considered multi hops inter cluster communication, the inter cluster transmission range Rt is assumed to be Rt> 6Rc, where Rc is the transmission range for intra cluster communication. The assumption of multi hops leads to severe packet loss in large-scale WSN. The node has maximum transmission range Rmax which is bounded by its hardware capability. If the network exists in any edge that is longer than Rmax, the network will be disconnected. Also Joint clustering and routing (JCR) protocol which adopts back off timer [11] and gradient routing [12], to generate connected and efficient network topology for data collection in large-scale WSN.

Based on the survey of the performance of these protocols, Energy Efficient Cluster head Selection (EECS) protocol along with Artificial Bee Colony

(ABC) algorithm to achieve optimal solution has been implemented.

1) Detailed analysis on the relations between clustering and routing is provided based on several typical dynamic clustering algorithms. The results show that, if the clustering and routing decisions are made separately, the clustering range Rc affects both the connectivity and the energy efficiency of the network. In this case, the energy efficiency can hardly be achieved with the limitation of network connectivity.
2) In EECS, a reasonable cluster formation algorithm is used to balance the traffic load in different clusters, and eventually prolong the network life time. EECS considers the difference of the distance between CHs and `sink, and then initiates a novel cost function so that it enables CMs to select proper CHs depending on their locations. The unbalanced energy consumption of inter cluster communication is balanced by intra cluster communication in EECS.
3) ABC algorithm is an optimization algorithm depending on the intelligent foraging behavior of honey bee swarm. The initial stage of the swarm consists of employed bees, and the final phase constitutes the onlooker bees.The number of employed bees or the onlooker bees are equal to the number of optimal solutions in the swarm.

II. RELATED WORKS

Dynamic clustering is first proposed in LEACH [9]. The basic idea is the periodic re clustering with a randomized CHs rotation such that energy consumption of CHs can be balanced all over the network. Due to the advantages of scalability and energy efficiency, dynamic clustering has considered to be a promising solution for large-scale data collection in WSNs, and it has attracted considerable attentions from various research communities. Since the network topology is built based on the set of CHs, the CHs selection is one of the fundamental problems in dynamic clustering. HEED [10] proposes an iteration-based algorithm which considers both residual energy and communication cost in CHs selection. The algorithm improves the CHs distribution in the network and hence has better efficiency than LEACH. Observing that HEED suffers from considerable overhead in the iteration, back off strategy clustering (BSC) [12] uses the random back off timer to control the process of CHs selection. The node with smaller back off time has greater probability to be CH. BSC can generate well-distributed CHs, whereas the overhead in CHs selection is greatly reduced. LEACH-SWDN [15] sets up a sliding window to ensure that the number of CHs is maintained in an optimum range. It improves the energy efficiency after some nodes runs out of energy. Different from the distributed algorithms given above, there search work in uses harmony search algorithm (HSA) to select the CHs with centralized optimization. It is expected to minimize the intra cluster communication cost and optimize the energy distribution of the network. Cluster formation is another important issue in dynamic clustering. A reasonable cluster formation algorithm can balance the traffic load in different clusters, and eventually prolong the network lifetime. EECS considers the difference of the distance between CHs and sink, and then initiates a function which enables the CMs to select proper CHs depending on their locations. The drawback of the inter cluster communication is overcome by intra cluster communication and hence lifetime of the network is improved. [11], The cluster size [11] is balanced by two threshold: 1) the distance of intra cluster communication and 2) the number of CMs. There are many designing algorithm to determine the clustering range in different scenarios [13], [14]. EECS [13] considers the multi hop data collection scenario, and formulates optimization problem that determines suitable clustering ranges depending on the hop distance to the sink. The research work in [14] provides a mathematical framework to determine the optimal number of clusters by minimizing the energy consumption in both single-hop and multi hop scenarios. Almost all the fore mentioned works deal with the dynamic clustering without in-depth consideration on the impact of inter cluster routing. Compared with related works, this paper distinguishes them in two aspects.

1) The relations between clustering and routing in the large-scale data collection have been emphasized. The EECS protocol is designed to

select the CHs with joint considerations on the inter cluster routing efficiency. On the other hand,it also analyses how does the multi hop routing leads to the unbalanced CHs selection, and provides the guideline to balance the energy consumption.

2) The limitation of transmission range in the design of EECS have been considered. Most related works, such as [9], [10], and [13], assume that all sensor nodes have enough transmission power to keep the network connected. However, the limitation of transmission range becomes nontrivial that may impact both the connectivity and the energy efficiency in large-scale WSN.

III. METHODOLOGY

In WSN enhancing the life span of network depends on the energy dissipation of the sensor devices. Reducing the energy dissipation of sensor devices will improve the lifetime and device failure which help in better connectivity and coverage of sensor network. There has been various approach that has been developed to improve energy efficiency of sensor network among that clustering is a significant technique that help in improving the network lifetime by reducing the energy consumption but the issues with existing methodology is the energy inefficiency in selecting the cluster head which result in loss of connectivity which reducing the life time of network. To overcome this here the author proposes a design for cluster head selection based on connectivity of node. The experimental result shows that the proposed PS-LEAH perform better than existing LEACH in term of network lifetime, number of active device.

A) Network Deployment

Assuming a set of nodes and a sink deployed in a sensing area, the sensor network has the following features.

1) The main aim of the sensor network is to collect sensing data from sensor nodes to the sink, such that the destination of every sensing data is the sink.
2) The network is organized into clusters based on their location. Depending upon the residual energy , The node with maximum energy is elected as a Cluster Head (CH).The remaining nodes are considered to be Cluster Members(CM).
3) The CM communicates with CH where the CH collects the information from CM , transmits it directly to the sink node.
4) The protocol also ensures periodic re-election for the selection of CH after communicating with the sink node.

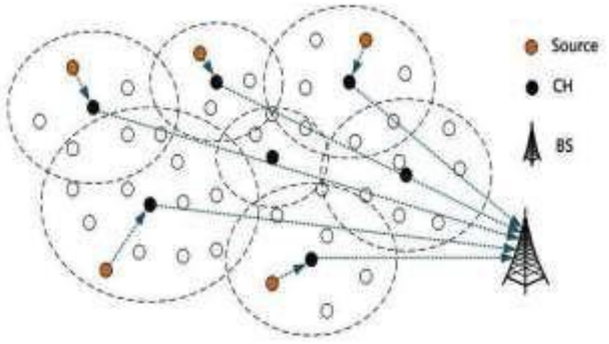


Fig.1 - Cluster formation and CH selection

Our system is deployed within an area of square region of about 1000*1000. In this , 100 nodes are deployed. The above fig.1 illustrates the working of EECS protocol .The model explains the region based clustering, a cluster with one cluster head (CH) and few cluster members, finally only the cluster head transmits the collected information directly to the Base Station (BS).Each cluster has a relative location based on the cluster information. The nodes are randomly distributed in the network.

B) Protocol Description

In EECS, a reasonable cluster formation algorithm is used to balance the traffic load in different clusters, and eventually prolong the network life time. EECS considers the difference of the distance between CHs and sink, and then initiates a function for CMs to determine proper CHs depending on their locations. The unbalanced energy consumption drawback in inter cluster communication is overcome by intra cluster communication in EECS.

EECS is similar to LEACH clustering scheme, where the network is sectioned into a set of clusters where each cluster contains a Cluster Head (CH).Communication between cluster head and BS is direct (single-hop).
In the network deployment phase, the BS broadcasts a test message to all the nodes at a certainpower level. In this way each node can compute the approximate distance to the BS based on the received signal strength. It helps nodes to select the proper power level to communicate with

the BS. that distance is taken into account to balance the load among cluster heads will be used. In cluster head selection phase, a distributed cluster heads are selected with a little control overhead. And In cluster formation phase, a weighted function is introduced to form load balanced clusters. Detailed descriptions of these two phases are in the following subsections.

1) Cluster formation:

In this data transmission phase, the consumed energy of cluster head i, E(CHi) is as follows, assuming

E(CHi) = milEelec+(mi+1)lEDA+l(Eelec+εmpd^4)

Observing formula 2, energy consumption of E(CHi) is composed of three parts: data receiving, data combination and data transmission. In the field, several cluster heads may be near the BS, while some are far away. The energy expended during data transmission for longer distance cluster heads is significant, especially in large scale networks. Since d(CHi,BS) has been fixed after cluster head election , the cluster size for each cluster head to balance their load across the network should be justified. The larger d(CHi,BS) is, the smaller member size mi the cluster head CHi should accommodate. Energy consumption of the PLAIN node Pj during transmitting the data to CHi satisfy the formula 1. Let E(Pj) be the energy consumed by Pj. If Pj always chooses the cluster head CH best with min{E(Pj)}, CH best may be bushed due to long distance data transmission to the BS and immoderate cluster size, although the energy of Pj is saved. In EECS, the PLAIN node Pj elects the CH by saving its own energy as well as it balances the work load of CH i.e. two distance factors: d(Pj,CHi) and d(CHi,BS). This paper introduce a weighted function cost(j,i) for the PLAIN node Pj to make a decision, which is

cost(j,i)=w×f(d(Pj,CHi))+(1−w)îg(d(CHi,BS)), (3)

andPj chooses CHi with min{cost} to join. In formula 3, f and g are two normalized functions for the distance d(Pj,CHi) and d(CHi,BS) respectively:

f =d(Pj,CHi) df max

g =d(CHi,BS)−dg min dg max −dg min (4)

where df max = EX(max{d(Pj,CHi)}); dg max = max{d(CHi,BS)} and dg min = min{d(CHi,BS)}. f subfunction in cost guarantees that members choose the nearest cluster head in order to minimize energy consumption of the cluster members, While g subfunction makes the nodes join the cluster head with minimum d(CHi,BS) to alleviate the workload of the cluster heads farther from the BS. w is the weighted factor for the will show that the optimal value of w depends on the specific network tradeoff between f and g. The experiments in Section 6 scale.

2) Cluster head selection:

In thisphase,several cluster heads are elected. Nodes become cluster members, nodes with a probability T and then broadcast the COMPETE HEAD MSGs within radio range R compete to advertise their wills. Each cluster member node checks whether there is a cluster member node with more residual energy within the radius R compete. Once the cluster member node finds a more powerful cluster member node, it will give up the competition without receiving subsequential COMPETE HEAD MSGs. Otherwise, it will be elected as CLUSTER HEAD in the end.

C) ABC OPTIMIZATION

The ABC algorithm is an extended algorithm for solving both constrained and un constrained optimization problems.In order to evaluate the performance of the ABC algorithm, a set of 13 benchmark problems is used. This set includes various forms of objective function such as linear, nonlinear and quadratic. The performance of the ABC algorithm is compared with that of the differential evolution (DE) and particle swarm optimization (PSO) algorithms.

1) ABC Performance:

ABC algorithm is an optimization algorithm depending on the intelligent foraging behavior of honey bee swarm. The initial stage of the swarm consists of employed bees, and the final phase constitutes the onlooker bees.The number of employed bees or the onlooker bees are equal to the number of optimal solutions in the swarm.

2) System Operations overview:

A system having randomly distributed sensor networks, is taken for our study. It is a square region of 1000*1000 nodes. The system is split into clusters, and each cluster has its relative location based on the information. The cluster separation is made such that 100 nodes are in each cluster. The location is expanded in a scale of 10 to identify the nodes, and to separate clusters when the node count reaches 100. Before sending the main information, a sample signal is sent over the network, and all the sensor nodes receive the sample signal and send it back to the sink. Based on the return signal, the residual energy of the nodes are calculated. The node with the high residual energy is taken as the Cluster Head (CH). The CH is selected periodically, based on the residual energy, by sending the sample signal. Because at any time, a node with high cluster energy can be added into a network else the current CH may have low residual energy over time. After each adding each node to the cluster, it is checked whether it is the CH. With each added node this residual energy check is done, to make sure that the CH selection is dynamic.

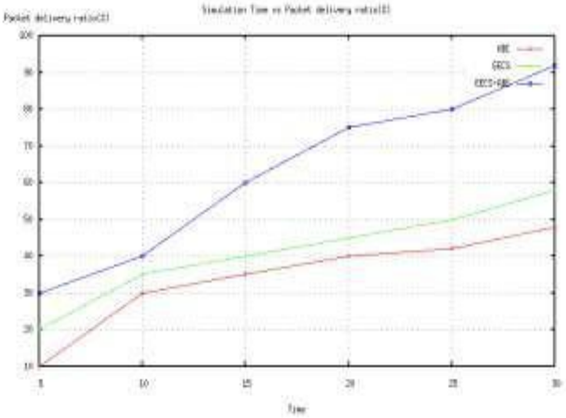
After the selection of the appropriate CH, ABC algorithm is implemented for hierarchical arrangement of the nodes. There are three bees of the ABC algorithm, namely Employed bees, Onlooker bees and the scout bees. The scout bees performs the operation of collecting the information from the CH and passing it to the sink. When both an Employed bee and the onlooker bee has data to be sent at the same time, the Employed bee is giving more preference than the Onlooker bee. The Scout bee moves in a random manner among the CH, with search for the food source, as soon as the reaches the food source, the CH transfers the data to the scout bees which in turn transfers the data to the sink. The advantage of this hierarchical method the collection of data is efficient since the nodes are arranged in hierarchical manner. After the collection of data, before sending the next information a sample signal is sent to select the CH, and the process repeats again. The data is transferred from the scout bees to the sink by EECS routing. Congestion avoidance mechanism is done to reduce congestion so that delay due to congestion is reduced, and the packet ratio is increased.

IV.RESULTS AND DISCUSSION

The performance of the combined action of EECS protocol and ABC algorithm in evaluated based on the following parameters

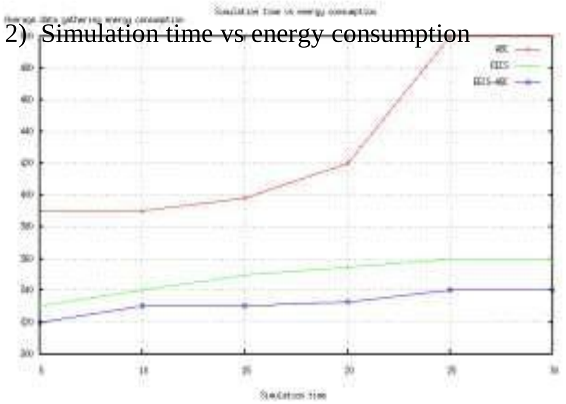
a)Packet delivery ratio b)Energy consumption

1) Simulation time vs packet delivery ratio (%)



The model designed consists of key features and behaviour of the process, the time taken for the model to perform the function is simulation time.The graph consists of individual performance of EECS and ABC also the combined action of EECS and ABC algorithm .The PDR is increased by 55% when compared to the existing system.

2) Simulation time vs energy consumption



The simulation output shows that the combined performance of EECS protocol and ABC algorithm is more efficient than the individual action of EECS protocol and ABC algorithm .The energy consumption is reduced by 68% .This paper provides the network to operate with minimum energy consumption, less packet loss, low delay and high throughput.

V. CONCLUSION

This paper, presents a novel distributed, energy efficient and load balanced clustering scheme applied for periodical data gathering. EECS form a uniform distribution of cluster heads through localized communication with little overhead. The protocol combined with ABC algorithm leads the network to perform a reliable and efficient data collection in large scale wireless sensor network .It is evident that the packets are delivered to long distance with minimal packet loss compared to the existing system and also it improves the life time of the network. There are still much space to improve the performance of data transmission. In the large scale sensor networks, multi-hop communication is a technique implemented for energy saving. This paper leads to design an energy efficient protocol for both intra cluster and inter cluster data transmission in the future.

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