Implementation of Multi-hop Technique in Dec Protocol

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***Abstract* - Due to various challenges existing in observing remote places, many researchers are attracted towards Wireless sensor networks. It helps in collecting the data, such as temperature, moisture, and so on. Sensor networks involve effective methods and practices to accomplish the constraints like energy consumption and structured system performance. The network life span is of major concern in wireless networks which can be prolonged significantly by considering the conservation of nodes energy. The research work focuses on DEC (Deterministic Energy-efficient Clustering) protocol i.e. enhancing DEC protocol with multi hop mechanism to utilize energy more effectually. To improve scalability and network lifetime of a sensor network, clustering techniques play an important role. In this paper, a multi hop cluster based routing protocol which is more energy efficient than single hop protocol has been taken in consideration. To achieve the higher degree in the lifetime of the nodes, the residual energy of the nodes for multi hop node choice is taken into attention. The simulation results prove that the protocol offer a better performance characteristics than single hop clustering routing protocols in favour of system lifetime and energy by improving the stability period of the network. To optimize the communication in the network, implementation of multi hop communication proved to be efficient mechanism rather than direct communication in cluster field.**

Keywords - Energy Efficient, Base Station (BS), Multi hop, Residual energy

I. INTRODUCTION

With the development of compact communication modules for example sensor network driven by batteries, solar cells are made easy by the improvements in sensors communication and microelectronics technologies. Sensors are capable of collecting data from the location and must be capable of accomplishing tasks like Sensing, Processing and Transmission. Sensors are made to work in a cooperative way so as to attain a robust WSN platform. This architectural design proposal gives rise to the well-structural studies in the domain of communication sector. For this purpose, it will remain to receive consideration in the ages ahead since they are potent for any type of monitoring applications extending from the health care to our home automation surroundings.

A. Wireless Sensor Network

In order to measure the parameters of a large geographical area few hundreds or thousands of sensor are deployed over that region. To sense the factors such as heat, pressure, moisture, etc., the sensor node designed with an embedded controller, wireless transceiver, and a memory that is inadequate in nature. The collected data by the sensor nodes from the sensing will be forwarded to the base station (BS). Due to the capability of WSN to transfer the ecological data to base station directly or through nearby node, sensor network are made suitable for distant regulator monitoring and observations The capabilities of a sensor is very limited in terms of bandwidth, energy supply and also with low mobility. The battery recharging of the sensor network in many cases may be difficult or impossible. Though the initial energies of each node is same at initial stages but as the communication process extends the energy levels of sensors changes based on their role of interaction and participation. By the efficient usage of energy the lifetime of the sensor network can be prolonged. Several energy effective systems and dynamical efficient designing protocols have been proposed for WSN[I. F. Akyildiz et al.,2002].

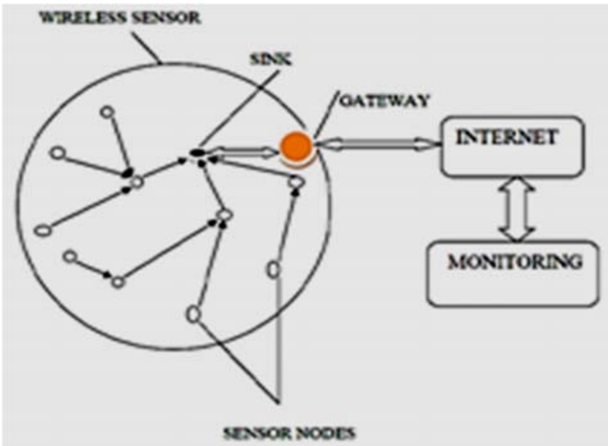

Figure 1. Network model

Usually preferred protocol in wireless sensor system is LEACH protocol which is proved to be energy efficient.

LEACH is a clustering based protocol in which, the sensor nodes are organized in the form of clusters for low energy consumption and for constant load distribution on the sensors over the network.[Y. Liu et al.,2009].

B. Problem Definition

There has been a rising awareness in WSN in recent years. Raising of energy-effective routing protocols is the foremost problems in sensor network. Energy protection is a serious problem in WSN for network life-time and nodes as all the instruments have controlled existing energy. The cluster member nodes will switch off their radio frequency totally till their pre-allocated time slot in LEACH. In LEACH due to the randomized turning round of local cluster- head, the clusters are not distributed frequently. DEC [F. A. Aderohunmu et al., 2011] is a hierarchal routing protocol with an improvement in election process of cluster head than that of LEACH. The 3 tier multi hop technique is implemented to enhance DEC. Many design issues must be considered to attain a useful and enceinte operation of WSNs due to hardware and software constraints. New application consequences lead to new challenges.

The given point shown few issues which are available in WSN:

(1) Energy-aware algorithms: It can be difficult to replace the external batteries of sensor nodes when they are used, so it is typical case to design algorithms and protocols that utilize minimum power. And provider must decrease make contact with between sensor nodes, simplify computations and affect irrelevant safety solutions which are based on an hierarchical clustering algorithm for sensor networks.

(2) Location discovery: In order to connect meaningful data with the target under analysis, many applications which can trace an object requires to know the correct or approximate physical position of a node. So, many biological routing protocols need the position of sensor nodes to forward data among the networks. Site finding protocols must be intended in a process that in order to discover their location the smallest amount of information is required to be exchanged among nodes.

II. RELATED WORK

The first cluttering routing protocol in wireless sensor network was LEACH protocol designed based on hierarchical routing system. The key scheme of LEACH protocol is dividing the total sensor network into many clusters. The cluster head (CH) is selected randomly, the chance of each and every node to be selected as cluster head is equal to the average of the energy consumption of whole network.

A. Problems in LEACH Protocol

In LEACH protocol [I. F. Akyildiz et al.,2002], CH selection is done randomly. After several rounds, there will be same likelihood or probability for the node with greater remaining energy or the node with lesser remaining energy to be chosen as cluster head. The life-time and the robustness of the system network can be affected if the node of smaller remaining energy is chosen as cluster head, energy runs out and dies quickly.

DEC (Deterministic Energy-efficient Clustering) protocol is implemented when the cluster heads and cluster members are elected based on their residual energy to address these problems. Initially, the cluster head is elected according to the threshold value. From then, the election is done by comparing the residual energy values of each node with neighboring nodes.

If we consider a case such that, all the cluster heads are located at a same place where the cluster members require more energy to communicate the information to the CH's and to Base Station.

This reduces the network lifetime as the energy usage by the each node is more than the necessary. In order to avoid these problems DEC protocol is introduced with improved election process of cluster heads. In DEC, the process of election of CH is done by comparing the residual energy of each node in every round. The node which is having more RE will be elected as a CH. In these protocols, setup phase is the beginning of the clustering process where all nodes use the indicator function for selection as CHs. Using the carrier sense multiple access (CSMA MAC) protocol with non-persistent technique, the elected CHs broadcasts their advertisement message(ADV). The advertisement message consists of a header that indicates it as a declaration message and the CH's ID. Based on the received signal strength of the declaration message the cluster members (CM's) determine their cluster by electing the CH with the minimum communication cost. The CMs forward join-request to their selected CH using CSMA MAC protocol. This joint-request message consists of the CM-ID (cluster member-ID), CH-ID (cluster head-ID) and the header that indicates the message as a request. For the intra-cluster communication, CH's sets up TDMA which finishes the setup phase. The steady-state phase starts when identified data are sent from CMs to CHs and from CHs to BS. [Habibulla Mohammad et al., 2017]

The main disadvantage of DEC is deployment of nodes, sometimes the cluster heads may have a chance of falling in the boundary of area i.e. far away from the BS (sink) due to randomization of nodes. The energy used by normal nodes to transmit the sensed data to the CH is very high. Due to this deployment the nodes which are close to the base station will die quickly. To overcome this problem, we are going to implement multi-hop in DEC. The routing between cluster heads for forwarding data can be direct or it can be in hops. In general direct routing approach is used in several cases as it is easy to implement and fast in delivery, but this method is inefficient when the size of the network grows so in order to improve scalability inter-cluster routing by multi-hop is employed. In multi-hop routing scheme the cluster heads are responsible of forwarding the data packets of all other cluster nodes to the sink, which are closer to the base station. Using multi-hop the nodes collect the data from environment and forward to the base station.

III. PROPOSED MULTIHOP DEC CONCEPT

A. Three-Tier Multi-Hop

For 3 tier multi hop implementation area of any shape can be chosen for our analysis we are choosing rectangular area[V. Tralli,2005;Jiguo Yu et al.,2008;Y. Deng et al.,2015]. Other shapes such as circular, square can also be chosen. The base station is placed at the center of the rectangular area.

The sensing nodes can be homogeneous (same type of nodes) or heterogeneous (different type of nodes). We are analyzing in heterogeneity [Guo J et al.,2016] i.e. it consists of normal nodes, intermediate nodes and super nodes.

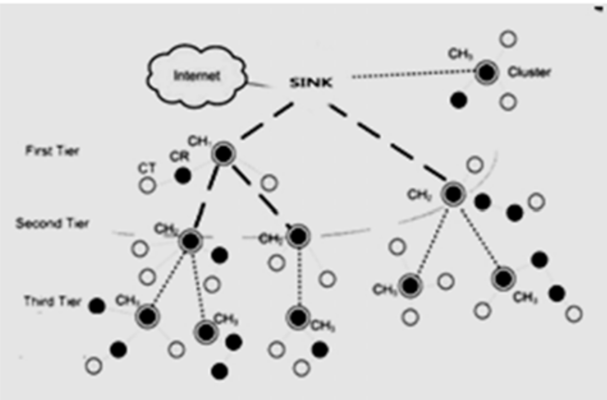

Fig 3.1 Three tire multiplier sensor network.

The above figure shows a part of the deployment of sensor nodes in multi-hop DEC in a rectangular area. As we are taking heterogeneous nodes the energies of the sensor nodes are different. Based on remaining energy transmission, the nodes with the higher energies will be elected as cluster heads. The nodes are placed randomly in region of communication and the coordinates of the sensor nodes are represented as Six and Siy indicating the position of the sensors in the region.

Even in the multi-hop DEC the CH's are elected on the basis of their energies of the sensors and the co-ordinates C(i)x and C(i)y represent The minimum distance between the cluster heads and sink are calculated using the given relation [Seung Jun et al.,2004]

$$d = \sqrt{(((Bx - C(i)x)^2) - ((By - C(i)y)\hat{}2)))}$$

On the basis of the distance calculated between the cluster heads and sink, the clusters are arranged into 3 tiers namely (t1, t2 ,t3) where t1 consists of the first 3 clusters with minimum distance from sink and the following three clusters are placed in the next tier t2 and the remaining 4 clusters are arranged in the tier t3. Now the distance between every cluster head in t1 to every cluster head in t2 is calculated. From these obtained distances, the cluster heads in second tier will choose their respective minimum distance cluster head and forward the data to it.

Similarly this process occurs between second and third tiers. The data from third tier CH's is collected at second tier CH's then it is sent to first tier CH's. From here the aggregated data is finally sent to the sink. In this manner the data reaches the base station in maximum of three hops. Transmission distance is the important criteria in this protocol. As the transmission distance increases the energy consumption increases so to reduce the energy consumption minimum transmission distance must be maintained. This can be done by dividing the region into three tires. This can be considered as a major advantage of multi-hop DEC, the exact location of the cluster head, where i is number of cluster head.

In the setup phase of multi-hop DEC, based on the distance obtained in between the base station and the cluster head the clusters formed previously are arranged in the 3-tiers.

B. The Designed Algorithm

Step 1:Start
Step 2:Base station selects N cluster heads(N=10);
Step 3: Cluster formation:
CH advertisement:
The elected CH broadcast their role using
CSMA_MAC, it contains CH-ID;
Wait for request from cluster members;
CM acknowledgement:
Receives announcements from CH;
Nodes send CM-ID, CH-ID,CM-RE and header
towards nearest header;
Wait for TDMA schedule from respective CH's;
The CH receives the acknowledgment and setup a
TDMA channels for data transmission;
Step 4: Multi-hop Algorithm:
Compute the distance between the elected CHs and BS, sort them into array (A) (ascending order);
The clusters are arranged in 3 tiers;
tier (t1)= A[1],A[2],A[3];
tier (t2)= A[4],A[5],A[6];
tier(t3)= A[7],A[8],A[9],A[10];
FIND the distance from every element in t2 to every element in t1 and sort them say (distance);
Similarly for t3 and t2

$$distance = sqrt((tx(1) - tx(2))\hat{}2 + (ty(1) - ty(2))\hat{}2)$$

The data is transmitted in HOPS using the minimum distances calculated above;
End of round;
Step 5: CH check it's RE with the RE of its members
If (CH_RE>CM_RE (i)) then (i belongs to respective cluster member)
Election won, remains CH;
Else
CHnew=CM_RE (i)
goto Step 3

C. Flowchart

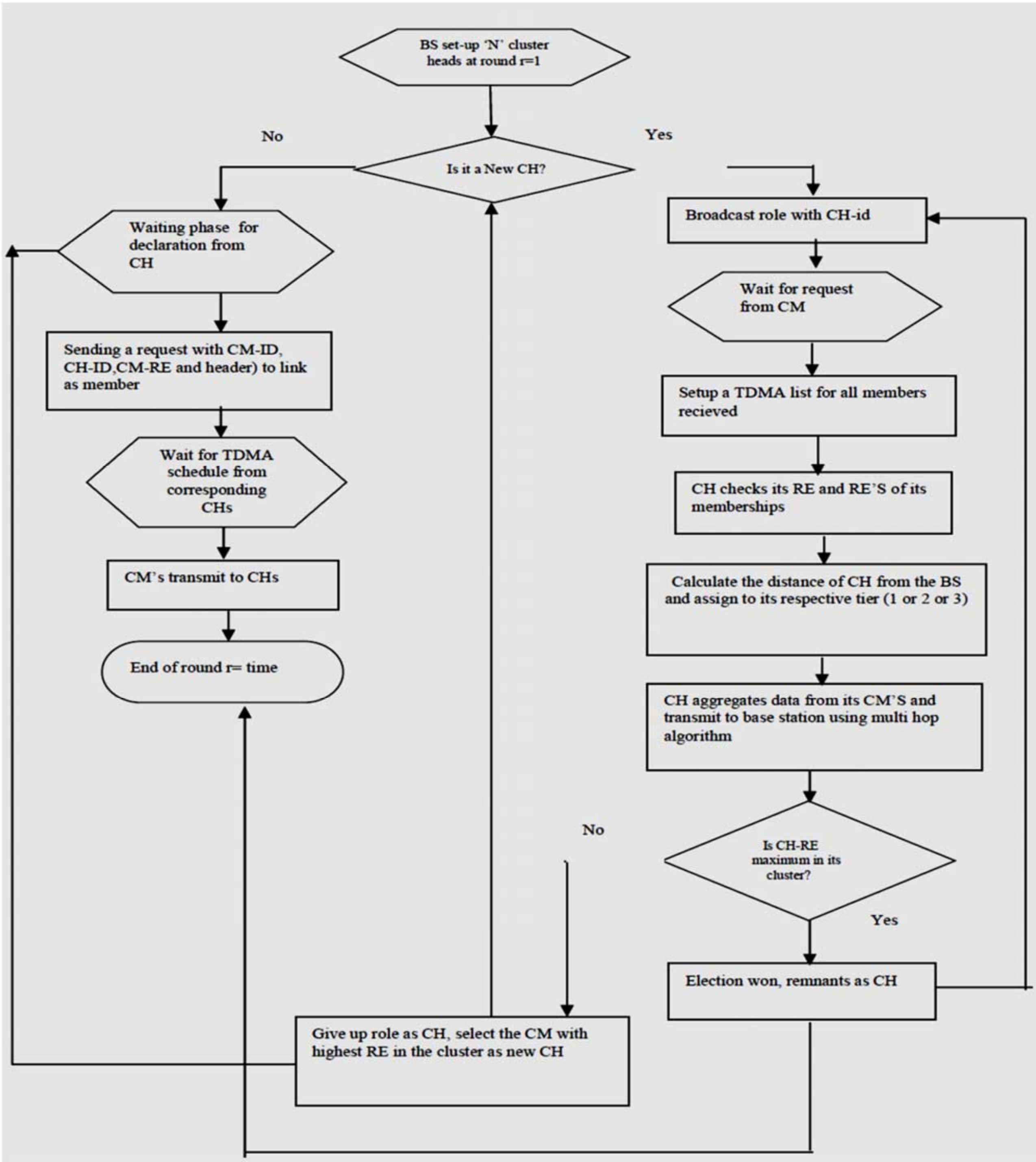

Fig 3.3 Flowchart for multi-hop DEC protocol

D. Mathematical Equations

General probabilistic model used by DEC protocol which is derived from leach by multiplying factor Q. The threshold indicator function is obtained as [F. A. Aderohunmu et al.,2011]

$$T(n_x) = \begin{cases} \dfrac{p}{1 - P_x(rmod\,\dfrac{1}{(P_x)})} \times Qif n_x \in G'; \\ 0 \qquad\qquad\qquad\qquad Otherwise, \end{cases} \quad (1)$$

Where $T(n_x)$ is the threshold based on which a node is elected as CH.For each round r, every sensor node decides to be a CH and they chooses a random number between 0 and 1.The sensor node becomes a CH,only when ,this is lower than the threshold for node n, $T(n_x)$

Q denotes the ratio of residual energy of each sensor node, denotes probability of CM of being elected as CH and is a set of non-elected cluster members (CMs).

Considering the energy dissipation and data aggregation model as shown in fig. 3.4.

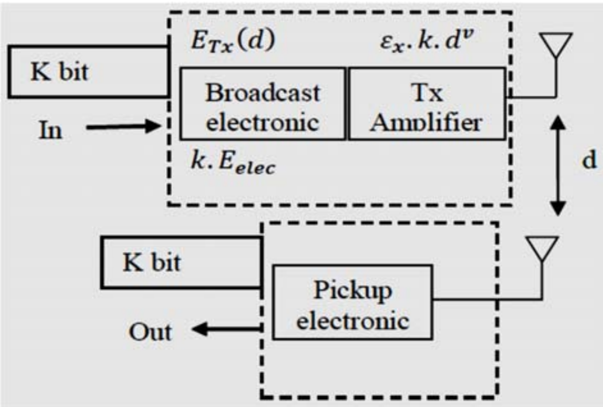

Fig.3.4 Energy Network model diagram

Transmitting the data bits towards a distance d with the suitable SNR, the amplification energy need to overcome either the free space (fs) or multipath loss (mp) depending on the transmission distances. Therefore, energy consumption to transmit k bits is:

$$Etx(k,d) = Etx - elec(k) + Etx - amp(k,d)$$

$$\begin{cases} kEelec + k\varepsilon fsd^2 & if\ d < d_o \\ kEelec + k\varepsilon fsd^4 & if\ d \geq d_o \end{cases}$$

where $Eelec$ is the energy dissipation per bit and do is the distance threshold required for swapping amplification models [Habibulla Mohammad et al.,2018]that can be calculated as do =√ $(\epsilon fs/\epsilon mp)$. $Etx$is the energy required to transmit k bits of a message, d is the distance of transmission. To receive a k –bit message, the radio will spend:

$$Erx(k) = Eelec * k.$$

In DEC, 20% of the nodes are of with 2J of energy, 30% are of with 1.25J of energy and 50% are of with 0.5J of energy. The total energy of the network remains 102.5J.In order to yield the highest performances the ideal parameters of the protocols are also taken in consideration.

The distance of transmission between cluster head to base station is calculated using,

$$d = \sqrt{(((Bx - C(i)x)^2) - ((By - C(i)y)\hat{}2)))}$$

Where (Bx, By) are the co-ordinates of sink and (C(i)x,C(i)y) are the co-ordinates of cluster heads (i denotes the number of cluster head).

Consider C1(x1,y1)& C2(x2,y2) are two CH's, where (x1,y1) and (x2,y2) are coordinates of C1 and C2 respectively. The distance of transmission two cluster heads is obtained using,

$$d = \sqrt{(((x1 - x2)^2) - ((y1 - y2)\hat{}2)))}$$

IV. SIMULATION AND ANALYSIS

This section contains the different parameters analysis and generated various simulation results for the proposed scheme. Then these results are compared with that of regular DEC results. The simulation results are achieved depending on the number of rounds. For evaluating the network lifetime, number of rounds are used before the first node dies (FND), half node dies (HND) and last node dies (LND).

A. System Parameters

In the proposed scheme, a sensing field of area 100m*100m, 100 sensor nodes are with same initial energy are randomly deployed. In each round 1bit of data can be transmitted by each node.

TABLE 6.1 PARAMETER SETTINGS

Parameters	**Values**
Area of network	100m*100
No. of nodes	100
Popt	0.1
K	4000 bits
Eelec	50nJ/bit
EDA	5nJ/bit/message
Efs	10pJ/bit/message
Emp	0.0013pJ/bit/m2

B. Simulation Outputs

B1. Simulation Results for DEC

Dead Nodes

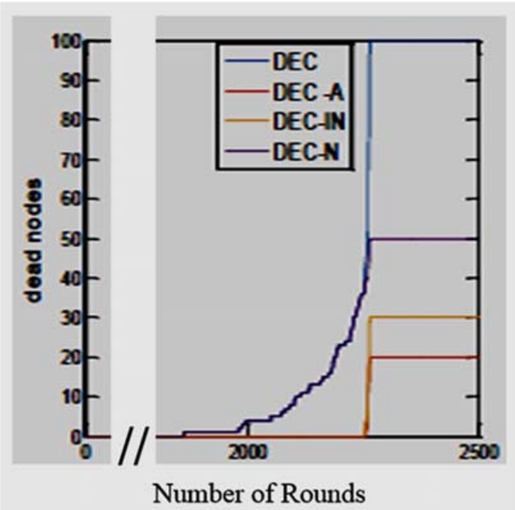

Fig 4.2.1: Dead Nodes graph for DEC

/ Normal nodes	Purple
/ Intermediate nodes	Yellow
/ Super nodes	Red
/ Total dead nodes	Blue

In the above figure the normal nodes started dying arounds 1860 rounds approximately. The total dead nodes (super, intermediate and normal nodes) that is completely dead at 2265 rounds.

Stability period (FND): 1860 round approx..

Instability period (LND): 2265 rounds approx.

<u>Half Dead Nodes</u>

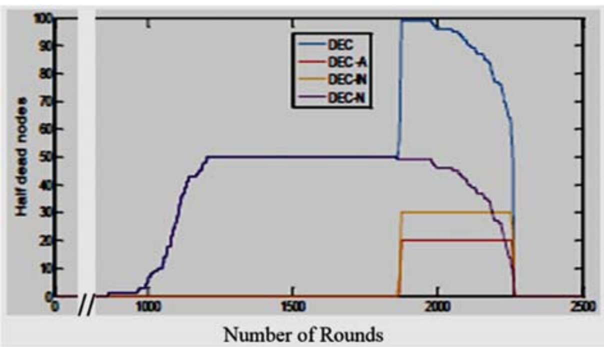

Fig 4.2.2: Half Dead Nodes of DEC

/ Normal nodes	Purple
/ Intermediate	Yellow
/ Super node	Red
/ Total dead	Blue

In the above figure, it is observed that first half dead is at 863 round approximately.

<u>Cluster Head Count</u>

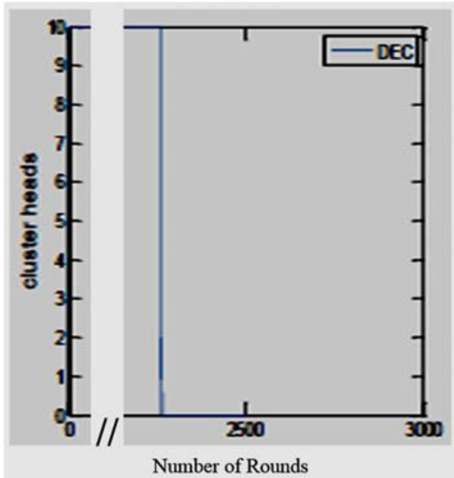

Fig 4.2.3: Cluster Head Count graph

The above figure shows the total number of cluster heads (CH's) throughout the total rounds i.e. 10 in number fixed CH's.

B2. Simulation Results for Multi-Hop DEC

<u>Dead Node</u>

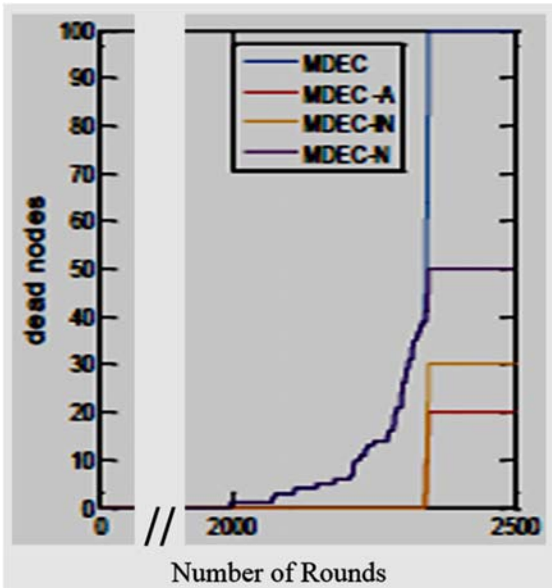

Fig 4.2.2.1: Dead nodes graph for DEC Multi Hop.

- Normal nodes Purple
- Intermediate nodes Yellow
- Super nodes Red
- Total dead nodes Blue

In the above figure the normal nodes (50) started dying around 1999 rounds approximately. The total dead nodes (super, intermediate and normal nodes) that is completely dead at 2401 rounds.

Stability period (FND): 1999 round approx.

Instability period(LND): 2401 round approx.

Half Dead Nodes

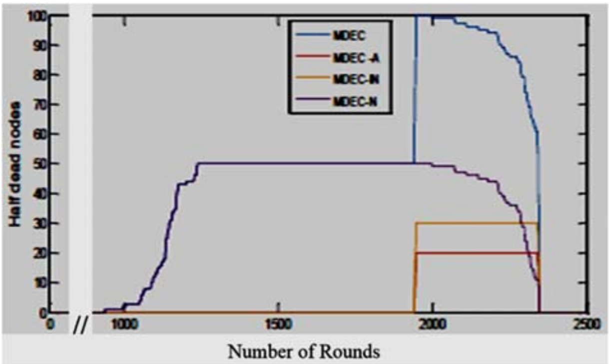

Fig 4.2.2.2 : Half Dead Nodes graph of DEC multi-hop.

Normal nodes Purple
Intermediate nodes Yellow
Super nodes Red
Total dead nodes Blue

In the above figure, it is observed that first half dead is at 940th round approximately.

Cluster Head Count

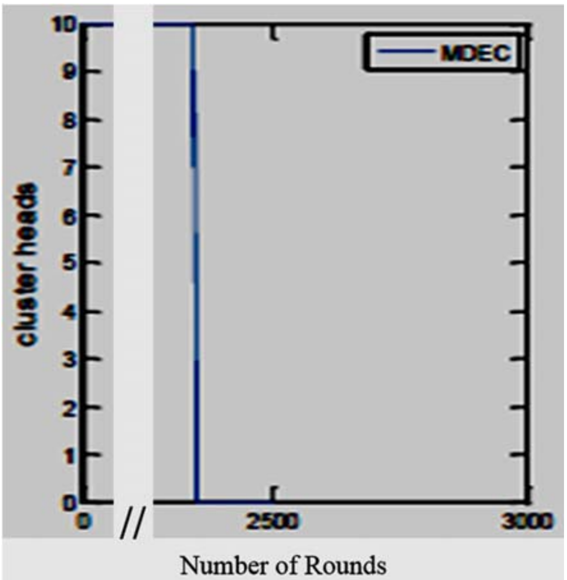

Fig 4.2.2.3 : Cluster Head Count graph

The above figure shows the total number of cluster heads (CH's) throughout the total rounds i.e. 10 in number fixed CH's.

Residual Energy

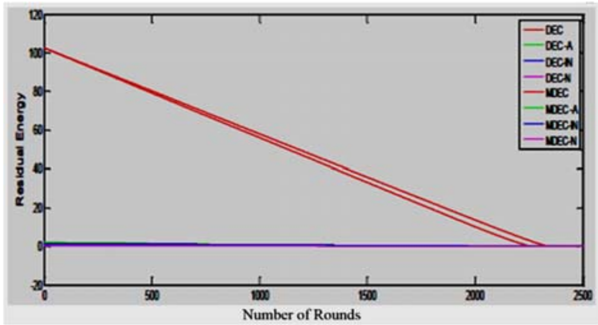

Fig 4.2.2.4: Residual Energy in multi-hop DEC

Residual energy is the amount energy remained at each sensor node after one transmission. The above figure shows the change in residual energy of nodes for every round.

V. CONCLUSION AND FUTURE WORK

In WSNs, the sensor nodes react immediately to the sudden and radical changes in the sensed quantity values due to occurrence of particular events. The proposed algorithm assures that the elected CH's are uniformly dispersed over the network. Hence, no CH's will be concentrated in one part of the network. The simulation results indicates that compared to LEACH based algorithms, the proposed clustering techniques is scalable and energy efficient and hence effective in extending the network life time. Hence from the results obtained in the simulation, the performance of the proposed scheme is efficient in terms of energy consumption compared to DEC protocol.

The other factors such as Security Issues and QOS in Wireless Sensor Network can be the focus of future work.

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