Cluster based on Load Balancing for Environmental Monitoring in Wireless Sensor Network

Shashikumar .R[1], Dr.Anupama A Deshponde[2], Dr. B.Mohankumar Naik[3]

[1]*Research Scholar, JJT University, E & C Department, Jhunjunu, Rajasthan India*

Abstract—*Present Wireless Sensor Networks (WSN) having huge number of applications in various fields. Developing a load balanced clusters and energy efficient data routing is a challenge in the WSN. The node requires more energy, when the node transmits the data directly to Base Station (BS) without any sink node. Clustering is optimal technique to reduce the energy consumptions in the network. When the equal clustering is done, the Cluster Head (CH) collects the data from the cluster members. Collected data is transmitted to BS through CHs. Hence CHs requires more amount of energy. Due to overload of data the CHs may dies early. This leads to data loss in the network and affects the performance of the network. Hence, the proposed work Hybrid Unequal Clustering algorithm has implemented to balance the load in the network. The nodes which are near to BS makes the data routing from CHs to BS, leads energy drain in CHs. Energy Efficient Data Gathering methods is used to gather data from the CHs. The proposed combined system improves the lifetime of network and balance the energy.*

Keywords — *Wireless Sensor Network (WSN), Hybrid Unequal Clustering Layer (HUCL), Energy Efficient Data gathering (EEDG), Cluster Head (CH).*

I. INTRODUCTION

A wireless sensor network is a type of wireless network, it includes large number of self directed, low powered, circulating devices defined as sensors nodes. These nodes are also known as motes. The wireless sensor network covers a huge number of small, embedded devices, battery-operated, and spatially spread devices. These networked devices compassionately gather process and send data to the operators. It has controlled the capabilities of computing and processing. Tiny computers are called nodes and are connected each other to create the network. The node in the sensors is an energy efficient, multi-functional wireless device. Fig.1 shows the Wireless Sensor Network. In industrial field, a node has more number of advantages and applications. Node interacts with each other through transceivers. In a wireless sensor network more numbers of nodes can be found. In comparatively, sensor Ad Hoc network will have less number off nodes when compared to WS network without any structure.

WSN includes a gateway to provide connectivity between the wired world and nodes which are distributed. Number of wireless protocols are developed in WSN, depends on the field and specification protocols are selected. Some standard protocols comprise of 2.4GHz radio depends on either IEEE 802.11 (Wi-Fi) standards or IEEE 802.15.4 or 900 MHz of proprietary radios.

Fig 1 Wireless Sensors Network

A WSN built-in of three main devices: Nodes, gateway and Software. The spatially distributed amounts of nodes are attached with sensor to track the environment. The gathered data is transmitted to the gateway wirelessly, through gateway the gathered data is transfer to wired world. The transferred data is collected, pre-processed, analyzed and presents measured information using software tools. To widen the distance and reliability, routers are implemented. Routers are helped to enlarge the distance between the nodes and gateway in WSN. A WSN gives more flexibility to make a stand-alone, simple wireless monitoring network or a totally integrated wireless system.

The network degrades as the increase number of nodes in the network. This is due to as the increases in the size of network; control overhead in WSN also increases. Generally clustering is one of the approaches used as solutions to scale down large sensor network and increase the network efficiency. In forming a clustering, the nodes are organized into

groups depends on parameters of the network and field specification. In comparison Cluster-based WSN has number of advantages than the flat WSN, such as increase in network lifetime and energy efficiency. The hierarchal organization of sensor nodes network are called cluster-based WSN. They are many number of research are conducted on clustering techniques in wireless sensor network.

Fig.2 shows the structure of cluster in network, where the nodes are grouped into cluster shown by dotted lines. The energy consumption by the direct transmission of data from the sensor nodes to BS is reduced by clustering technique. The nodes which exhibits same characteristics or the neighbor nodes are grouped to form clusters. One of the nodes in the group is elected as a cluster head. The clusters with an unequal number of member nodes are defined as unequal clustering.

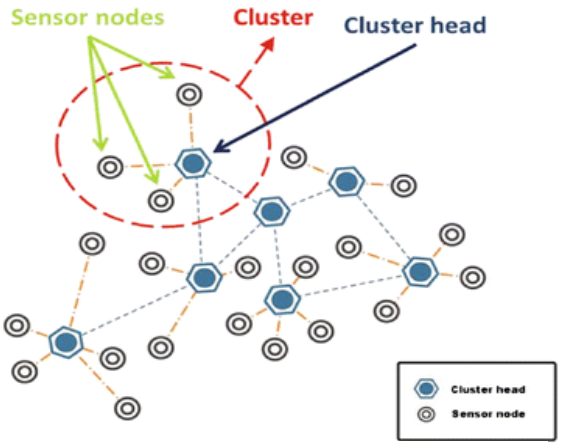

Fig.2 Clusters formation in Wireless sensor network

The entire network is basically divided into three sub types of nodes, namely, sensor nodes, cluster and cluster head (CH). In the cluster, CH is the local director that collects information from the member nodes and forwards that information to BS. The sensor member nodes are the base nodes that forward data to cluster-head.

Communication Bridge between two nodes is called gateway. The gateway is capable to predefine the multihop, inter cluster communication route, known as backbone of the network. Each cluster head holds neighboring gateways information in it is routing table, these routing table helps in making routing decision exactly. There are number of research work done in the field of WSN for clustering the nodes and efficiently gather the data from the different sensor, the below section describes about the survey of different algorithms, techniques and protocols.

II. RELATED WORK

Wireless senor network cluster head consumes more energy compare to nodes, it is due to extra load of different actions such as data aggregation, data collection and communication if aggregated data to the base station. Balancing the load for longer time is challenging in the wireless sensor network. The algorithm has developed to balance the clustering scheme foe wireless sensor network [01].

M. Mehdi Afsar et.al [02] has proposed a system to overcome the energy and bandwidth limitation by introducing a Energy and Proximity based Unequal Clustering algorithm (EPUC Clustering is done depends on the distance between the cluster heads that is adaptively adjusted, inter-cluster heads are get closer to base station. The number cluster is reduced. The algorithm overcomes the uneven energy consumption rate of nodes. Cluster heads are selected based on energy reserved and the proximity to the base station. As the cluster gets closer to base station the counts of clusters get increased and the given area is divided into tracks centred at the base station. The nodes with the high energy chosen as a cluster heads in a competition of track-based, EPUC algorithm increase the network lifetime.

Yanjun et.al [03] has proposed system to overcome the difficulty of Open Vehicle Routing (OVR), the system resolve or prove certain challenging problems in WSN applications by the data gathering protocol called Energy-Efficient Delay aware (EEDA) Lifetime-balancing information gathering has implemented.

Naveed Ilyas et.al [04] has proposed a system that consumption very less amount of energy for data gathering. Rendezvous points (RPs) are the few points selected to collect the data from the sensors. To gather the information from the RPs mobile elements are used, Mobile elements gather the data efficiently from the wide data from the RPs within the given time. The RPs is positioned in such a way that it should avoid the maximum traffic in the network and also the network life time is increased. The mobile elements are placed with a tree shaped network. The information to sink node pass through the mobile elements.

Nueraili Aierken et.al [05] has proposed a system that provides scalability, better network lifetime and load balancing in WSN. Clustering is method that has been commonly implemented for achieving these goals. In the WSN energy holes are the major problems which cause uneven energy utilization in equally created clusters. The nodes very close to base station expire early since they transmit its own data and also the rest of the network data. The Rotated Unequal Clustering protocol (RUCHEED) it alleviates the energy hole problem. By avoiding the energy hole problem the lifetime of the network is increased, the number of cluster head election and cluster formation phase reduce the number of control messages.

Zhao Han et.al [07] wireless sensor network composed of a more number of micro sensors. This networks are use to gather and transmit different type of messages to a Base Station (BS). WSN includes low-cost networks with limited resources like battery

power and replacing a battery is not an easy for the WSN with number of embedded nodes, means energy efficient routing protocol is necessary to offer a long work life. The system has achieved energy balance and low energy consumption..

III. METHODOLOGY

The architecture of the proposed system for unequal clustering and energy efficient data gathering is as shown in the Fig.3. In the proposed system, wireless sensor network is employed with a Temperature Sensor, Humidity Sensor, and Light Sensor and Voltage sensor. These sensors nodes will sense the information and transmits the collected data to the sink node. When the numbers of nodes are increased in the network, it causes data overhead problem at the sink node. The application of clustering method helps to transmit the data to sink node without any data loss in the network. To form an unequal cluster the most familiar network parameters are considered i.e. energy in the node, node distance to BS, sensed data and number of neighboring nodes. The proposed system which forms the clusters depends on the load (i.e. sensed data) and the energy.

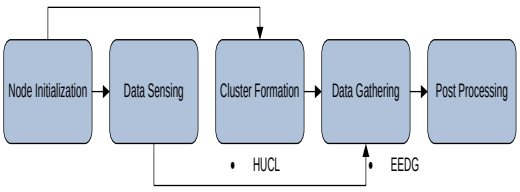

Fig.3 Block Diagram for Cluster Formation and Data gathering

The unequal clustering in the wireless sensor network is as shown in the Fig 4.

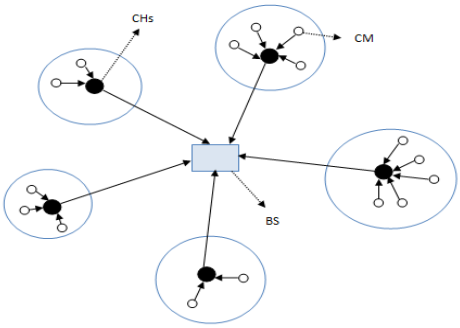

Fig. 4 Unequal Clustering

Nodes are initialized to sense the physical data continuously. The sensed data stored in the device for a period of time. The algorithm is implemented to form the clusters. Depends on the initial energy in the sensor nodes and load, the clustering is done. Each cluster in the network consists of equal amount of load to overcome the data overhead problem in the network. Based on the operating distance the cluster head select its neighbor nodes for the cluster formation. The nodes which are present within the threshold distance will become a part of cluster. Once the clustering is completed, the load and minimum functional energy in the each cluster is determined. Every sensor node has its own functional capacity i.e. in term of energy and data handling. The load in the each cluster should be equal, if not the re-clustering is done. Clustering is formed with unequal number of nodes with an equal load to balance the data in the network.

Hybrid Unequal Clustering layer algorithm is used to form the unequal clustering. The data in the network transmitted to sink node through the shortest path with the efficient energy. Energy Efficient Data Gathering algorithm is implemented to gather all the sensor node data to the sink node. The shortest path is discovered first to route the data. According to packet header the data is post-processed and arranged in a sequence.

A. Hybrid Unequal Clustering Layer algorithm.

Cluster formation is depends on neighbor node energy and node distance to BS. Once the clustering is done, the function of cluster head differs as compared to normal nodes like data collection from cluster member, data transmission to BS. A cluster head work as a manger for its cluster members and intra-cluster transmission is provided.

In traditional methods CH make use of single hop for communication and to forward the data to the sink, by using the single hop the network lifetime is reduced. The network lifetime can be increase by multi hop communication. Hot spot is one of the key problems in clustering, irregular size clusters resolve the clustering in unequal clustering [09].

The proposed algorithm Hybrid Unequal Clustering layer used to fulfill the requirements of application of wireless sensor network. The Low Energy Adaptive Clustering Hierarchy (LEACH) same radio model is used in Hybrid unequal clustering. The energy used by 1-bit data a distance 'd' as shown in the Eq. (1).

$$GTY_{(l,d)} = \begin{cases} l * G_{elec} + l * G_{fs} * d^2, d \leq dl_1 \\ l * G_{elec} + l * G_{amp} * d^4, d \geq dl_1 \end{cases} \quad (1)$$

Eq. (1) shows the radio model of the network, where, G_{fs} is the energy consumed by free space model, G_{amp} is the energy reduced by a multi-path amplifier and dl_1 is the distance form layer 1. From the Eq. (1) it is clear that only the layer 1 CHs is the single nodes to broadcast data to the sink directly.

After operation, the distance from the Sink Node (SN) to node is calculated to form the layers and an ID is allotted to the entire node in the network, the ID is unique to all the nodes according to layers. First the SN sends a HELLO message with a unique-id by utilizing a minimum power, the messages are received by the nodes and the distance is designed based on the received message length. The power

level is increased and the message is broadcasted again to all the nodes in the network, this is because for the inter-cluster communication.

The clusters are not dependent on the layers. The entire operation of hybrid unequal clustering is divided into rounds, all the nodes has a data transmission stage and setup stage. 'M' major slots are divided for data sending to reduce the overhead, and all the major slots consist of 'm' mini slots. The data transmission takes place in the mini slots. The operations covered by the mini slots are, the data collection from the sensors by cluster head, data aggregation by cluster head, TDMA schedule distribution and sending data to the sink node. The operation of the key slots is cluster head revolving within the boundary of the cluster and hand over the cluster members and the data forwarding path to new cluster head.

The random waiting period is computed by all the nodes by using the formula as shown below in Eq. (2).

$$Pw_{(Si)} = \frac{G_{init}(Si)}{G_{rem}(Si)} * \frac{1}{\alpha |Nl_{(Si)}|} * T_2 * R \qquad (2)$$

Pw is the random waiting time calculated by all the nodes. T_2 is the time set for this phase. G_{init} and G_{rem} are the initial and residual energy of the node ***Si*** respectively. Where α indicates the number of time the nodes ***Si*** acts as a CH. $|Nl_{(Si)}|$ is the number of neighbor nodes for the ***Si*** and ***R*** is the random number chosen between 0.1 and 0.2. All the ***Si*** nodes wait for time $Pw_{(Si)}$ to receive the head message from other nodes as shown in Eq. (4).

$$Pc_{(si)} = \left[1 - C\ \frac{d_{max} - d_{(si,Bs)}}{d_{max} - d_{mi}}\right] PL_{max} \qquad (3)$$

When there is message from any nodes, it assumes itself as a head and sends the head message within its competition radius ***Pc***. Where, ***PLmax*** is the layer-dependent on highest competition radius, which are predetermined during the network initialization. The 0 and 1 are the values taken from the weighted *C* factor. Whenever the head message is received, the head list is updated to find the closest head. When the time has expired, nodes find the closet CH and transmit the join cluster message. When the join cluster message is received, the member list is updated.

The algorithm for the cluster setup phase is as shown below.

Algorithm: Cluster Setup Phase
Input: Number of nodes *Output:* Cluster formation *Step 1:* Start *Step 2:* Initialize all the nodes *Step 3:* Broadcast Neighbour_Msg to all the nodes *Step 4:* Discover the neighbor node distance by received msg *Step 5:* Update the neighbor list NL[ ] *Step 6:* Next broadcast the Head_Msg to all the nodes *Step 7:* All the nodes in the network receives the Head_Msg from the competition CH *Step 8:* Store the entire Msg in the Head_List HL [ ] along with the distance. *Step 9:* Select nearest CH from the HL [ ] list *Step 10:* Broadcast cluster Join_Msg to all the nodes *Step 11:* By considering the load, distance and energy select the members of cluster *Step 12:* Stop

B. Energy Efficient data gathering

Title The unequal grouping of the nodes in the network to balance the load is done by the HUCL algorithm. To enhance the life span of the network the energy efficient algorithm is proposed based on the length constrained. Vehicle Routing Protocol (VRP) is used to route the data by finding the shortest distance. This shortest distance finds the short length by using which Mobile Element (ME) can travel through all the nodes based on the Earliest Deadline First (EDF) once in the each cluster as explained in the algorithm [10].

C. Combined Flow Chart

The combined flowchart for both the cluster formation and data gathering is as shown in the fig.5 The first phase of the work starts with initialization for the cluster formation. Once the cluster formations are completed, the next step is to chose the cluster head among the nodes. Only one will be elected a cluster head in each of the clusters. The load of each cluster head is computed. If the load is same, it goes to the second phase of the work i.e. data gathering. Suppose if the load is not same in all of the clusters, initialization of the re-clustering takes place until the load gets balanced. The energy efficient data gathering will be initiated once the load balancing done in the clusters.

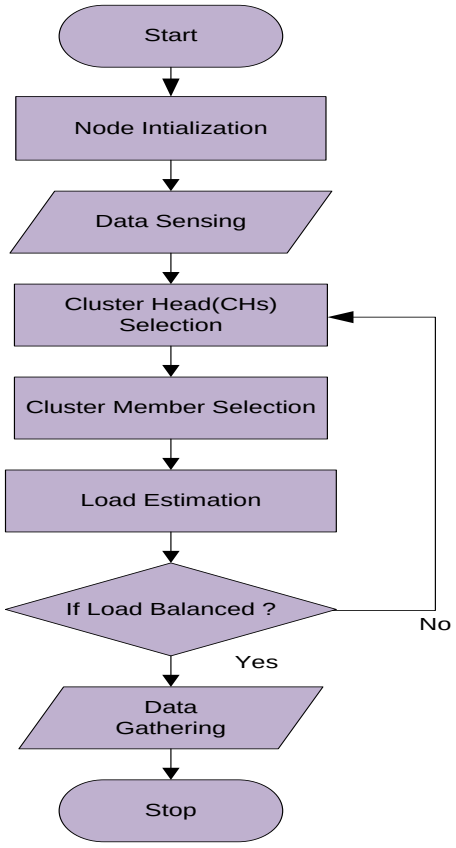

Fig 5 Flowchart for Cluster Formation and Data Gathering in WSN

IV. RESULTS

A simulation of the proposed system is performed by using MATLAB 2012a. The system has been analysed with the parameters of cluster head distribution, energy balancing and efficient data gathering. The performance evaluation of the work had tested by considering two scenarios. In the scenario1, we have taken 20 nodes for the deployment and 20 nodes have deployed in scenario2. In both the cases, nodes are randomly deployed in the wireless sensor network of area dimension 100m*100m. Assume all the sensor nodes are fixed nodes with the initial energy E_o. The Fig.6 and Fig.7 shows the sensor node initialization for 20 and 50 sensor nodes.

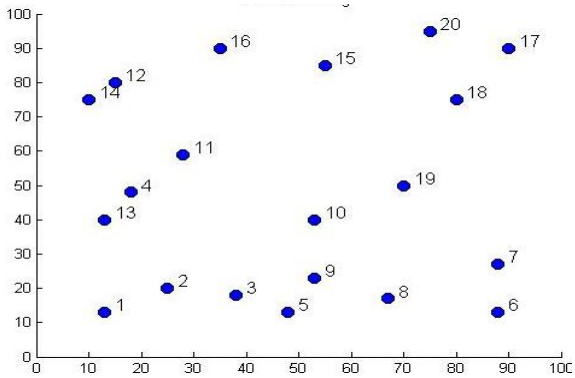

Fig 6 Sensor node initialization (N=20)

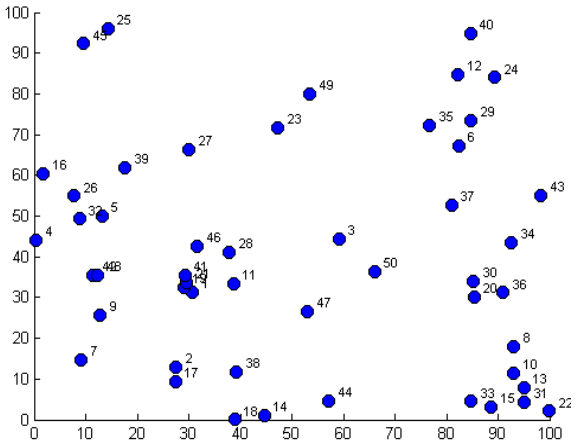

Fig 7 Sensor node initialization (N=50)

The sensors nodes are initialized according the defined X –axis and Y-axis locations as shown in the Fig.8 and Fig.9. The Base Station is located at the centre (50m * 50m) of the network as shown in Fig.8 in both the scenarios.

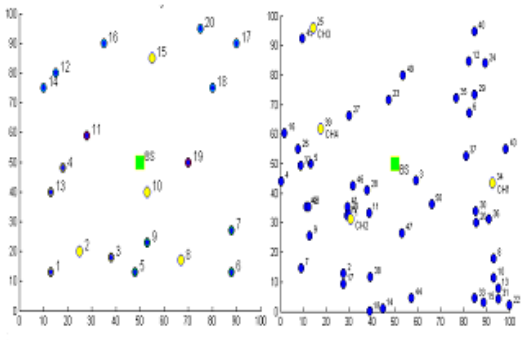

Fig 8 Base Station initialization (N=20 and N=50)

We have chosen value k=4 i.e. number of cluster heads. The cluster formation along with the Cluster Heads is as shown in the Fig. 9 and Fig.10. The clusters are formed based on the distance. The standard Intel Berkeley research lab dataset is considered as a load and four different physical environment sensing sensors are taken as first 20 data. The sensors chosen for the evaluation of the system are Temperature, Humidity, light and voltage [12].

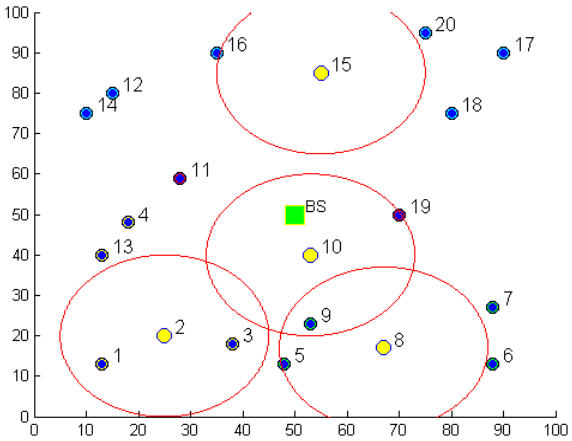

Fig 9 Cluster formation (N=20)

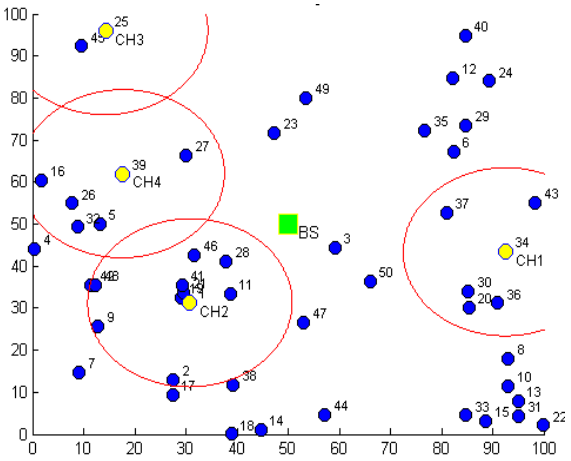

Fig 10 Cluster formation (N=50)

The CHs collect the data from all the member nodes and calculate the mean of overall data as shown in the Fig 11. The mean values of all the CHs are compared with each other. The load of all the cluster heads are not equal (CH1=106, CH2= 106, CH3= 105 and CH4=105) as shown in the Fig 10 for node N=20. Similarly, the load calculation for sensor node N=50 is as shown in the Fig 12 (CH1=104, CH2=105, CH3=104 and CH4= 104). This initiates the re-clustering of the sensor nodes and the iteration process is carried out until the load gets balance.

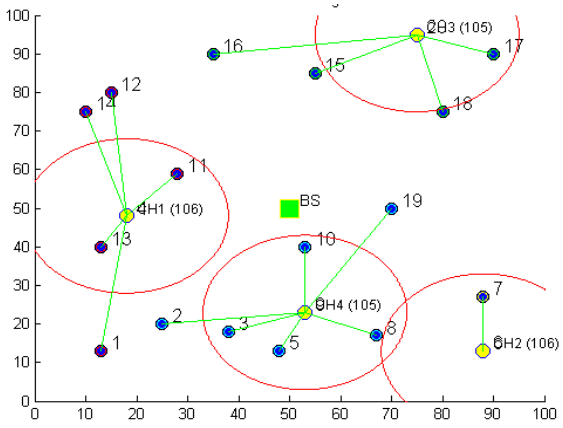

Fig.11 Load calculation (N=20)

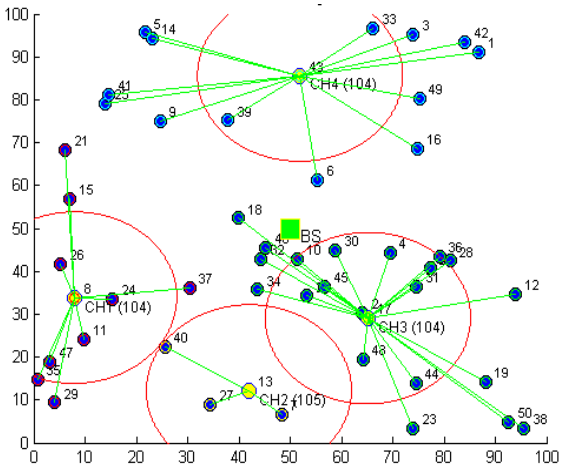

Fig.12 Load calculation (N=50)

The re-clusteirng of the nodes for both scenorios is as shown in Fig.13. The loads are balaced and load computed for N=20 is eual to 105. Similarly ths laod computed for the N=50 is is equal to104.

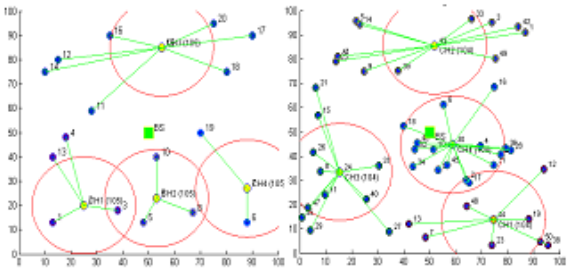

Fig.13 Load calculation (for both N=20 and N=50)

The data gathering by the cluster heads form its member nodes happened once the load gets balanced. The energy efficient data gathering algorithm is used for the data gathering. The data gathering of the nodes is as shown in the Fig 14 and Fig 15.

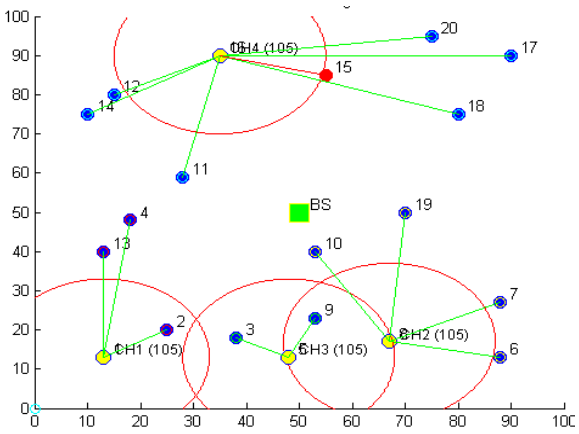

Fig 14 Data Gathering (N=20)

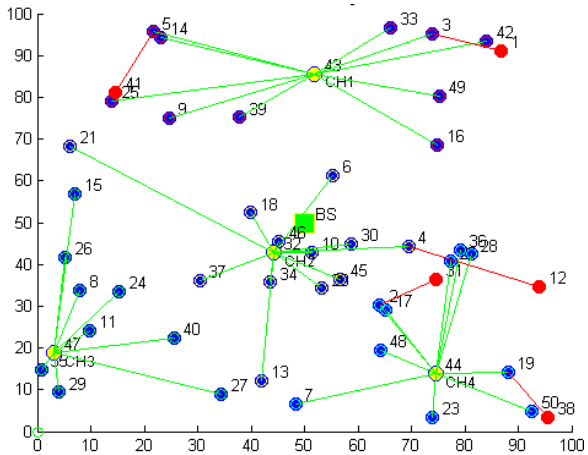

Fig 15 Data Gathering (N=50)

When the sensor nodes have started to transmit the data to the sink node, energy drain may cause the loss of data in the node. As shown in the Fig 14 and Fig 15, the node which is having below the average energy transmits data first to the neighbour node before it dies (red colour sensor node).

In WSN, sensor nodes are requiring more energy for transmitting the data rather than sensing, processing and receiving. The Energy consumption depends on the parameters such as distance, data packet length, free space or multi-hop. The Figure shows the initial energy in the network and energy reduced after data collection. At the time T, the energy at the sensor node is calculated using the Eq. (4).

$$E = E_o - ((E_{Tx} + E_{da}) * L + E_{mp} * L * (d))^2 \quad (4)$$

Where E_o denotes initial energy of the all the sensor nodes, E_{Tx} is amount of energy required to transmit the data. E_{da} Represents the energy reduced to aggregate sensor data. L is the packet length and d is the distance between cluster head to its member nodes. The proposed system require minimum energy for it operation when compared to the other existing system as shown in the Table 1.

Table 1: Existing and Proposed Model Performance Comparison Table

S. No	Author	Methods	Energy
1	B Baranidharan et.al [13]	DUCF	0.0853
2	Proposed model	HUCL	0.0793

The average energy consumed for each round is as shown in the following Fig 16.

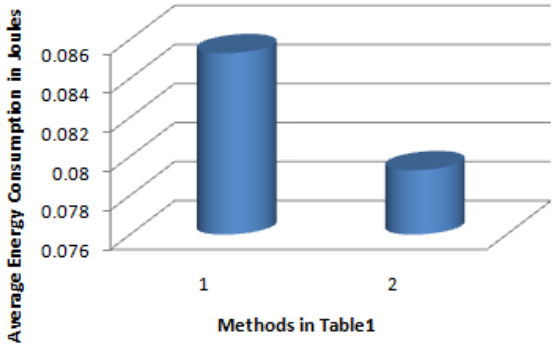

Fig 16 Energy consumption

The energy consumed by the sensor nodes in the WSN after the data collection is as shown in the Fig 17.

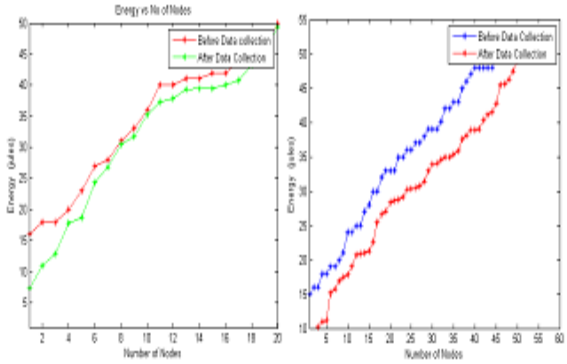

Fig 17 Energy Required for Data Collection

V. Conclusions

Clustering is one of the optimal techniques for cyclic data collection in the WSN. The Hybrid Unequal Clustering algorithm is proposed to overcome the clustering overhead problem through unequal clustering. The network is partitioned into number of layers and cluster of various groups. The number of neighbour nodes, energy available, available data in the node and the distance to base station are the parameters considered to select the nodes as a CHs. Efficient Energy based data Gathering is a routing protocol to gather the data to sink node from all the member nodes. Compare to the other dynamic clustering, these algorithms reduces the clustering overhead and provides an efficient data gathering. When the node energy is reduced to below threshold, before the nodes dies the data is transferred to the nearby node. Hence there is no loss of data in the network. The performance of the system shows that energy consumption in the network is reduced and the lifetime of the network is increases.

References

[1] Pratyay Kuila and Prasanta K. Jana, "Approximation Schemes for Load Balanced Clustering in Wireless Sensor Networks", The Journal of Supercomputing. Springer, Vol. 68, No. 1, pp. 87-105, 2016.

[2] M Mehdi Afsar and Mohamed Younis, "An Energy and Proximity-based Unequal Clustering Algorithm for Wireless Sensor Networks", IEEE, pp 262-269, 2014

[3] Yanjum Taol and Qing Cao, "EDAL : "an Energy Efficient Delay Aware for wireless sensor network", mobile adhoc and sensor systems (MASS) IEEE 10th international conference, IEEE, Vol 23, Issue 3, pp 810-823, 2015..

[4] Naveed Ilyasa, Turki Ali Alghamdib, Muhammad Nauman Farooqa, Bilal Mehbooba, Abdul Hannan Sadiqa, Umar Qasimc, Zahoor Ali Khand and Nadeem Javaida, "AEDG AUV-Aided Efficient Data Gathering Routing Protocol for Underwater Wireless Sensor Networks" , Procedia Computer Science. Elsevier, Vol. 52, pp. 568-575, 2015.

[5] Nueraili Aierken, Roberto Gagliardi, Leonardo Mostarda and Zaib Ullah, "RUHEED- Rotated Unequal Clustering Algorithm for Wireless Sensor Networks", Advanced Information Networking and Applications Workshops (WAINA) IEEE 29th International Conference. IEEE, pp.170 – 174, 2015.

[6] Chuan Zhu, Shuai Wu, Guangjie Han, Lei Shu And Hongyi W, "A Tree-Cluster-Based Data-Gathering Algorithm for Industrial WSNs With a Mobile Sink" , IEEE, Vol. 3, pp. 381 – 396, 2015.

[7] Zhao Han, Jie W, Jie Zhang, Liefeng Liu and Kaiyun Tian, "A General Self-Organized Tree-Based Energy-Balance Routing Protocol for Wireless Sensor Network", IEEE, Vol. 61, No. 2, pp. 732 - 740, 2014.

[8] Pratyay Kuila and Prasanta K Jana, "A Novel Differential Evolution Based Clustering Algorithm for Wireless Sensor Networks", Applied soft computing. Elsevier, Vol. 25, pp. 414–425, 2014.

[9] L Malathi, R.K. Gnanamurthy and Krishnan Chandrasekaran, "Energy Efficient Data Collection through Hybrid Unequal Clustering for Wireless Sensor Networks", Computers and Electrical Engineering. Elsevier, Vol. 48, pp. 358 – 370, 2015.

[10] Bhat Geetalaxmi Jayram and D. V. Ashoka, "Validation of Multiple Mobile Elements based Data Gathering Protocols for Dynamic and Static Scenarios in Wireless Sensor

Networks", Procedia Computer Science. ELESVIER, Vol. 92, pp. 260-266, 2016.

[11] Geetha V. A, Pranesh V. Kallapurb and Sushma Tellajeerac, "Clustering in Wireless Sensor Networks: Performance Comparison of LEACH & LEACH-C Protocols Using NS2", Procedia Technology. Elsevier, Vol. 4, pp. 163–170, 2012.

[12] http://db.csail.mit.edu/labdata/labdata.html

[13] Baranidharan B and B Santhi, "Ducf: Distributed Load Balancing Unequal Clustering in Wireless Sensor Networks using Fuzzy Approach", Applied Soft Computing. Elsevier, Vol. 40, pp. 495-506, 2016.