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Heterogeneous Four Level Active Weighted Threshold Scheme

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Abstract-In this paper, active weighted probability function is used for enhancing network life. The heterogeneous four level weighted threshold scheme (H4LAWTS) is supporting four levels of nodes in terms of energy heterogeneity. The clustering approach is selecting master node bagged by probability function usingnode's left energy and average energy of network.The functionself-adjustsit for saving high energy nodes. This results in balance energy consumption. A threshold function is based on residual energy which further enhancing network lifetime parameters. The simulation results shows that this protocol performs 15-27% enhancement in network stability, 9-12% rise in network lifetime and approximately 15 % enrichment in throughput, compared against existing scheme EDEEC and also performing better than DEEC by about 10%,60% , 80 % in relation to parameters network stability , network lifetime and rate of flow of information respectively.

Keywords: Wireless sensor nodes, Homogenous, Heterogeneous, Hybrid, Clustering, and Threshold function

I. INTRODUCTION

WSN is considered to be flock of geographically dispersed nodes for measuring various physical and environment conditions. The micro sensor deployed may be used for sensing different parameters such as temperature, atmospheric pressure, rainfall, and pollution level and body area. [1] The tiny interconnected sensor nodes comprised of microprocessor, sensing unit, power unit and transceiver section. There are various types of sensors available in the market depending on its application such as pressure sensors, light sensors, temperature sensors, seismic and infrared sensors. These sensors sense physical parameters, microprocessor process them and store the data. The sensed data is collected, aggregated and finally transmit to the sink which may be gateway to another network. The communication in sensor network is through radio/wireless communication. [2]

WSN is subject to various concerns and challenges like resource limitation, fault tolerance and self-organization. Energy is being viewed as one of the key resource being utilized in communication, processing and performing sensing operations. As network operates in harsh environment and nodes are battery powered, energy conservation becomes one of the prime areas of concern for researchers. Numerous network life saving protocols has been developed in the past and still researchers are putting constant effort in this direction.

Cluster based routing protocols have emerged as key role player in enhancing energy efficiency. In clustering methodology, master node is chosen based on certain parameters like distance, location and energy of node. Member nodes perceive the information from environment, transfer the information to its master node (CH), then CH do summation of information, remove the redundant data and finally transferitto the sink for further analysis[3].

In homogenous approach, the various sensor nodes are operational with equal quantity of initial energy, computation power and storage capacity where as in heterogeneous setting, the nodes will be varied in terms of battery energy, processing and storage capacity. LEACH [4] protocol was homogenous assuming the nodes possess same amount of initial energy. The cluster head chosen is irrespective of residual energy of nodes. Hence energy depressed node die early compared to strong nodes. DEEC[5] is another protocol having two levels of nodes where residual energy of nodes and average energy of network are considered for choice of CH.

The paper presents a heterogeneous network model comprising of sensor nodes of four different types N1, N2, N3, and N4vary in their initial energy level. A dynamic weighted probability function is defined which is making selection of cluster head based on residual energy of node. The higher energy nodes will have maximum chances to be elected as cluster head. The cluster head node use up more energy than other member nodes, as it is performing the task of collecting values from different nodes, aggregating them,thereby sending it to the base station. Hence after some rounds, the high energy nodes are more likely to exhaust their energy. In order to avoid penalizing high energy nodes, this protocol dynamically adjusts the probability function for cluster head selection where after some rounds when remaining energy of high energy node comes in range of normal one, their election probability will be same as that of normal one i.e. they will be treated as normal node in terms of cluster head selection.

II. Related work

This section gives overview of various cluster based protocols, providing solution for enhancing network stability and energy conservation.LEACH [4] is cluster based approach used for homogenous environment where energy load is scattered by dynamically created cluster and further cluster head is selected according to prior optimal probability.Further PEGASIS [5] is chain based protocol where information is send and received through neighboring node.

DEEC [6] is protocol where probability for selection of CH is on basis of two main parameters: node's left energy value and network's average energy. DDEEC [7] is improving further network performance by balancing the distribution of energy equally among nodes. Enhanced DEEC [8]is DEEC based protocol adding another level of heterogeneity to nodes called super nodes. The selection of CH is based on threshold value computed by suggested fraction of cluster heads for the network and number of times node has become CH up to now.

EEHC[9] is energy efficient heterogeneous cluster scheme where cluster head is selected in distributed manner. The weighted election probabilitywhich is based on residual energy of node is used for selection of cluster head. The scheme is effective in increasing life time of network in comparison to LEACH. SDEEC[10] is routing protocol for heterogeneous network. This protocol is providing balanced cluster head election as it is using stochastic technique. EEICCP[11]is protocol, based on multi hop clustering scheme which minimize energy usage by uniformly distributing energy across the network. The coordination protocolsuper passes another conventional protocolwhere data is directly to base station through their respective cluster head.Novel energy efficient multi hop protocol [12] for heterogeneousenvironment where every node electeditself as CHon basis ofits preliminary energycomparative to others. Here global knowledge of energy is not required. It uses multihop approach for data communication from cluster head to base stationIn Link aware clustering algorithm [13]cost effective routing pathway is used, in terms of reliability and energy efficiency. The cluster is formed using PTX(Predicted Transmission Count), clustering metric based on node status and link condition.SOSAC [14] is self organized and smart adaptive clustering scheme using three sub procedures to alterwellness value with respect to time.HeterogeneousLEACH [24] was based on distributed routing protocol. It has been analyzed theresult ofheterogeneousness of nodes in enhancing the network lifetime.

HEER [16] is hybrid energy efficient reactive protocol using hard and soft threshold values for better energy consumption. The protocol works by selectingCHgrounded on fraction of remaining power of sensor node andmean power ofwsn.

TABLE 1 COMPARISON AMONG PROTOCOLS

	LEACH	SEP	DEEC	EDEEC	H4LAWTS
SPHERE	HOMOGENOUS	HETEROGONOUS	HETEROGONOUS	HETEROGONOUS	HETEROGONOUS
APPROACH	CLUSTER BASED	CLUSTER BASED	CLUSTER BASED	CLUSTER BASED	CLUSTER BASED
TYPES OF NODES (IN REGARD TO ENERGY	NODES POSSESS SAME ENERGY	SUPPORT TWO LEVELS OF NODES	SUPPORT TWO LEVEL OF NODES	SUPPORT THREE LEVEL OF NODES	SUPPORT FOUR LEVEL OF NODES
CLUSTER HEAD SELECTION	RANDOM CH SELECTION	WEIGHTED CLUSTER HEAD SELECTION	WEIGHTED CLUSTER HEAD SELECTION	WEIGHTED CLUSTER HEAD SELECTION	DYNAMIC WEIGHTED CLUSTER HEAD SELECTION
DESIGN PHILOSOPHY	LOW ENERGY NODES WILL DIE SOON AS CH SELECTION IS RANDOM	POWERFUL NODES ARE PUNISHED	HIGH ENERGY NODES ARE PUNISHED	NODES WITH MORE ENERGY ARE BURDENED	DYNAMIC PROBABILITY FUNCTION SAVE HIGH ENERGY NODES FROM PENALIZED.
DYNAMIC LOAD BALANCING	NO	NO	NO	NO	YES

III. FOUR LEVEL HETEROGENEOUS ACTIVE WEIGHTED SCHEME

This section is describing detail of scheme. The section 3.1 is describing heterogeneous network model based on four level of heterogeneity. The next section 3.2 is covering energy consumptionmodel for calculating power consumed. The section 3.3 is describing cluster head selection procedure usingdynamic weighted probability function for appointment of CH. The probability function adjusts itselfbased on residual energy of node resulting in even energy depletionAlso the section is mentioning how high energy nodes are saved from getting penalized by dynamic probability function used for selection of cluster head. Thesection 4 is presenting experimental evaluation of protocol. Finally section 5 is presenting concluding remarks.

A Heterogeneous Network Model

The protocol is using heterogeneous network model,in which nodes are categorized based on its energy level. As SEP, DEECoperate on two levels of nodes, the EDEEC support three level heterogeneity. The proposed protocol carriesfour type of nodes: N1, N2,N3,N4 and their energy levels (E1.E4) , satisfying condition E1<E2<E3<E4.The modelis using assumptions as follows

The sensor network area to be monitored is of dimension MxM.

The randomly installed sensor nodes are motionless.

The locality of sink is at center of field having no resource constraint.

The nodes are alike in computation and communication ability but differ in initial energy.

The N nodes are deployed randomly in area MxM. Let μ, μ0, μ1 are fraction of different types of nodes whose value lies between 0 and 1.The number of nodes in all categories is determined as

$$
\begin{aligned}
Nc4 &= N.\mu.\mu0.\mu1 \\
Nc3 &= N.\mu.\mu0.\,(1-\mu1) \qquad (1) \\
Nc2 &= N.\mu.\,(1-\mu0) \\
Nc1 &= N.\,(1-\mu)
\end{aligned}
$$

The initial energy of all types of nodes is

$$
\begin{aligned}
E4 &= Nc4.(1+x3).E0 \\
E3 &= Nc3.\,(1+x2).E0 \qquad (2) \\
E2 &= Nc2.\,(1+x1).E0 \\
E1 &= Nc1.E0
\end{aligned}
$$

As mentioned above, N4nodes carry x3 time more energy than N1nodewhereasN3 nodes possessing x2 times and N2nodes have x1 times extra energy than N1type respectively.

The amount ofwsn energy is defined in equation (9)

$$Etot.=E4.+E3.+E2.+E1$$

Thus,

$$Etot.=N.\mu.\mu0.\mu1.\,(1+x3).E0 + N.\mu.\mu0.(1-\mu1).\,(1+x2).E0 + N.\mu.(1-\mu0).(1+x1).E0 + N.(1-\mu).E0$$

$$Etot= N.E0.(1+\mu.((x1+\mu0.(-x1+x2))+\mu1.(-x2+x3))) \qquad (3)$$

The energy of four level heterogeneous system if enhanced by factor μ. ((x1+μ0.(-x1+x2))+μ1.(-x2+x3))

B Radio Energy Dissipation Model

In energy dissipation model [4], radio transmitter consumepower tooperate radio electronics for transmitting and amplifying the signals whereas receiver dissipates power for receiving only.

Etx(b,d)= E_elx+E-amp(b,d)

Erx = E_elx

As radio energy model describe in figure1, power expanded to pass on b bit message over a gap d is given by

$$Etx(b,d)=\begin{cases} b * E\_elx + b * \mathcal{E}fs * d2 & \text{if } d \leq d0 \\ b * E\_elx + b * \mathcal{E}mp * d4 & \text{if } d \geq d0 \end{cases} \quad (4)$$

Based on gap d, free space model (Ɛfs) or multipath model (Ɛmp) is used, do is threshold distance measured as $\sqrt{\frac{\epsilon fs}{\epsilon mp}}$

.

And the energy consumed in receiving b bit message will

Erx = b*E_elx (5)

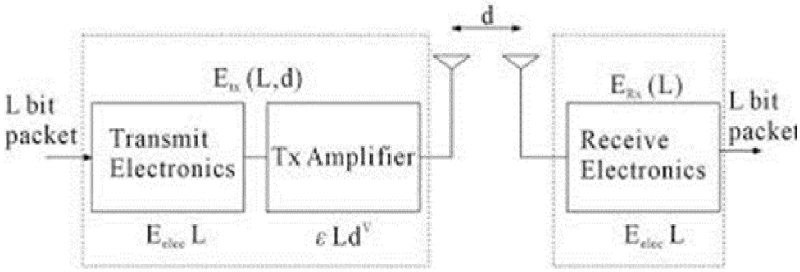


Fig 1 Radio Energy model

The network energy consumption per round is evaluated as

Eround = b (2NE_elx + NEag + kεmpd4toBS+ Nεfsd2toCH) (6)

Eag= Data aggregation cost

dtoBS&dtoCH= Area distance between CH and sink & node and CH respectively

N = number of sensor nodes

K = cluster count

The value of various radio characteristics are mentioned in table 3

TABLE 3: RADIO PARAMETERS

CHARACTERISTIC	VALUE	ACRONYM
ENERGY CONSUMED IN TRANSMITTER AND RECEIVER CIRCUIT ELECTRONICS	50NJ/BIT	EELEC
ENERGY CONSUMED IN DATA AGGREGATION	5NJ/BIT	EDA
AMPLIFIER USING ENERGY ATLESSER DISTANCE I.E. DTOBS≤ D0	10PJ/BIT /M2	ƐFS

Considering the uniformity of N nodes being placed in M2 field, then dtoCHcan be calculated as

dtoch = $\int_0^{x_{max}} \int_0^{y_{max}} ((x^2 + y^2) * p(x, y))dxdy = \frac{M^2}{2\Pi K}$ (7)

Wherep(x,y) is node distribution.

The average distance between master node and sink is calculated as

dtoBS = $\int_A (x^2+y^2) * \frac{1}{A}$ = 0.765*$\frac{M}{2}$ (8)

In order to calculate kopt, take derivative of equation with respect to k

kopt = $\frac{\sqrt{N}}{\sqrt{2\pi}} \sqrt{\frac{\epsilon_{fs}}{\varepsilon_{mp}}} \frac{M}{d_{toBS}} = \sqrt{\frac{n}{2\pi}} \frac{2}{0.765}$ (9)

The idea chance of node to become CH is as follows

Pideal = $\frac{K_{ideal}}{N}$

C Cluster head selection procedure

The rotating epoch ei denotes frequency of node Si to be acted as CH .In case of homogenous network like LEACH, the eiis same for entire nodes, so nodes carrying lower energy expire fast. Thechoice of CH in the proposed protocol is founded on basis ofenduring energy of node and network's mean energy. The value of rotating epoch eiin this protocol will be depending on leftover node energy. The average probability pi is fixed as pi=1/ei. The mean energy Eavg(r) of wsn during round ris summation of node energy can be calculated as

Eavg(r)=$\frac{1}{N}\sum_{i=1}^{N} NEi(r)$ (10)

Where NE is

Considering E(r) as reference energy,

pi = pideal$\left[1 - \frac{Eavg\,(r) - NEi\,(r)}{Eavg\,(r)}\right]$ = pideal$\frac{NEi\,(r)}{Eavg\,(r)}$ (11)

To calculate average probability piof network, it is required to know average energy of network.This is considered as ideal energy that each node should have in current round in order to keep network alive. E(r) can be measured as

Eavg(r) = $\frac{1}{N} E_{total}$ (1- $\frac{r}{R_{tot}}$) (12)

Where Rtotspecifying count of round .The value of Rtot can be calculated measured as

Rtot=$\frac{E_{total}}{E_{round}}$ (13)

WhereasEtotal is total energy

Eround is energy consumed per round

DEEC is protocol supporting two levels of heterogeneity while EDEEC is having three levels of nodes normal, advance and super nodes. As the protocol carries four types of nodesN1….N4, their weighted probabilities are definedas

$$pN1= \frac{p_{ideal}}{(1+\mu.((x_1+\mu0.(-x_1+x_2))+\mu1.(-x_2+x_3)))}$$

$$pN2 = \frac{p_{ideal}\ (1+X_1)}{(1+\mu.((x_1+\mu0.(-x_1+x2))+\mu1.(-x_2+x_3)))} \quad (14)$$

$$pN3= \frac{p_{ideal}\ (1+X_2)}{(1+\mu.((x1+\mu0.(-x1+x_2)+\mu1.(-x_2+x_3)))}$$

$$pN4 = \frac{p_{ideal}\ (1+X_3)}{(1+\mu.((x_1+\mu0.(-x_1+x_2))+\mu1.(-x_2+x_3)))}$$

As per above equation N4 type node is having highest probability of becoming cluster head. Hence high energy nodes will depletes its power quickly as for more number of times they will be elected as cluster head. As DEEC and EDEEC punishes high energy nodes,thus for balance energy utilization and to escape high energy nodes to be penalize, the protocol is using reference energy valueER, under which nodes ofall types will have same prospect for cluster head choice. The protocol is modified as

$$pi= \begin{cases} \frac{p_{ideal}\ .NEi(r)}{\left(1+\mu\left(x_1+\mu_0(-x_1+x_2)+\mu_1(-x_2+x_3)\right)\right)Eavg\,(r)} & beingN1\ type \quad for(NEi(r)>E_R) \\ \frac{p_{ideal}\ (1+x1).NEi(r)}{\left(1+\mu\left(x_1+\mu0(-x_1+x_2)+\mu1(-x_2+x_3)\right)\right)Eavg\,(r)} & beingN2\ type \quad for(NEi(r)>E_R) \\ \frac{p_{ideal}\ .(1+x2)NEi(r)}{\left(1+\mu\left(x_1+\mu0(-x_1+x_2)+\mu1(-x_2+x_3)\right)\right)Eavg\,(r)} & beingN3\ type \quad for(NEi(r)>E_R) \\ \frac{p_{ideal}\ (1+x3)NEi(r)}{\left(1+\mu\left(x_1+\mu0(-x_1+x_2)+\mu1(-x_2+x_3)\right)\right)Eavg\,(r)} & beingN4\ type \quad for(NEi(r)>E_R) \\ h\frac{p_{ideal}\ (1+x3)NEi(r)}{\left(1+\mu\left(x_1+\mu_0(-x_1+x_2)+\mu1(-x_2+x_3)\right)\right)Eavg\,(r)} & foralltypes \quad where(NEi(r)\leq E_R) \end{cases} \quad (15)$$

The value of referenceenergy, ER is defined as

$$ER = (f)*E0 \quad (16)$$

The value of kis placed between 0 and 1. Based on parameter network stability of wsn, the best value of f is chosen as 0.7. The variable hdirect the CH count. Assignment of value 0 to h leads to zero CH in network, hence the nodes will directly transmit to base station. The value of c taken as 1 will consider all the nodesto act as CH leading to direct transmission to base station. Through various simulations the value of h is observed as 0.02 based on network performance.

The probability threshold function for fixing up node to turn it to CH is defined as

$$Threshold\ (Si)= \begin{cases} \frac{p_{N1}}{1-p_{N1}\left(mod\left(r,\frac{1}{p_{N1}}\right)\right)} * \frac{Si.E}{E_{total}} & ifS_i\ \in G \\ \frac{P_{N2}}{1-p_{N2}\left(mod\left(r,\frac{1}{p_{N2}}\right)\right)} * \frac{Si.E}{E_{total}} & ifS_i\ \in G' \\ \frac{p_{N3}}{1-p_{N3}\left(mod\left(r,\frac{1}{p_{N3}}\right)\right)} * \frac{Si.E}{E_{total}} & ifS_i\ \in G'' \\ \frac{p_{N4}}{1-p_{N4}\left(mod\left(r,\frac{1}{p_{ult}}\right)\right)} * \frac{Si.E}{E_{total}} & ifS_i\ \in G''' \\ 0 & else \end{cases} \quad (17)$$

Whereas G, G', G''and G''' are group of N1, N2, N3 and N4types, those nodes not been chosen as CHduring previous 1/pN1,1/pN2,1/pN3 and 1/pN4rounds respectively. In case node Si is qualified for becoming CH, it will choose random figure between {0,1} . In casethe figure is lower than Threshold figure,that particular node will be choice for CH.

D Simulation results

The H4LWTS protocol is simulated in MATLAB and its network performances are compared with DEEC (two levels) and EDECC (three levels). We are assuming that there are 100 nodes deployed in area of dimension 100m X100m where sink is positioned at central position in the area.

The performance measure used for validating results is as follows

WSN Lifetime: It is measured as timeframe between commence of network and collapse of entire nodes in network.

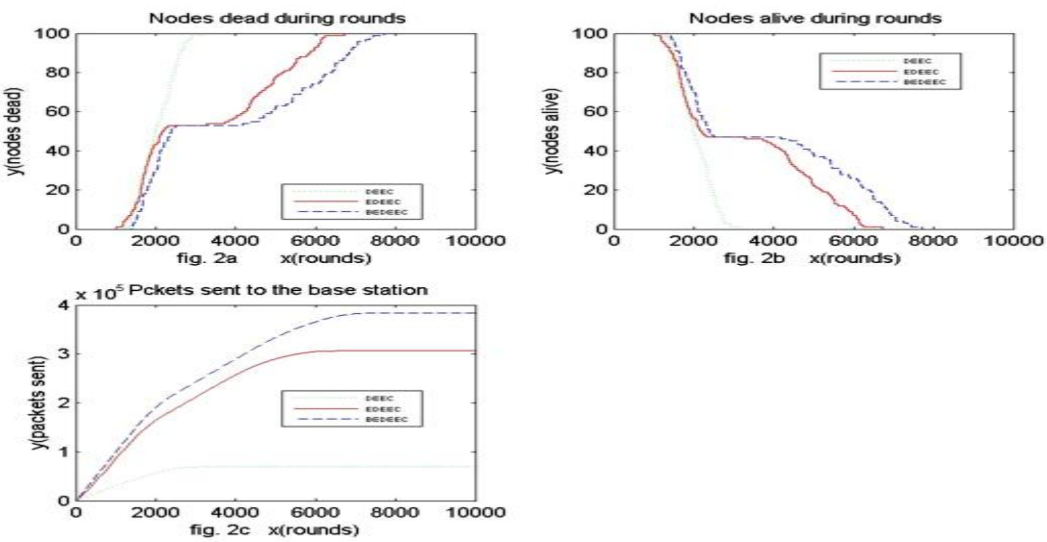
No. of data packets delivered to base station: It is defined as no. of data packets send to sink.

Network Stability period: This is calculated as interval between start of network and loss of foremost node as it lapses completely in terms of energy. The simulation parameter are mentioned in table 2.

TABLE 2 SIMULATION PARAMETER

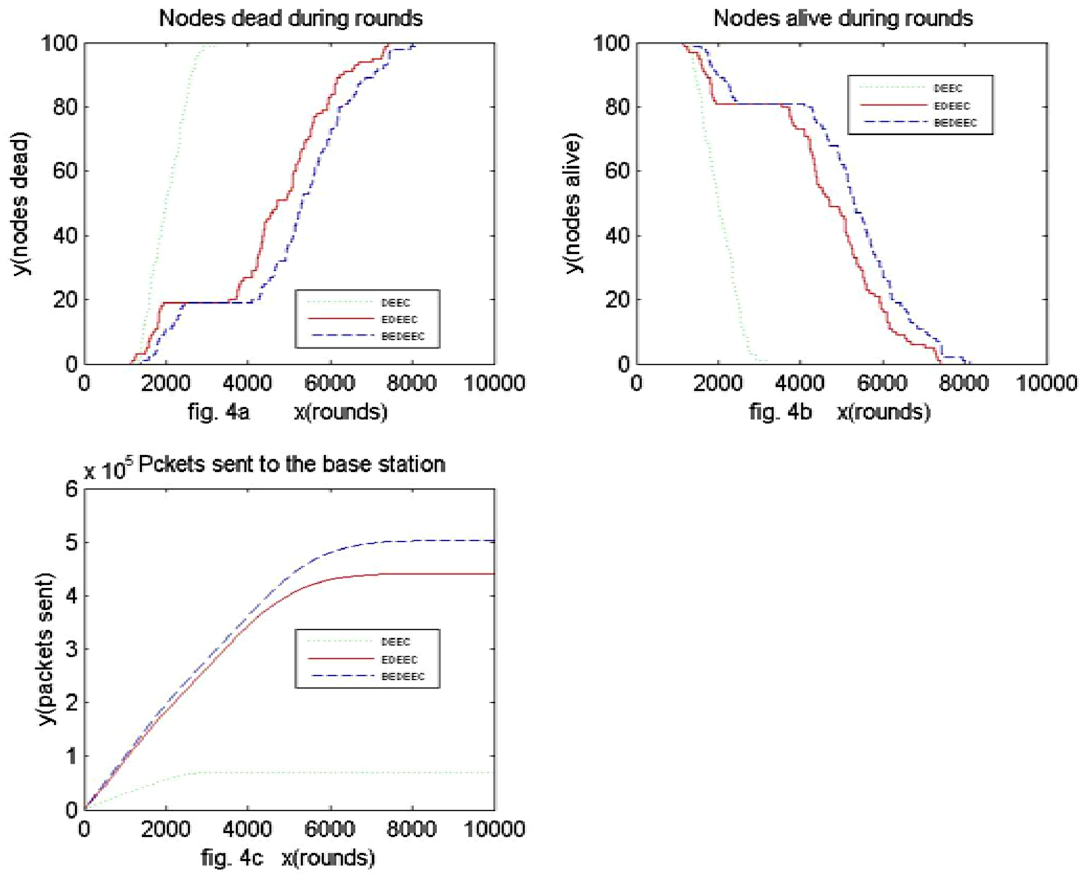
PARAMETER	VALUE
NETWORK FIELD	100X100
NO. OF NODES	100
EO	0.5J
POPT	0.1
ƐMP	0.0013PJ/BIT/M4
ƐFS	10 NJ/BIT/M2
EELEC	50NJ/BIT
EDA	5 NJ/BIT/SIGNAL
L	4000 BITS

In case 1 scenario the first node die forDEEC, EDEEC and H4LAWTS is at 1240, 1014 and 1395rounds respectively. Figure 2ais validating the result by simulating the number of dead nodes in various rounds. This is validating the network performance in terms of network stability which is defined as time gap between start of network and first node die in network. Figure2b is depicting number of alivenodes in various rounds for DEEC, EDEEC and H4LAWTSrespectively. Figure 2b is further concluded that last node die in DEEC, EDEEC and H4LWTSat 3188, 6726 and 7719 rounds respectively. Figure 2c is showing Number of packets sent to base station for DEEC, EDEEC, and H4LWTS. It has been concluded from figure 2a,2b and 2c that H4LWTS performs better in showing enhancement in various network lifetime parameters.



For case 2 Figure 3a isdepicting no. of dead nodes for DEEC, EDEEC, H4LWTS protocols respectively,showing first node dies at 1240, 1171 and 1383 respectively. As shown in figure 3b the last node of DEEC, EDEEC and H4LWTS dies at 3188, 7294 and 7977. Figure 3c is showing data transmission rate to BS in case of H4LAWTS protocol in comparison to DEEC and EDEEC protocol. It is showing that H4LWTS is most efficient protocol showing improvement in stability period, network system lifetime and amount of packets forward to base station.

Finally case 3 depicting the result as theforemost node of DEEC, EDEEC and H4LAWTSexpires at 1232, 1145 and 1389 round respectively and last node of DEEC, EDEEC and H4LWTS protocol ends at 3375, 7438 and 8378respectively. Figure 4 c is showing 516121 packets send to base station in comparison to442061in case of EDEEC protocol. The H4LWTS protocol is showing maximum throughput as in this case as there are more high energy nodes than normal.



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IV. CONCLUSIONS

The proposed H4LAWTS is energy aware heterogeneous routing protocol possessing four levels of nodes. Further it is considered to be adaptive protocol where cluster head is selected dynamically in more balanced way. The said protocol isenhancing network stability and hence strengthening network lifetime.There is also significantimprovement inthroughput from cluster head to base station.

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