IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 9, Issue 3, March 2021

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.488

International Journal of Innovative Research in Computer and Communication Engineering

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 7.488 |

|| Volume 9, Issue 3, March 2021 ||

| DOI: 10.15680/IJIRCCE.2021.0903221 |

Region based Modified Distributed Energy Efficient Clustering (R-DEEC) Algorithm

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ABSTRACT: The clustering algorithm is a kind of key technique used to reduce energy consumption in wireless sensor networks. Sensor nodes usually have limited energy supply and they are battery operated. Nowadays, abundance of energy efficient clustering algorithms is on hand to obtain better outcomes and intensify the scalability as well as the lifetime of sensor nodes. In Hierarchical based routing, high energy nodes are randomly selected for sensing, collecting the data from its neighboring nodes, processing and sending the data to the base station while low energy nodes are used for sensing and sending the information to the cluster heads. In the proposed Region based modified Distributed Energy Efficient Clustering algorithm, controlled random deployment method used for heterogeneous node deployment. Also, the energy consumption has been reduced through controlled random deployment of nodes with their different energy levels in predefined regions. The sensing field is divided into three regions where normal, advanced and the combination of advanced and super nodes are deployed near, away and farther away from the base station respectively to balance energy consumption. In evaluation of simulation outcomes with existing cluster approaches like SEP and DEEC obviously show that the proposed algorithm gets done prolonged lifetime to nodes in heterogeneous environment.

KEYWORDS: Clustering, energy efficient, controlled random deployment

I. INTRODUCTION

Wireless Sensor Networks (WSNs) comprises of massive amounts of sensor nodes for monitoring the region of interest and send data about the targets or events of interest to the base station. Wireless sensor network senses the physical parameters of the environment in terms of temperature, humidity, light, sound, vibration, etc. WSNs can be widely used to perform military tracking and surveillance, natural disaster relief, hazardous environment exploration and health monitoring, etc.[1]. These sensor nodes gather the data from the sensing field as well as aggregate the data and send this information to the end user via sink as shown in Figure 1.

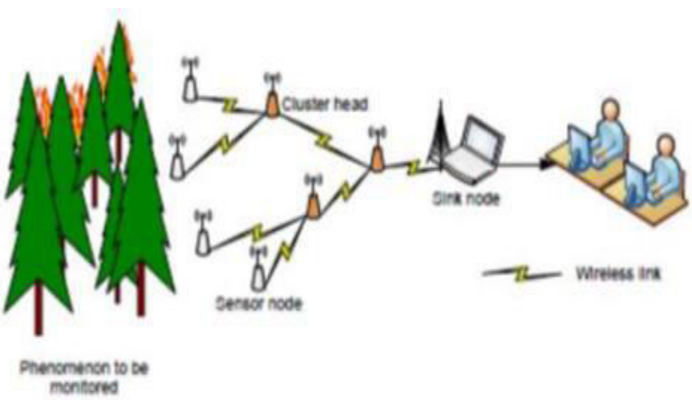

Figure 1. Architecture of a typical WSN

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 7.488 |

|| Volume 9, Issue 3, March 2021 ||

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Nodal Architecture of WSN
A basic sensor node comprises shows in Figure 2, has five main components:
Controller: A controller to process all the relevant data, capable of executing arbitrary code.
Memory: Some memory to store programs and intermediate data; usually, different types of memory are used for programs and data.

Sensors and actuators: The actual interface to the physical world: devices that can observe or control physical parameters of the environment.
Communication: Turning nodes into network requires a device for sending and receiving information over a wireless channel.

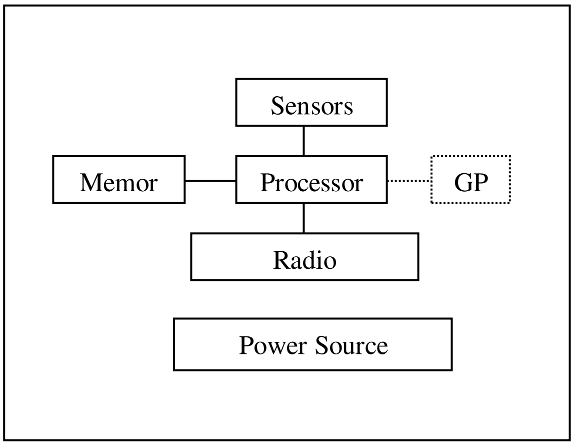

Figure 2. Sensor node Architecture

Power supply: As usually no tethered power supply is available, some form of batteries is necessary to provide energy. Sometimes, some form of recharging by obtaining energy from the environment is available as well (e.g. solar cells). Some of the optional features like GPS, mobility are also available.

Higher energy is required to communicate the sensed data than sensing operation. Clustering techniqueis one of the options for the sensor network to work more energy efficiently. The idea is to select a set of cluster heads from the set of nodes in the network, and then cluster the remaining nodes with these heads. The data gathered are transmitted through cluster heads to remote base stations or sink nodes.However, sensor networks with one fixed sink node often suffer from hotspot problem since nodes near sink have more traffic burden to forward during a multi-hop transmission process [2]. Wireless sensor network are of two types that are homogeneous and heterogeneous. Homogeneous networks are those in which nodes has same initial energy while heterogeneous networks are those in which nodes have different initial energy. Homogeneous network becomes heterogeneous during the runtime due to unequal energy spent by the individual nodes as a cluster member and cluster head. So the heterogeneous wireless sensor networks are chosen. Many clustering algorithms have been proposed for homogeneous WSN in [2], [3] and [4] does not perform well in heterogeneous networks.

In this work, region based DEEC algorithm is proposed in which node deployment done using controlled random method. The entire sensing field is divided into three regions of equal area and sink is placed at the centre as shown in figure 3.The nodes are deployed randomly within the specified region. i.e., region 1 contains normal node (energy E_0), region 2 contains advanced node (aE_0) and region 3 contains advanced nodes and super nodes(bE_0, $a < b$ & $a > 1$). Hence it shows a promising performance in balancing the energy and prolonging lifetime and stability of the network.

The rest of this paper is organized as follows: Section 2 describes the related work about the various approaches in literature that deal with enhancement of network lifetime using clustering in WSN. Section 3 describes the proposed model. Section 4 discuss about simulation results and discussion and conclusion.

II. RELATED WORK

Some of the heterogeneous networks in the literature are briefly givenhere. The system proposed by Smaragdakis et.al [5], the cluster head selection is based on the initial energy of the nodes. It requires global knowledge of the

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energy of all the nodes. Hence it is not efficient enough. Modified Stable Election Protocol (MSE) which employs a mobile sink with non-uniform node distribution [7]. MSE protocol is an energy efficient routing protocol in WSNs which forms hierarchical routing by dividing the network into clusters and selecting cluster heads based on the fraction of advanced nodes with additional energy and the ratio between residual and initial energy. Distributed Energy Efficient Clustering algorithm (DEEC) in which the cluster head selection is based on the probability of the ratio of residual energy of the nodes to the average energy of the network[6]. Hence the performance of DEEC is better than [5] and [7].The Enhanced Distributed Energy Efficient Clustering (E-DEEC) [8].Thus E-DEEC has three types of nodes namely super nodes, advance nodes and normal nodes which prolongs the lifetime and stability of the network and also increases the energy level of the network. In heterogeneous environment, Zonal Stable Election Protocol (ZSEP) has two level heterogeneity with two nodes namely advanced and normal nodes [9 - 11]. The field is divided into three zones: Zone 0, Head Zone 1and Head Zone 2. Normal nodes are only deployed in Zone 0 to reduce the energy consumption and they transmit data directly to base station[12-13]. Half of advanced nodes are deployed in Head Zone 1 and half in Head Zone 2 and they use clustering technique to transmit data to base station.

III. PROPOSED SYSTEM

A Region based Modified Distributed Energy Efficient Clustering (R-DEEC) algorithm which uses the Zonal concept from Z-SEP and clustering technology from DEEC. The entire sensing field is divided into three regions of equal area such as region 0, region 1and region 2 and sink is placed at the centre as shown in figure 3. The nodes are deployed randomly within the specified region.

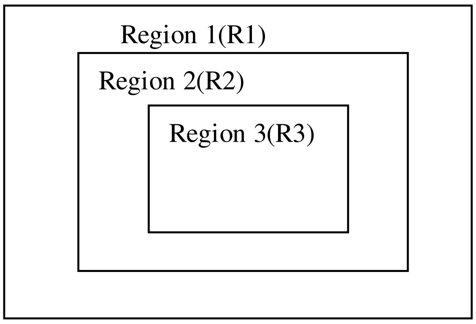

Figure 3 Regional classification of the sensing field

It has three different levels of nodes namely Normal, Advanced and Super nodes during initial deployment. The initial energies of normal nodes, advanced nodes and the super nodes are E_0, aE_0,and bE_0 such that $a > 1$ and $b > a$. Region 1 contains normal node (energy E_0), region 2 contains advanced node (aE_0) and region 3 contains advanced nodes and super nodes(bE_0, $a < b$ & $a > 1$). Hence it shows a promising performance in balancing the energy and prolonging lifetime and stability of the network. Base Station is placed in the centre of the square shaped sensing field and it is divided into three regions with equal area. Nodes in region R1 are closer to the BS, so the nodes needs less energy for communication. So the normal nodes are randomly deployed within region R1. The region R2 is behind the region R1 so the nodes in this region needs higher energy for communication compared to the region R1. Hence the advanced nodes are deployed randomly within the region R2. The region R3 is far away from the BS compared to region R1 and R2 therefore it needs very high energy for communication and so a certain number of advanced and super nodes are randomly deployed within this region R3 and the node distribution shown in figure4.

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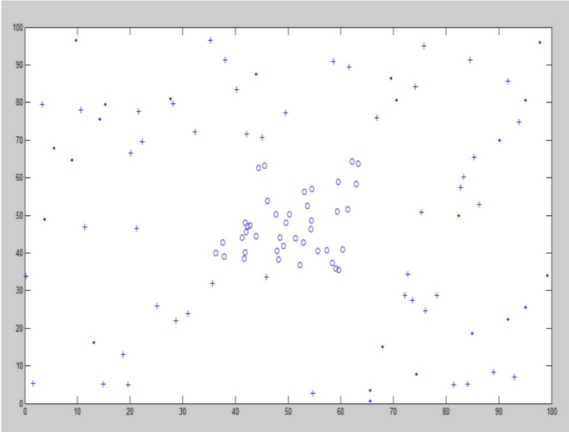

Figure 4 Regional Node Distribution

3.1 CLUSTER FORMATION PROCESS

There are two phases in cluster formation using DEEC algorithm are set up and steady state phase. In set-up phase, advertisement phase and cluster set-up operations are done. In the advertisement operation, the cluster head (CH) send the advertisement packet to their nearby nodes to inform that they become CH. In the cluster set-up operation, non-cluster nodes send "join-packets", to CH to inform that they become the member of the cluster. In steady State phase, the actual transmission of data begins in this phase. According to the TDMA slot nodes send their data to its CH. Thetransceivers of nodes areturned off during the times which do not communicate. After receiving all the data, CH aggregates the data and sends to the base station.

1.2 RADIO ENERGY DISSIPATION MODEL

In radio hardware energy dissipation, the transmitter dissipates energy to run the radio electronics and the power amplifier, and the receiver dissipates energy to run the radio electronics. Here both the free space (d^2 power loss) and the multipath fading (d^4 power loss) channel models were used depending on the distance between the transmitter and the receiver.Figure5 shows the radio energy dissipation model.

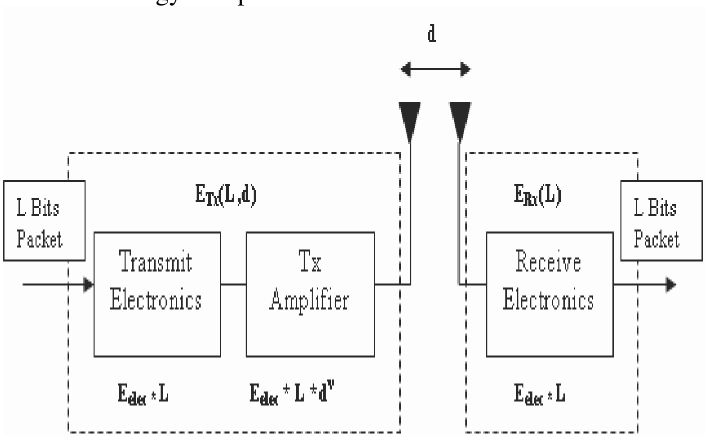

Figure 5 Radio dissipation model

Thus to transmit an L bit message a distance, the radio expense

$$E_{Tx}(L,d) = \{L.E_{elec} + L.E_{fs}.d^2 \quad ; d<d_0$$
$$L.E_{elec} + L.E_{amp}.d^4 \quad ; d>=d_0\}$$

The electronics energy, Eelec ,depends on factors such as the digitmodulation, filtering and spreading of the signal. The value of threshold distance d0 is given by

$$d_0 = E_{fs}/ E_{amp}$$

1.3NETWORK MODEL

Sensor network is used with 'n' nodes in M×M network field. There are three types of sensor nodes namely normal nodes, advanced nodes and super nodes. Let 'm' be the fraction of the total number of nodes n which have additional

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energy than normal node and m0 is the percentage of the super nodes which are equipped with 'b' times more energy than the normal nodes. The total number of super nodesare n.m.m0 and total initial energy of super nodes are n.m.mo(1 + b) E_0.The rest n.m.(1-m0) nodes are equipped with 'a' times more energy than the normal nodes, called as the advanced nodes and remaining n.(1-m) as normal nodes.

The total initial energy of the three level heterogeneous networks is given by

$$E_{total} = n.(1-m).E_0 + n.m.(1-m_0).(1+a).E_0 + n.m.m_0.E_0.(1+b)$$

$$= n.E_0.(1+m.(a+m_0.b))$$

Therefore, the three level heterogeneous networks have m.(a+m0.b) times more energy or we can say that the total energy of the system is increased by a factor of (1+m.(a+m0.b)).

The average energy is estimated as

$$E(r) = 1/N * E_{total}(1-r/R)$$

Where R denotes the total rounds of the network lifetime. R can be calculated as

$$R = E_{total}/E_{round}$$

Eround is the energy dissipated in the network in a round.

The total energy dissipated Eround is equal to

$$E_{round} = L(2NE_{elec} + NEDA + kE_{amp}d^4{toBS} + NE_{fs}d^2{toCH})$$

Where k is number of cluster 'd'toBS is the average distance between CH and BS and 'd' toCH is the average distance between the cluster members and the CH.

Now, $dtoCH = M/\sqrt{2\pi k}, dtoBS = 0.765M/2$

By calculating the derivative of Eround with respect to k to zero we get optimal number of clusters as

$$K_{opt} = (\sqrt{(N/2\pi)}) * M / d_2toBS * (\sqrt{E_{fs}/E_{amp}})$$

IV. ALGORITHM

1. Set the base station location at the Centre of the network
2. Initialize the values for fraction of advance nodes, fraction of super nodes,initial energy for the normal nodes and the area of different regions(xd1,yd1)
3. In Region3(R3),super nodesand fraction of advanced nodes deployed in the network
4. In Region2 (R2), remaining advanced nodes are deployed in the network
5. In Region1 (R1), normal nodes are deployed in the network
6. The entire regions are divided into number of cluster and each cluster have a cluster head with highest energy.
7. Foreach round calculate residual energy of the cluster head
8. If cluster head energy is greater than or equal to energy required to communicate with the base station, then the same cluster head is continued for the next round, otherwise the cluster head has been changed
9. If none of the node has energy is greater than or equal to energy required to communicate with the base station, then the process has been halted.

V. SIMULATION ENVIRONMENT

In this section, evaluating the performance of R-DEEC done using MATLAB. Consider a wireless sensor network with N = 100 nodes randomly distributed in a100mX100m field. The base station is in the centre of the sensing region. To compare the performance of R-DEEC with other protocols, the effect caused by signal collision and interference in the wireless channel are ignored. The radio parameters used in the simulations are shown in Table 1. The protocols compared with R-DEEC, SEP and DEEC. Consider following scenarios and examine several performance measures.

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Table 1. Simulation Parameters

Parameter	Definition	Default settings
E_o	Initial energy of each node	0.5J
E_{elec}	Energy dissipated per bit to run the transmitter or the receiver	50x10-9J/bit
EDA	Data aggregation energy	5x10-9J/message
E_{fs}	Energy dissipation for free space	10x10-12J/m2
Emp	Energy dissipation for multipath	0.0013x10-12J/m4
d_o	Minimum Distance from the node to base station	70m
p	Probability for cluster head selection	0.1
N	No of nodes	100
x_m, y_m	Area of network	100x100

Here the graph shows the following results:
1. Comparison between SEP,DEEC,R-DEEC for dead nodes, alive nodes and packets send to base station.
2. Performance of R-DEEC by varying the percentage of advance nodes and super nodes.
3. Performance of R-DEEC by varying the energy in advance and super nodes.

VI. SIMULATION RESULTS

6.1 Comparison between SEP,DEEC,R-DEEC

Figure 6 shows the network lifetime with m = 0.6, m0 = 0.335, a= 3 and b = 4. It is obvious that the life time of R-DEEC is prolonged compared to that of SEP and DEEC. DEEC performs better than SEP, but it is not efficient than R-DEEC protocol. It is because the nodes which are farther away from base station die quickly.

R-DEEC performs well and achieves improved performance on dead nodes by about 38% than SEP and 3.2% than DEEC by considering the first dead. This is because SEP considers the initial energy only but R-DEEC considers both initial and residual energy while selecting the cluster heads.

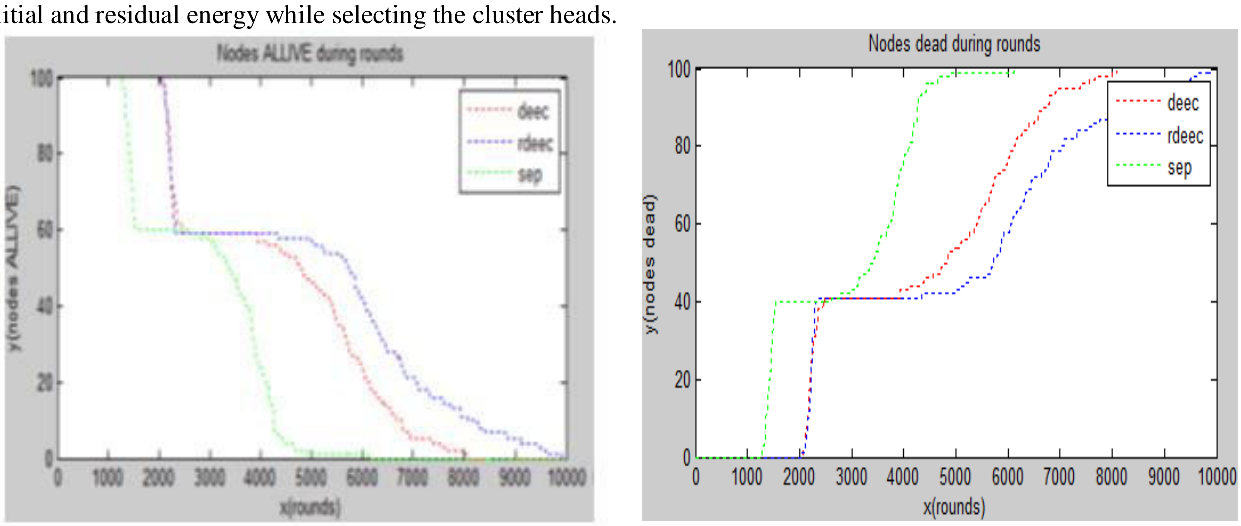

Figure 6. Comparison of SEP, DEEC, R-DEEC

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6.2 Comparison of SEP, DEEC, R-DEEC for packets send to BS

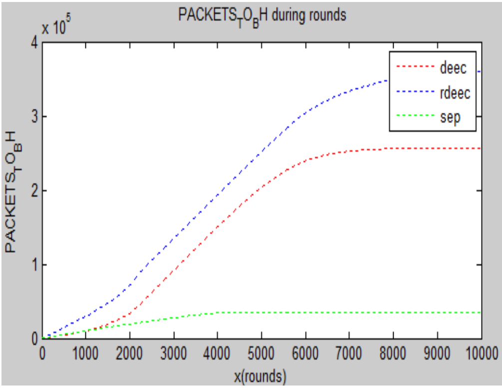

Figure 7 Comparison of SEP, DEEC, R-DEEC for packets send to BS

Figure 7 shows the number of packets send to the base station with m = 0.6, m0 = 0.335, a = 3 and b = 4. R-DEEC performs well and send more packets to the base station. It sends $3x10^5$ packets more than SEP and $0.7x10^5$ packets than DEEC.

6.3 Performance of R-DEEC by varying the percentage of advance nodes and super nodes

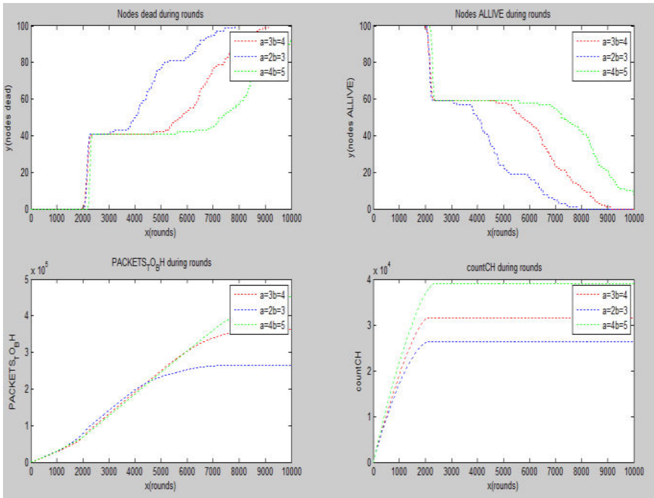

Figure 8 Comparison of R-DEEC for different values of a and b

It has been observed that the life time of the nodes increases with a and b because the initial energy of advanced and super nodes are increases hence packets send to the cluster head and base station increases.

6.4 Performance of R-DEEC by varying the percentage of advance nodes and super nodes

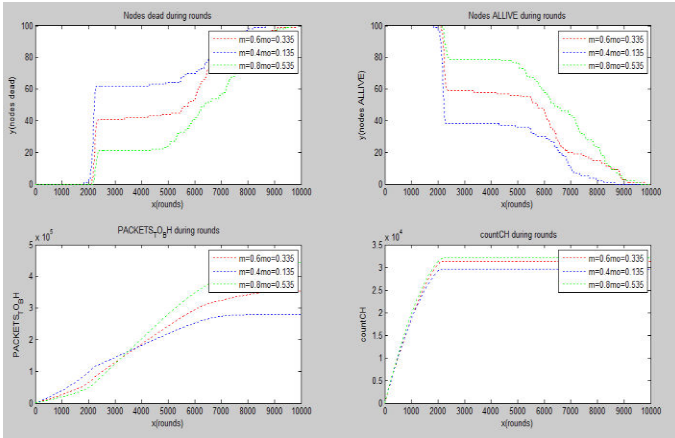

Figure 9 Comparison of R-DEEC

Figure 9 Comparison of R-DEEC for different values of m and m0. From the graph it has been observed that the life time of the nodes increases with m and m0 because the number of nodes which are having higher energy increases hence packets send to the cluster head and base station increases.

VII. CONCLUSION

In the proposed work, R-DEEC is an energy aware adaptive clustering protocol used in heterogeneous wireless sensor networks. In R-DEEC, every sensor node independently elects a CH based on its residual energy of each node and average energy of the network. The network is an energy efficient with longer stability and longer lifetime. R-DEEC performs well and achieves improved performance by about 38% than SEP and 3.2% than DEEC by considering the first dead.It performs well and sends more packets to the base station. It sends 3x105 packets more than SEP and 0.7x105 packets than DEEC. Hence from the above results R-DEEC helps to achieve a promising performance in balancing the energy and prolonging lifetime and stability of the network.

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| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 7.488 |

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