



# DWEDDEEC: Distance Aware Waiting based EDDEEC Protocol for Hetrogeneous WSNS

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## ABSTRACT

As Wireless Sensor Networks (WSNs) contain numerous sensor nodes containing limited battery power that collect and transmit the data collected from all the nodes towards the Base Station which needs much energy utilization. There are several routing protocols which are already proposed under this consideration attaining effectiveness of energy in heterogeneous circumstances. Although, every protocol is unsuitable for heterogeneous WSNs. Efficiency of WSNs declines as varying the heterogeneity of sensor nodes. Though EDDEEC has depicted quite considerable outcomes compared to already developed existing WSNs protocols but it has ignore the utilization of waiting time of node to become cluster heads (CHs). Therefore might a few nodes will not turn out to be CHs for a very long time still they contain more confidence to become CHs. Therefore to conquer this issue we have used a waiting counter called  $W_r(i)$ .  $W_r(i)$  is then total number of waiting rounds for a given node to become CH. It will generate a +ve value that will constantly amplify the node to T (n) value for a specified node to become CH. So it will produce more optimized CHs. For getting the better results more we have used the minimum allowed distance (MDCH) between two CHs to cover the sensor field in the most proficient manner.

## General Terms

Energy efficiency, Throughput, network Lifetime.

## Keywords

WSNs, DEEC, heterogeneity, super nodes, T-absolute

## 1. INTRODUCTION

Wireless sensor networks are a vast field of sensor nodes. WSNs involve of tiny nodes containing detecting, calculation, and wireless interaction and transmission potential. There is a variety of routing, data broadcasting, and power management protocols are exclusively planned for WSNs where energy alertness is a crucial design apprehension. Wireless communication mechanization keeps on growing in various regions to give new prospects for communications and facilities. This is exciting part is WSN. With the development in micro-electro mechanical machines, sensor machines can be designed as little as lightweight wireless nodes. WSN are extremely dispersed networks of these types of sensor nodes, and their deployment in great numbers to observe the atmosphere or manufacture systems. There is an increasing requirement for the nodes to tackle extra difficult tasks in data acquirement and processing, and energy saving results remains a main need for such power based batteries sensor nodes. Three major functions are performed by three sensor

subsystems the surroundings sensor; the data processor that performs local calculations on the data sensed; and the communicator that performs information swap between neighboring nodes [1]. Every sensor node is generally controlled in their energy values, capability of operating power and sensing. Though, networks of such sensors provide grow to a network that is robust, correct, and reliable network. The sensors can work together and help with each other, choose heads collect their data and then broadcast a more results from the sensing [2]. A lot of learning on WSN has been carried out in Labs. WSN technology is progressively more requiring by latest applications in a variety of areas, WSN are made up of thousands of small sensor nodes that cover a huge geographical area. These sensors are capable to communicate with each other to mutually sense things, gather data and broadcast information. Though, as sensors are generally little in dimensions, they have numerous physical constraints – like battery, processing power and storage. Due to those restrictions, energy-efficient methods are major research challenges in WSN There are number of protocols for heterogeneous and homogeneous WSN environment. As in homogeneous environment Low-Energy Adaptive Clustering Hierarchy (LEACH) [5], Hybrid Energy-Efficient Distributed clustering (HEED) [8], Power Efficient Gathering in Sensor Information Systems (PEGASIS) [7], these are some algorithms that are created for only one type of nodes. The energy level of these nodes is equal. Whereas, for heterogeneous WSN environment the protocols like Stable Election Protocol (SEP) [9], Distributed Energy-Efficient Clustering (DEEC) [10], Developed DEEC (DDEEC) [11], Enhanced DEEC (EDEEC) [12] and Threshold DEEC (TDEEC) [13] are created.

This paper described various heterogeneous protocols. The energy levels of these protocols are represented in two level, three levels and multilevel heterogeneity level. The study and analysis of the performance of protocols EDEEC, DDEEC, EDDEEC and the proposed protocol DWEDDEEC is covered in this paper. In the heterogeneous WSNs environment there are normal nodes, intermediate nodes, advanced nodes and super nodes. Every protocol concentrates only to achieve better stability time, extended network lifetime and good throughput. All the nodes in network contains same proportion of normal, advanced and super nodes alongside the multilevel heterogeneous WSNs. This has been discovered that every protocol that is different among all the other protocols in terms of stable periods, network lifetime. The protocols EDEEC and EDDEEC achieve great network lifetime performance when they are in three level heterogeneous WSNs containing much energy level distinction between normal, advanced and super nodes

regarding stability period. However, it is deficient in results as contrast with DDEEC.

The rest of the paper is ordered as follows: section 2 briefly reviews the related work. In section 3, describes the network model. In section 4, radio dissipation model is explained. Proposed overview of Heterogeneous Protocols explained in section 5. In section 6, elaborates the performance of different DEEC protocols by simulations and comparison. At last, section 7 provides the conclusion and future work.

## 2. RELATED WORK

W.R. Heinzelman, *et al.* [5] proposed a LEACH clustering algorithm for homogeneous WSNs in which nodes randomly choose among them to be CHs and transmit this choice criterion over the whole network to issue energy load. G. Smaragdakis, *et al.* [9] introduced SEP protocol SEP is relied on weighted election possibilities of every sensor node to turn out to be CH as to the residual energy in every node Heterogeneity-aware Hierarchical Stable Election Protocol (HSEP) [16], protocol is heterogeneous-aware in the fact that the initial energy of a node comparative to the other nodes in the network is relied on the weighted election probabilities.

Extended Stable Election Protocol (ESEP) [17] three-tier clustered heterogeneous network is defined where the intermediate and advanced nodes choose as CHs for the growing quantity of rounds relied on their advanced initial energy comparative to other sensor nodes. The CH selection procedure is regarded relied on the battery power and remaining energy of the sensor node

L. Qing, Q. Zhu and M. Wang [10] the election of CHs is done from a possibility lied on the proportion among remaining energy of every node and the average remaining energy of the sensor network. The numbers of rounds for being CHs for sensor nodes are dissimilar according to the sensor node's initial and remaining energy. Brahim Elbhiri, *et al.* [11] introduced a protocol DDEEC; the protocol is DEEC relied and perform same function in which all the sensor nodes utilize initial energy and residual energy level for election of CHs. To enhance the DEEC protocol outcomes, the DDEEC executed a stable and dynamic method to allocate the exhausted energy better rightfully among sensor nodes.

P. Saini *et al.* [12] proposed a protocol EDEEC technique is relied on DEEC with accumulation of super nodes. They have comprehensive the DEEC upto three-level heterogeneity in sensor nodes. CH algorithm is broken down into rounds. At every round sensor node make a decision whether to be a CH relied on threshold computed by the recommended proportion of CHs for the sensor network and the amount of periods the sensor node has been a CH far away. Parul Saini and Ajay K Sharma [13] proposed a protocol TDEEC On every round, sensor nodes make a decision whether to be a CH or not with deciding a likely random number among 0 and 1. If value is smaller than threshold value ( $T_s$ ) then sensor node make a choice to be a CH for the present round. M.Y. Khan *et al.* [14] developed a protocol called H-DEEC, this protocol is founded on DEEC method for heterogeneous WSNs, where all the sensor nodes make use of initial and remaining energy level for CH selection. Every sensor node in the network contain the data of the whole the other associate sensor nodes.

N. Javaid *et al.* [15] developed EDDEEC protocol exercises the idea of possibilities for CH election founded on initial, residual energy level of the nodes and average remaining energy of the sensor network.

## 3. HETEROGENEOUS WSN MODEL

Here in this segment there are N number of nodes scattered in a square area of dimension M x M. The WSN which is heterogeneous WSNs contain two, three or multi types of nodes that are equipped with different proportion of energy which is called one level, two level and multilevel heterogeneous WSNs.

### 3.1 Two level Heterogeneous WSN Model

The networks those are two level heterogeneous WSNs are equipped with two power stages of sensor nodes, regular and innovative nodes. Where  $S_o$  is the stage of power of regular node and  $S_o(1+d)$  is the power of advanced nodes containing a periods greater power as in comparison to normal nodes.

Given the count of nodes is R so the variety of innovative nodes is Rm where m is the portion of innovative nodes and the variety of regular nodes is R(1-m). So, the complete power of the whole system is given by:

$$S_T = R(1-m)S + Rm(1+d)S_o = RS_o(1+dm) \quad (1)$$

Therefore it is worth to say that the two level heterogeneous networks contain am times much battery power compared to homogeneous WSNs.

### 3.2 Three level Heterogeneous WSN Model

In these kinds of networks there are three energy levels of sensor nodes, normal, advanced and super nodes. The energy level of normal node is  $S_o$ , the energy level of every advanced node of fraction m with d times more energy than normal nodes is  $S_o(1+d)$  and the energy level of every super node of fraction  $m_o$  with b times greater power compared to the normal nodes is  $S_o(1+k)$ . As R is the total number of nodes in the network, then Rmmo is sum of number of super nodes and Rm(1-mo) is the total number of super nodes and Rm(1-mo) is the total number of advanced nodes. Here the sum of energy of whole network is specified by:

$$S_T = R(1-m)S_o + Rm(1-m_o)(1+d)S_o + Rm_oS_o(1+k)$$

$$S_T = RS_o(1+m(d+m_o k)) \quad (2)$$

Thus, the three level heterogeneous networks have  $(d+m_o k)$  times greater energy as contrast to homogeneous WSNs.

### 3.3 Multilevel Heterogeneous WSN Model

In the environment where multilevel of energy in nodes is equipped called heterogeneous networks, they contain the three levels of energies in sensor nodes. The sensor nodes are equipped with initial energy that is circulated among the set  $[S_o, S_o(1+d_m)]$ , where the minimum energy level value is denoted by  $S_o$  and the maximum energy value is  $d_m$ . Initially, sensor node  $u_i$  is prepared by energy of  $S_o(1+d_i)$ , which is  $d_i$  more compared to than  $S_o$ . Therefore, the complete power of the whole network is specified by:

$$S_T = \sum_{i=1}^R S_o(1+d) = S_o(R + \sum_{i=1}^R d_i) \quad (3)$$

CH nodes used more power as in comparison to group participant nodes. Therefore after some units stage of power of every node will be dissimilar among every other node. So, the systems having heterogeneity are essential than homogeneous systems.

#### 4. RADIO DISSIPATION MODEL

The energy consumed by network should be as minimum as possible, therefore the radio dissipation model is we use should be appropriate. Here model that shows that 1 bit message is transmitted over a distance  $d$  as in [5.6], energy exhausted is then given by:

$$E_{Tx}(1, d) = \begin{cases} lE_{elec} + l\epsilon_{fs}d^2, & d < d_o \\ lE_{elec} + l\epsilon_{mp}d^4, & d \geq d_o \end{cases} \quad (4)$$

Where,  $E_{elec}$  is the energy dispersed for every bit to drive the transmission circuit.  $d$  is the separation among transmitter and receiver. But if the distance is minimum than the threshold value, then the model called free space (fs) is utilized otherwise the model called multi path (mp) is utilized. Hence, total energy dissipated throughout the network round is specified by [5.6]

$$E_{round} = L(2NE_{elec} + NE_{DA} + k\epsilon_{mp}d_{toBS}^4 + N\epsilon_{fa}d_{toCH}^2) \quad (5)$$

Here,  $K$ = total number of clusters

$EDA$ = Data aggregation cost expensed in CH

$d_{toBS}$ = Average distance among the CH and BS

$d_{toCH}$ = Average distance among the cluster members and the CH

$$d_{toCH} = \frac{M}{\sqrt{2\pi}}, d_{toBS} = 0.765 \frac{M}{2} \quad (6)$$

$$k_{opt} = \frac{\sqrt{N}}{\sqrt{2\pi}} \sqrt{\frac{\epsilon_{fs}}{\epsilon_{mp}} \frac{M}{d_{toBS}^2}} \quad (7)$$

#### 5. OVERVIEW OF DISTRIBUTED HETEROGENOUS PROTOCOLS

##### 5.1 DEEC

DEEC [10] is proposed to concern with nodes of heterogeneous WSNs. For CH selection, DEEC uses initial and residual energy level of nodes. Let  $n_i$  denote the number of rounds to be a CH for node  $s_i$ .  $p_{opt}N$  is the optimal number of CHs in the network through each round. A CH selection condition in DEEC is formulated on energy level of nodes.

1. Firstly, deploy nodes randomly
2. Normal nodes identify :if( $i \geq (m \times n)$  //  $i$  is the fraction of node,  $m$  is the fraction of advance nodes.
3.  $N(i). E = E_o$  //  $E_o$ =Initial energy
4. end if
5. Advance nodes identify: if( $i < (m) \times n$ )
6.  $N(i). E = E_o \times (1 + a)$  //  $a$  is extra energy for advance nodes.
7. end if
8. Calculate weighted probabilities used to select CHs:

$$p_{nrm} = \frac{P_{opt}}{(1+m*a)}, \text{ for normal nodes}$$

$$p_{adv} = \frac{P_{opt}(1+a)}{(1+m*a)}, \text{ for advance nodes}$$

// $p_{opt}$  is the optimum probability for CH selection

9. Calculate thresholds to select CHs

$$p_i = \begin{cases} \frac{p_{opt}E_i(r)}{(1+am)\bar{E}(r)} & \text{if } s_i \text{ is the normal node} \\ \frac{p_{opt}(1+a)E_i(r)}{(1+am)\bar{E}(r)} & \text{if } s_i \text{ is the advanced node} \end{cases}$$

10. Where estimate average energy  $E(r)$  of the network for any round  $r$ .

$$\bar{E}(r) = \frac{1}{N} E_{total} \left(1 - \frac{r}{R}\right)$$

$R$  denotes total rounds of network lifetime and is estimated as follows:

$$R = \frac{E_{total}}{E_{round}}$$

$E_{total}$  is total energy of the network where  $E_{round}$  is energy expenditure during each round.

11. Broadcasting of message by elected CH to sensor nodes (SNs).
12. Allocation of TDMA schedule by CH to CMs (Cluster Members).
13. For CH, for CMs
14. Data sent from CMs to CHs as per TDMA schedule.
15. end for CMs
16. Send data from CHs nodes to BS.
17. end for CHs
18. Evaluate the energy dissipated:
 
$$E_{Tx}(l, d) = lE_{elec} + l\epsilon_{fs}d^2, \quad d < d_o$$

$$E_{Tx}(l, d) = lE_{elec} + l\epsilon_{mp}d^4, \quad d \geq d_o$$
19. Repeat steps 12 to 19 until all nodes become dead.
20. End of code

##### 5.2 DDEEC

DDEEC utilize the theory for evaluation of average energy in the network and CH selection algorithm relied on remaining energy as defined in DEEC [10].

1. Firstly, deploy nodes randomly
2. Normal nodes identify :if( $i \geq (m \times n)$  //  $i$  is the fraction of node,  $m$  is the fraction of advance node.
3.  $N(i). E = E_o$  //  $E_o$ =Initial energy
4. end if
5. Advance nodes identify: if( $i < (m) \times n$ )
6.  $N(i). E = E_o \times (1 + a)$  //  $a$  is extra energy for advance nodes.
7. end if
8. Calculate weighted probabilities used to select CHs

$$p_{nrm} = \frac{P_{opt}}{(1+m*a)}, \text{ for normal nodes}$$

$$p_{adv} = \frac{P_{opt}(1+a)}{(1+m*a)}, \text{ for advance nodes} \quad //p_{opt} \text{ is the optimum probability for CH selection}$$

9. Calculate the threshold residual energy level.

$$Th_{REV} = E_o \left( 1 + \frac{aE_{disNN}}{E_{disNN} - E_{disAN}} \right)$$

$E_{disNN}$  is the energy dissipated by Normal nodes.

$E_{disAN}$  is the energy dissipated by advance nodes.

The calculated Threshold residual energy given as:

$$Th_{REV} = \left( \frac{7}{10} \right) E_o$$

10. Calculate thresholds to select CHs

$$p_i = \begin{cases} \frac{p_{opt}E_i(r)}{(1+a*m)\bar{E}(r)} & \text{for Normal nodes,} \\ & E_i(r) > Th_{REV} \\ \frac{(1+a)p_{opt}E_i(r)}{(1+a*m)\bar{E}(r)} & \text{for Advance nodes,} \\ & E_i(r) > Th_{REV} \\ c \frac{(1+a)p_{opt}E_i(r)}{(1+a*m)\bar{E}(r)} & \text{for Aadvance, Normal nodes,} \\ & E_i(r) \leq Th_{REV} \end{cases}$$

11. Broadcasting of message by elected CH to sensor nodes (SNs).

12. Allocation of TDMA schedule by CH to CMs (Cluster Members).

13. For CH, for CMs

14. Data sent from CMs to CHs as per TDMA schedule

15. end for CMs

16. Send data from CHs nodes to BS.

17. end for CHs

18. Evaluate the energy dissipated:

$$E_{Tx}(l, d) = l E_{elec} + l \epsilon_{fs} d^2, \quad d < d_0$$

$$E_{Tx}(l, d) = l E_{elec} + l \epsilon_{mp} d^4, \quad d \geq d_0$$

19. Repeat steps 12 to 19 until all nodes become dead.

20. End of code

### 5.3 EDEEC

EDEEC utilize the theory of three level heterogeneous networks as described in [12]. It considers three types of nodes normal, advanced and super nodes relied on initial energy.

1. Firstly, deploy nodes randomly

2. Normal nodes identify : *if* ( $i \geq (m + u) \times n$ ) //  $i$  is the fraction of node,  $m$  is the fraction of advance node and  $u$  is the fraction of super nodes.

3.  $N(i).E = E_o$  //  $E_o$ =Initial energy

4. end if

5. Intermediate nodes identify: *if* ( $m * n < i < (m + u) \times n$ )

6.  $N(i).E = E_o \times (1 + b)$  //  $b$  is extra energy for intermediate nodes

7. end if

8. Advance nodes identify: *if* ( $i < (m) \times n$ )

9.  $N(i).E = E_o \times (1 + a)$  //  $a$  is extra energy for advance nodes.

10. end if

11. Calculate thresholds to select CHs

$$p_{nrm} = \frac{P_{opt}}{(1+m*a+u*b)}, \text{ for normal nodes}$$

$$p_{int} = \frac{P_{opt}(1+b)}{(1+m*a+u*b)}, \text{ for intermediate nodes}$$

$$p_{adv} = \frac{P_{opt}(1+a)}{(1+m*a+u*b)}, \text{ for super nodes} \quad //p_{opt} \text{ is the optimum probability for CH selection}$$

$$p_i = \begin{cases} \frac{p_{opt}E_i(r)}{(1+m(a+u*b))\bar{E}(r)} & \text{if } s_i \text{ is the normal node} \\ \frac{(1+a)p_{opt}E_i(r)}{(1+m(a+u*b))\bar{E}(r)} & \text{if } s_i \text{ is the advance node} \\ \frac{(1+b)p_{opt}E_i(r)}{(1+m(a+u*b))\bar{E}(r)} & \text{if } s_i \text{ is the super node} \end{cases}$$

13. Broadcasting of message by elected CH to sensor nodes (SNs).

14. Allocation of TDMA schedule by CH to CMs (Cluster Members).

15. For CH, for CMs

16. Data sent from CMs to CHs as per TDMA schedule

17. end for CMs

18. Send data from CHs nodes to BS.

19. end for CHs

20. Evaluate the energy dissipated:

$$E_{Tx}(l, d) = l E_{elec} + l \epsilon_{fs} d^2, \quad d < d_0$$

$$E_{Tx}(l, d) = l E_{elec} + l \epsilon_{mp} d^4, \quad d \geq d_0$$

21. Repeat steps 12 to 19 until all nodes become dead

22. End of code

### 5.4 EDDEEC

This paper implements the proposal of possibilities for CH selection relied on initial, residual energy level of the sensor nodes and average energy of network. The protocol guards the super and advance nodes from over punished, as following a few rounds a few super and advance nodes contain equal remaining energy level same as normal nodes because of constantly CH selection. EDDEEC computes possibilities of normal, advance and super nodes. These modifications are relied on (ARL) absolute residual energy level  $T_{absolute}$ , which is the value in which advance and super nodes contain equal energy level as that of normal nodes. The proposal defines that under  $T_{absolute}$  all normal, advance and super nodes contain equal possibility for CH selection [15].

1. Firstly, deploy nodes randomly

2. Normal nodes identify :if ( $i \geq (m + u) \times n$ ) //  $i$  is the fraction of node,  $m$  and  $u$  are fractions of advance nodes and intermediate nodes respectively
3.  $N(i).E = E_o$  //  $E_o$ =Initial energy
4. end if
5. Intermediate nodes identify: if ( $m * n < i < (m + u) \times n$ )
6.  $N(i).E = E_o \times (1 + b)$  //  $b$  is extra energy for intermediate nodes
7. end if
8. Advance nodes identify:if ( $i < (m) \times n$ )
9.  $N(i).E = E_o \times (1 + a)$  //  $a$  is extra energy for advance nodes.
10. end if

11. Calculate weighted probabilities used to select CHs:

$$p_{nrm} = \frac{P_{opt}}{(1+m*a+u*b)}, \text{ for normal nodes}$$

$$p_{int} = \frac{P_{opt}(1+b)}{(1+m*a+u*b)}, \text{ for intermediate nodes}$$

$$p_{adv} = \frac{P_{opt}(1+a)}{(1+m*a+u*b)}, \text{ for advance nodes}$$

// $p_{opt}$  is the optimum probability for CH selection

12. Calculate the absolute residual energy level

$$z = 0.7$$

$$T_{absolute} = z * \text{Initial energy}$$

Where  $z$  is the fraction to evaluate the absolute residual energy level

13. Calculate thresholds to select CHs

$$T_{nrm} = \frac{P_{nrm} * E_i(r) * (1 + W_r(i) * p)}{1 - p_{nrm} \left( r \cdot \text{mod} \left( \frac{1}{p_{nrm}} \right) \right)}$$

for normal nodes, if  $E_i(r) > T_{absolute}$

$$T_{int} = \frac{P_{int} * E_i(r) * (1 + W_r(i) * p)}{1 - p_{int} \left( r \cdot \text{mod} \left( \frac{1}{p_{int}} \right) \right)}$$

for intermediate node if  $E_i(r) > T_{absolute}$

$$T_{adv} = \frac{P_{adv} * E_i(r) * (1 + W_r(i) * p)}{1 - p_{adv} \left( r \cdot \text{mod} \left( \frac{1}{p_{adv}} \right) \right)}$$

for advance node if  $E_i(r) > T_{absolute}$

$$T_{arl} = \frac{P_{opt} * E_i(r) * (1 + W_r(i) * p)}{1 - P_{opt} \left( r \cdot \text{mod} \left( \frac{1}{P_{opt}} \right) \right)}$$

for all nodes otherwise

14. Broadcasting of message by elected CH to sensor nodes (SNs).

15. Allocation of TDMA schedule by CH to CMs (Cluster Members).

16. For CH, for CMs

17. Data sent from CMs to CHs as per TDMA schedule

18. end for CMs

19. Send data from CHs nodes to BS.

20. end for CHs

21. Evaluate the energy dissipated:

$$E_{Tx}(l, d) = l E_{elec} + l \epsilon_{fs} d^2, \quad d < d_0$$

$$E_{Tx}(l, d) = l E_{elec} + l \epsilon_{mp} d^4, \quad d \geq d_0$$

22. Repeat steps 12 to 19 until all nodes become dead

23. End of code

## 6. SIMULATIONS AND DISCUSSIONS

This part defines the simulations and discussions; here we simulate the different heterogeneous clustering protocols in WSN with the help of MATLAB and to make simulations 100 nodes are used randomly deployed in the area of dimension 100m×100m. To make it easy, all the nodes are supposed to be either fixed or micro-mobile and avoid energy loss because of signal collision and meddling among signals of dissimilar nodes that are due to dynamic random channel situations.

**Table 1. WSNs Set-up**

Parameter	Value
Area(x,y)	100,100
Base station(x,y)	50,50
Nodes(n)	100
Probability(p)	0.1
Initial Energy	0.1
transmitter_energy	$50 * 10^{-9}$
receiver_energy	$50 * 10^{-9}$
Free space(amplifier)	$10 * 10^{-13}$
Multipath(amplifier)	$0.0013 * 10^{-13}$
Effective Data aggregation	$5 * 10^{-9}$
Maximum lifetime	2500
Data packet Size	4000
m (fraction of advanced nodes)	0.3
a (energy factor between normal and advanced nodes)	3
$m_o$ fraction of super nodes	0.3

## 7. PROPOSED ALGORITHM

1. Firstly, deploy nodes randomly.
2. Normal Nodes Identify, :if ( $i \geq (m + u) \times n$ ) //  $i$  is

the fraction of node, m and u are fractions of advance nodes and intermediate nodes respectively.

3.  $N(i).E = E_o$  //  $E_o$  = Initial energy
4. end if
5. Intermediate nodes identify: if  $(m * n < i < (m + u) * n)$
6.  $N(i).E = E_o \times (1 + b)$  // b is extra energy for intermediate nodes
7. end if
8. Advance nodes identify: if  $(i < (m) * n)$
9.  $N(i).E = E_o \times (1 + a)$  // a is extra energy for advance nodes.
10. end if

11. Calculate weighted probabilities used to select CHs:

$$p_{nrm} = \frac{P_{opt}}{(1+m*a+u*b)}, \text{ for normal nodes}$$

$$p_{int} = \frac{P_{opt}(1+b)}{(1+m*a+u*b)}, \text{ for intermediate nodes}$$

$$p_{adv} = \frac{P_{opt}(1+a)}{(1+m*a+u*b)}, \text{ for advance nodes} \quad // p_{opt}$$

is the optimum probability for CH selection

12. Calculate the absolute residual energy level

$$z = 0.7$$

$$T_{absolute} = z * InitialEnergy$$

Where z is the fraction to evaluate the absolute residual energy level

13. Evaluate the MDCH and waiting nodes

- a)  $d_m(i)$  is either +ve 1 or -ve 1. //  $d_m$  is the distance between two CHs

Algorithm is depend upon total CHs in the network area.

$$\text{Total Area} = X_m * Y_m$$

Total Cluster Required = Depend upon probability

Area occupied by one cluster = Total Area/no of Cluster  
 i.e.  $\frac{\text{Total Area}}{1/P}$

$$1/P$$

Now Area Occupied by one cluster =  $\frac{\text{Total Area}}{1/P}$

$$1/P$$

$$\pi r^2 = P * \text{Total Area}$$

$$r^2 = (P * \text{Total Area}) * 7/22$$

$$r = \sqrt{(P * \text{Total Area}) * 7/22}$$

Appropriate Distance from One CH to another CH

$$= \sqrt{(P * \text{Total Area}) * 7/22}$$

So we take this distance is 36.

$$d_m = 1$$

If  $d > 36$  then node can become CH.

End if.

$$d_m = 0, \text{ if } d \leq 36$$

That node cannot be a cluster head

End if

b)  $W_r(i)$  is then total number of waiting rounds for a given node to become CH. It must produce a +ve value more than 1 so that it can increase the chance of node to become a CH.  $r$  is the current round in WSNs network lifetime,  $E_i(r)$  is the current energy of each node.

14. Calculate thresholds to select CHs

$$T_{nrm} = \frac{P_{nrm} * E_i(r) * (1 + W_r(i) * p) * d_m(i)}{1 - P_{nrm} \left( r \cdot \text{mod} \left( \frac{1}{P_{nrm}} \right) \right)}, \text{ for normal nodes, if } E_i(r) > T_{absolute}$$

$$T_{int} = \frac{P_{int} * E_i(r) * (1 + W_r(i) * p) * d_m(i)}{1 - P_{int} \left( r \cdot \text{mod} \left( \frac{1}{P_{int}} \right) \right)}, \text{ for intermediate nodes, if } E_i(r) > T_{absolute}$$

$$T_{adv} = \frac{P_{adv} * E_i(r) * (1 + W_r(i) * p) * d_m(i)}{1 - P_{adv} \left( r \cdot \text{mod} \left( \frac{1}{P_{adv}} \right) \right)}, \text{ For advance node if } E_i(r) > T_{absolute}$$

$$T_{arl} = \frac{P_{opt} * E_i(r) * (1 + W_r(i) * p) * d_m(i)}{1 - P_{opt} \left( r \cdot \text{mod} \left( \frac{1}{P_{opt}} \right) \right)}, \text{ for all nodes otherwise}$$

15. Broadcasting of message by elected CH to Sensor Nodes(SNs)

16. Allocation of TDMA schedule by CH to CM.

17. For CH, for CMs

18. Data sent from CMs to CH as per TDMA schedule.

19 end for CMs

20. Sent data from CHs nodes to BS.

21. end for CHs

22. Evaluate the energy dissipated:

$$E_{Tx}(l, d) = l E_{elec} + l \epsilon_{fs} d^2, \quad d < d_0$$

$$E_{Tx}(l, d) = l E_{elec} + l \epsilon_{mp} d^4, \quad d \geq d_0$$

23. Repeat steps 12 to 22 until all nodes become dead.

24. End of code

## 8. PERFORMANCE ANALYSIS

The existing EDDEEC and the proposed waiting round time and MDCH EDDEEC has been designed and implemented in MATLAB tool. This section contains the comparative analysis between proposed and existing EDDEEC.

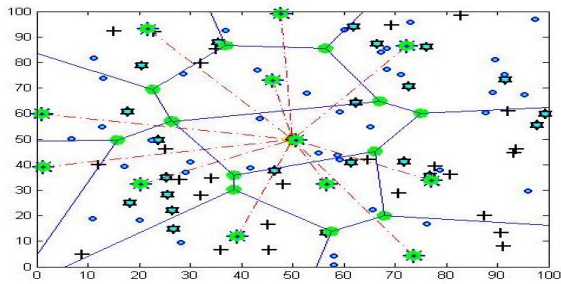


Figure 16 Where Every Sensor Node is Alive

Figure 16 depicts the active environment of the proposed algorithm in which circled nodes are normal nodes, starred nodes are advance nodes, and (+) plus nodes are super nodes. Also diamond is base station of this sensor field.

Figure 17 has shown the some dead nodes with red crossed (X) signs. Dead nodes means it has zero energy.

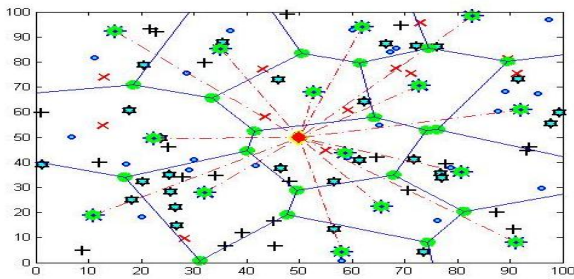


Figure17 where a few sensor nodes become dead

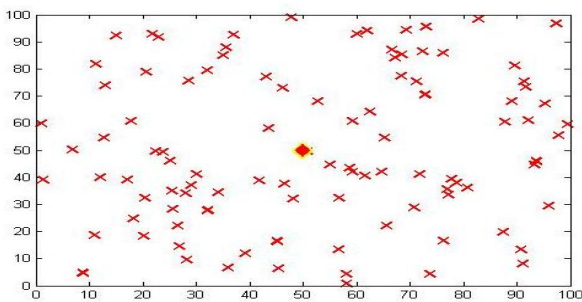


Figure 18 where every sensor node becomes dead

Figure 18 has shown the dead end of sensor field. All nodes are dead. This is also called network lifetime.

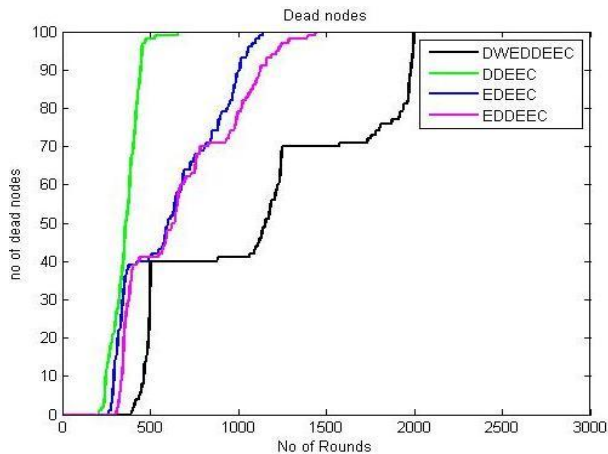


Figure 19 Dead nodes

Figure 19 has shown the analysis of DEAD nodes of DDEEC, EDEEC, EDDEEC and DWEDDEEC. It has been clearly shown that the first node dead time and last node dead time has been prolonged. The first node dead time is 201, 231, 252 and 423 respectively. Last node dead time is 617, 1058, 1199 and 1995 respectively. Therefore DWEDDEEC has shown significant improvement over the existing technique.

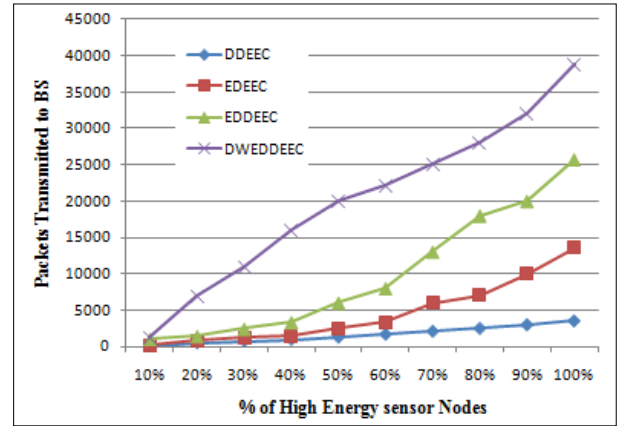


Figure 20 Packets sent to BS

Figure 20 and Figure 21 have shown the packets transmitted to the BS and CH respectively.

The comparison of all the protocols that shows the first dead nodes, last dead nodes, tenth dead nodes, packets to BS and packets to CH.

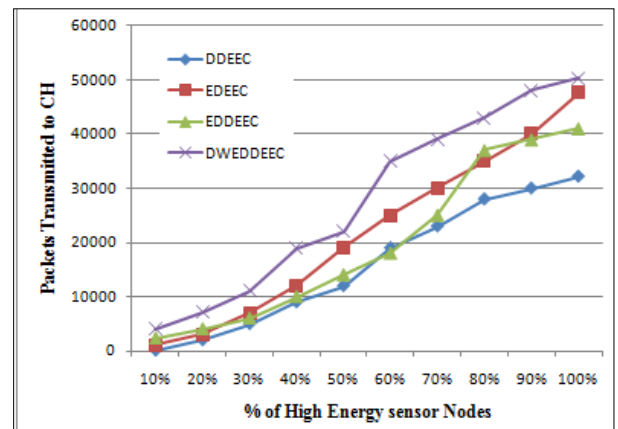


Figure 21 Packets sent to CH

Table 2. Results of Simulation

Protocols	First node dead	Last node dead	Packets to CH	Packets to BS
DDEEC	201	617	32184	3525
EDEEC	231	1058	47618	13551
EDDEEC	252	1199	41033	25721
DWEDDEEC	423	1995	50331	38766



## 9. CONCLUSION AND FUTURE WORK

Though EDDEEC has depicted pretty considerable outcomes over existing WSNs protocols except it has ignore the utilization of waiting time of node to become CHs. Therefore might a few nodes will not turn out to be CHs for a very long duration still they contain additional confidence to become CHs. Therefore to conquer this, a waiting counter called  $W_r(i)$  is used. To improve the results further MDCH between two CHs has also been used to deploy the sensor field in the most proficient manner. MDCH has capability to conquer the issue of the too small and too high CHs. MDCH is based on mathematical radius theory of a circle to evaluate the optimized sensor field distribution. If distance between node going to become CH and any existing CH is less than the threshold distance then it will produce a -ve value so node will not become CH. The proposed algorithm is designed and implemented in MATLAB. The comparisons have shown significant improvement over the existing EDDEEC.

In near future we will use ant colony based data aggregation strategy for CHs to improve the performance of the proposed EDDEEC further.

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