IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.8, Issue.8, August 2020 E-ISSN: 2347-2693

Behaviour Analysis of EDEEC for 4-Level Heterogeneous Wireless Sensor Networks

H.Kaur[1*], S. Sharma[2]

[1,2]Dept. of Computer Science, Baba Banda Singh Bahadur Engineering College, Fatehgarh Sahib, Punjab India

**Corresponding Author: k.harjitcse@gmail.com*

DOI: https://doi.org/10.26438/ijcse/v8i8.512 | Available online at: www.ijcseonline.org

Received: 17/Jul/2020, Accepted: 07/Aug/2020, Published: 31/Aug/2020

Abstract— Wireless Sensor Network consists of large number of Sensor nodes, which firstly sense the data and then transmit the sensed data to the base station which is known as the Sink. Network lifetime is one of the key challenges for Wireless Sensor networks because of the limited battery life of the nodes. As we know sensor nodes are energy constraint devices and to increase the lifetime of the network it is very necessary to minimize the consumption of energy of nodes while sensing and transmitting the data. Clustering in Wireless networks is one of the pre-eminent ways to improve the lifetime of the network. In EDEEC clustering-based hierarchical model is used where data is aggregated in the cluster and sent to a higher-level cluster head where the cluster hear is selected randomly on the basis of residual energy of the network. EDEEC works on 3-level heterogeneous wireless sensor networks in which there are three type of sensor nodes named as normal nodes, advanced nodes and super node, which still have scope of improvement because if the levels of heterogeneous wireless sensor networks are to be increased then more complexity will be there in the network and then a more stable behaviour of network is required. In this work it is proposed that performance of the network can enhanced if the level of heterogeneity in the network increased because in real world there can exist more than three types of nodes in the network.

Keywords— Clustering, Energy, Stability period, Heterogeneous, Wireless Sensor Networks**.**

I. INTRODUCTION

A Wireless Sensor Network or WSN is supposed to be made up of a large number of sensors and at least one base station (sink) as shown in Figure 1. The sensors are autonomous small devices with several constraints like the battery power, computation capacity, communication rang and memory. They also are supplied with transceivers to gather information from its environment and pass it on up to a certain base station, where the measured parameters can be stored and available for the end user. In wireless Sensor network, each sensor node has a limited battery life, thus the network formed by these nodes is also energy constraint. These sensor nodes have limited range and energy in the network.

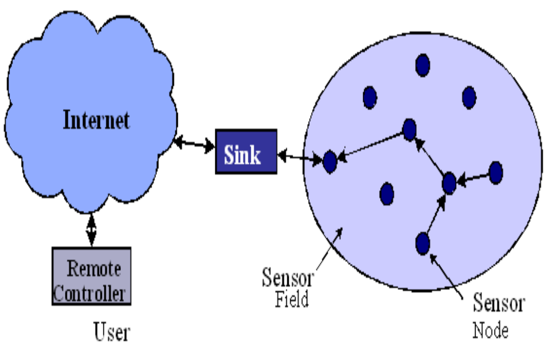

Figure.1. Wireless Sensor Network [1]

Sensor node is a tiny device that senses the data from surrounding environment, process it and then transmits it either to the base station. Thus it includes three basic components: a sensing subsystem for data acquisition from the physical surrounding environment, a processing subsystem for local data sensing subsystem for data acquisition from the physical sensing subsystem for data acquisition from the physical surrounding environment processing and storage, and a wireless communication subsystem for data transmission.

Sink is the destination base station system that receives the data sent by all the sensor nodes. It can be considered as an interface between the sensor field and the user.
Thus Wireless Sensor Networks consist of a large number of small sensing nodes that monitor their environment, process data if necessary and send/receive processed data to/from other sensing nodes. These sensing nodes, distributed in the environment, are connected to a sink.

Wireless networks are used in wide range of applications like area and environment monitoring, forest fire detection and greenhouse monitoring, landslide detection and machine health monitoring etc. In addition to these application Wireless Sensor Networks are also used in various important areas like military, health-care and scientific research and infrastructure protection etc.

Mostly wireless sensor networks are used in those areas where continuous human intervention is impractical and it is unrealistic to remove a dead node and implant a new node in the network.

So there is need to minimize the energy consumption of nodes during the transmission of data in the network. There are various routing protocols that are useful to achieve energy efficiency by using clustering.

There are many clustering based protocols like LEACH, SEP, PEGASIS and DEEC etc. EDEEC protocol is a variant of DEEC and EDEEC works on 3-level heterogeneous wireless sensor networks in which there are three type of sensor nodes named as normal nodes, advanced nodes and super node. This paper presents the behaviour analysis of EDEEC protocol for 4-level heterogeneous wireless sensor network in which there are four types of nodes named as normal, advanced, super and ultra-super nodes.

Rest of the paper is organized as follows, Section I contains introduction and applications of wireless sensor networks, importance of energy conservation in wireless sensor networks and motivation for the proposed work, Section II contains the related work of clustering protocols used for energy conservations in heterogeneous wireless sensor networks, Section III contains the motivation of work for implementing EDEEC in a 4-level heterogeneous wireless sensor network, Section IV represent the radio energy dissipation model that how the energy is consumed in sending and receiving the data packet, Section V depicts the heterogeneous WSN model and introduced to the various levels in corresponding models, Section VI contains the assumptions and properties of the network that are considered while doing simulation, Section VII includes the methodology used for implementing the EDEEC protocol for 4-level heterogeneous wireless sensor network, Section VIII includes the parameters used for performance evaluation, Section IX describes the simulation results of EDEEC protocol for three and four types of nodes, Section X concludes the research work.

II. RELATED WORK

Clustering is the hierarchical method to extend the network lifetime through efficient resource utilization. In clustering approach the Sensor network is divided into groups, called clusters. Nodes in grouped in clusters on the basis of some parameters and one node in each cluster that are selected by using some probability mechanism act as cluster head which collect the data from its cluster and after aggregating and processing it sends it to the base station(sink). In homogenous network it is assumed that the energy level of each node is equal, in this scenario the sensing, processing and communication capabilities of each node same. But in heterogeneous network the level of energy vary. The energy level of nodes can be two-level, three-level and multilevel respectively.

Heinzelman, et al. [4] introduced cluster- based protocol, named as LEACH (Low Energy aware clustering) protocol for homogeneous Wireless sensor networks to minimize the energy use in sensor networks by randomly choosing the sensor node as cluster heads. In Leach protocol there are two phases of data transmission namely setup and steady-state phases. In the setup phase, the nodes are randomly selected as cluster-heads using cluster selection algorithm based on a certain probability. In the steady-phase, the nodes within the clusters transmit their data to the appropriate CH with in a specific region, and then CH further aggregates and transfer the received data to the Sink. LEACH selects data transmission phases in each round based on their time and selects a random CH to balance the energy. However, this protocol does not guarantee the selection of an optimal number of CHs, and its performance does not improve in a heterogeneous environment. LEACH does not guarantee optimal number of CHs in each round and selection of CHs is random which makes cluster heads of different sizes.

LEACH protocol is only suitable for homogeneous WSN. So to overcome this problem, G. Smaragdakis, et al. [5] proposed a protocol for two-level heterogeneous wireless sensor networks in which the network is composed of two types of nodes according to the initial energy. The advance nodes are equipped with more energy than the normal nodes at the beginning. SEP prolongs the stability period, which is defined as the time interval before the death of the first node. SEP is not fit for the widely used multi-level heterogeneous wireless sensor networks, which include more than two types of nodes.

As SEP is not fit for widely used multi-level heterogeneous wireless sensor networks, L .Qing, et al. [6] proposed a protocol DEEC which is also fit for the multilevel heterogeneous networks and performs well. It selects the cluster heads with the help of probability based on the ratio between residual energy of each node and the average energy of the network. How long different nodes would be cluster heads, is decided according to the initial and residual energy. The authors assume that all the nodes of the wireless sensor network are equipped with different amount of energy, which is a source of heterogeneity. CH selection is based on probability which depends upon the residual energy of nodes and average energy of the network.

DEEC always penalizes the advanced nodes, especially when their residual energy depletes and become in the range of the normal nodes. In this situation, the advanced nodes die quickly than the others. B. Elbhiri, et al. [7] proposed a protocol, DDEEC, Developed Distributed Energy-Efficient Clustering, which permits to balance the cluster head selection overall network nodes following their residual energy. This protocol is based on residual energy for CH selection to balance it over the entire network. So, the advanced nodes are more likely to be selected as CH for the first transmission rounds, and when their energy decreases, these nodes will have the same CH election probability like the normal nodes.

In order to increase the heterogeneity of the DEEC protocol, P. Saini, et al. [8] proposed EDEEC protocol which extended to three-level heterogeneity by adding an extra energy level. The nodes are categorized as normal, advanced, and super. However, the CHs selection probabilities are not adjusted according to nodes' energy levels.

III. MOTIVATION

Many clustering based protocols like LEACH, SEP, DEEC and EDEEC etc. have been proposed to for wireless sensor networks to increase the life span of the network by using the available energy in an efficient manner. LEACH is a clustering-based protocol that minimizes energy dissipation in sensor networks. It is suitable for homogeneous wireless sensor networks. The purpose of LEACH is to randomly select sensor nodes as cluster-heads, so the high energy dissipation in communicating with the base station is spread to all sensor nodes in the sensor network. The operation of LEACH is separated into two phases, the set-up phase and the steady phase. The duration of the steady phase is longer than the duration of the set-up phase in order to minimize the overhead. During the set-up phase, cluster-heads assign the time on which the sensor nodes can send data to the cluster-heads based on a TDMA approach. During the steady phase, the sensor nodes can begin sensing and transmitting data to the cluster heads. The cluster-heads also aggregate data from the nodes in their cluster before sending these data to the base station. In SEP is a two-level heterogeneity based protocol in which the probability of an advanced nodes is higher than normal nodes. However in SEP, it is assumed that the energy of nodes is not properly utilized and it needs further improvement which overcomes by DEEC protocol. DEEC protocol is a heterogeneity based protocol that chooses the cluster heads on the basis of residual energy of the network. EDEEC is a variant of DEEC, it work on 3-level heterogeneity based wireless networks in which there are three type of sensor nodes named as normal nodes, advanced nodes and super node, which still have scope of improvement because if the levels of heterogeneous wireless sensor networks are to be increased then more complexity will be there in the network and then a more stable behaviour of network is required. This work aims to propose the implementation of EDEEC protocol for 4-level heterogeneous wireless sensor networks in which there are four types of nodes named as normal, advanced, super and ultra-super nodes to show that performance of the network can enhanced if the level of heterogeneity in the network increased because in real world there can exist more than three types of nodes in the network.

IV. RADIO ENERGY DISSIPATION MODEL

We have assumed the same radio model which has been used in earlier works. For the radio hardware, the transmitter dissipates energy to run the transmitter radio electronics and power amplifier, and receiver dissipates energy to run the transmitter radio electronics as shown Figure 2. For the scenarios described in the project work, both the free space (d2 power loss), and multipath fading (d4 power loss) channel model were used depending on the distance between the transmitter and receiver, if distance is less than a threshold, the free space model is used; otherwise, the multi path model is used.

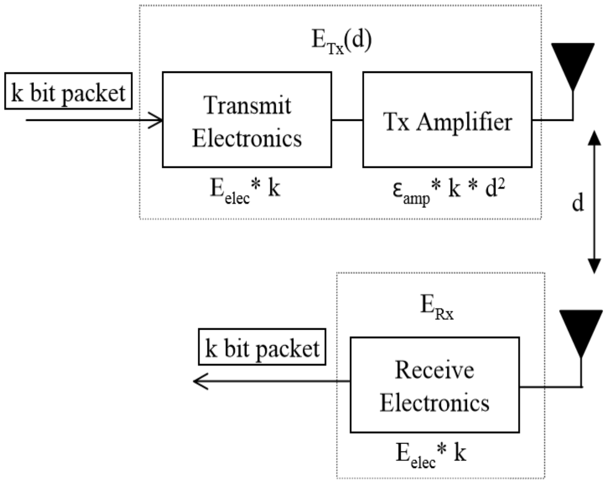

Figure.2. Energy Dissipation Model

V. HETEROGENEOUS WIRELESS SENSOR NETWORKS

As we know basically there are two types of wireless sensor networks known as homogeneous and heterogeneous wireless sensor networks. Homogeneous network is the type of network in which the nodes are equipped with the same amount of communication, sensing and processing capabilities. While in Heterogeneous network, nodes are equipped with variable sensing, communication and processing capabilities. Heterogeneous WSNs contain two, three or multi types of nodes with respect to their energy levels and are termed as two, three and multi-level heterogeneous WSNs respectively.

A. Two -Level Heterogeneous WSN

Two level heterogeneous WSNs contain two energy levels of nodes: normal and advanced nodes. Where, E_o is the initial energy of normal node and $E_o(1+a)$ is the initial energy of advanced nodes containing a times more energy as compared to normal nodes. Let N be the total number of nodes and m be the fraction of advanced nodes then the total number of advanced and normal nodes are:

$$N_{adv} = N.m \quad (1)$$

$$N_{nrm} = N.(1-m) \quad (2)$$

The initial energy associated with total number of advanced and normal nodes is given as:

$$E_{adv} = N.m.(1+a).E_o \quad (3)$$

$$E_{nrm} = N.(1-m).E_o \tag{4}$$

The total initial energy of the network is the sum of energies of normal and advanced nodes:

$$E_{total} = N.(1-m).E_o + m.N.(1+a).E_o$$

$$= N.E_o.(1-m+m+am)$$

$$= N.E_o.(1+am) \tag{5}$$

The two level heterogeneous WSNs contain am times more energy as compared to homogeneous WSNs.

B. *Three-Level Heterogeneous WSN*

Three level heterogeneous WSNs contain three different energy levels of nodes i.e. normal, advanced and super nodes. Normal nodes contain initial energy of E_o, the advanced nodes of fraction m are having a times extra energy than normal nodes equal to $E_o(1+a)$ whereas, super nodes of fraction m_o are having a factor of b times more energy than normal nodes so their energy is equal to $E_o(1+b)$. Let N be the total number of nodes and m be the fraction of advanced and super nodes. Further that fraction m has m_o been the fraction of super nodes then the total number of advanced and normal nodes is:

$$N_{nrm} = N.(1-m) \tag{6}$$

$$N_{adv} = N.m.(1-m_o) \tag{7}$$

$$N_{sup} = N.m.m_o \tag{8}$$

The initial energy associated with total number of advanced and normal nodes is given as:

$$E_{adv} = N.m.(1-m_o).(1+a).E_o \tag{9}$$

$$E_{nrm} = N.(1-m).E_o \tag{10}$$

$$E_{sup} = N.m.m_o.(1+b).E_o \tag{11}$$

The total initial energy of three level heterogeneous WSN is therefore given by:

$$E_{total} = N.(1-m).E_o + m.N.(1-m_o).(1+a).E_o + m.N.m_o.(1+b).E_o$$

$$= N.E_o.(1+m.(a+m_o.b)) \tag{12}$$

The three level heterogeneous WSNs contain $(a+m_o b)$ times more energy as compared to homogeneous WSNs.

C. *Four-Level Heterogeneous WSN*

Four level heterogeneous WSNs contain four different energy levels of nodes i.e. normal, advanced and super and ultra-super nodes. Normal nodes contain initial energy of E_o, the advanced nodes of fraction m are having a times extra energy than normal nodes equal to $E_o(1+a)$ whereas, super nodes of fraction m_o are having a factor of b times more energy than normal nodes so their energy is equal to $E_o(1+b)$ and ultra-super nodes of fraction m_1 are having a factor of c times more energy than normal nodes so their energy is equal to $E_o(1+c)$. Let N be the total number of nodes and m be the fraction of advanced, super nodes and ultra-super nodes. Further that fraction $m1$ has m_o been the fraction of ultra-super nodes and super nodes then the total number of advanced and normal nodes is:

$$N_{nrm} = N.(1-m) \tag{13}$$

$$N_{adv} = N.m.(1-m_o) \tag{14}$$

$$N_{sup} = N.m.(1-m_o)(1-m_1)$$

$$N_{ultra} = N.m.m_o m_1 \tag{15}$$

The initial energy associated with total number of advanced and normal nodes is given as:

$$E_{adv} = N.m.(1-m_o).(1+a).E_o \tag{16}$$

$$E_{nrm} = N.(1-m).E_o$$

$$E_{sup} = N.m.(1-m_o)(1-m_1)(1+b).E_o \tag{17}$$

$$E_{ultra} = N.m.m_o.m_1(1+c).E_o \tag{18}$$

The total initial energy of three level heterogeneous WSN is therefore given by:

$$E_{total} = N.(1-m).E_o + m.N.(1-m_o).(1+a).E_o + N.m.(1-m_o)(1-m_1)(1+b).E_o + N.m.m_o.m_1(1+c).E_o \tag{19}$$

D. *Multi-level Heterogeneous WSN*

Multi-level heterogeneous WSN is a network that contains nodes of multiple energy levels. Most of the recent researches have been made considering the WSN model to be two level or three level heterogeneous WSN. CH nodes consume more energy as compared to member nodes so after some rounds energy level of all the nodes becomes different as compared to each other. Therefore, heterogeneity is introduced in homogeneous WSNs and the networks that contain heterogeneity are more important than homogeneous networks.

VI. PREPARE YOUR PAPER BEFORE STYLING

The heterogeneous WSN is provided with different energy levels. Some nodes have more energy than the normal nodes at the time of initialization. Some assumptions have been made for the network as well as sensor nodes in the network as well as sensor network model described above. Those assumptions are:

- Sensor nodes are uniformly distributed and randomly placed in the wireless sensor network.
- At the centre of sensing field, there is a base station also called a sink which is placed in the centre of the field.
- Sensor nodes are always provided with data to transmit to sink.
- Sensor nodes are not aware of each other's locations.
- All nodes have similar processing and communication capabilities and of equal significance.
- All the nodes are considered to be either fixed or micro-mobile, so their energy loss due to collision and interference between signals of different nodes are ignored.

VII. METHODOLOGY

EDEEC with 4-level of heterogeneous nodes (proposed protocol) is implemented same way as that of EDEEC, but it improves simply by increasing the level of heterogeneity in the network. Below are the steps which are involved in implementing EDEEC with 4-level of heterogeneous nodes:

a. **Create Network:** Consider a network of 100*100 meters and 100 nodes randomly deployed on it and a sink node is located at the centre of the field.
b. **Add Heterogeneity of the Nodes:** Based of the fractional division calculate the number of normal, advanced, super and advanced nodes. For this thesis work, the fraction parameters m, mo and m1 are considered to be 0.8, 0.5 and 0.4 respectively. Therefore, number of normal, advanced, super and ultra-super nodes are 20, 40, 24 and 16 respectively by calculating using equations 13,14 and 15
c. **Energy initialization:** Initialize the energy to each type of nodes using equation 16, 17 and 18 for normal, advanced, super and ultra-super nodes. For this scenario, the initial energy appears to be 0.5, 1.25, 1.5 and 2.5 Joules for each normal, advanced, super and ultra-super node. Thus the total energy of the network is 124 Joules.
d. **Cluster Head Selection:** The cluster head selection is performed on the basis of residual energy of each node and average network energy using cluster head selection algorithm. This algorithm will be executed for 10000 rounds so as to evaluate the network stability.

VIII.PARAMETERS USED FOR PERFORMANCE EVALUATION

To study and evaluating the clustering protocols, various performance metrics are used such as stability period, number of alive nodes, throughput, energy dissipation and number of data packets received at base station and cluster head.

Stability Period: The time interval of network from the start of network operation until the death of the first sensor node.

Instability Period: The time interval from the death of the first node until the death of the last sensor node.

Number of alive nodes: This instantaneous measure reflects the total number of nodes and that of each type that has not yet expended all of their energy.

Data Packets Received at Base Station: The total number of messages or data packets that sink receives.

Data Packets Received at Cluster Head: The total number of messages or data packets that cluster head receives from other cluster members.

Table 1. Simulation Parameters

Parameters	Value
Network area	100*100
Number of nodes	100
Location of Sink	50,50
Initial Energy	0.5J
E_{TX}	50nJ
E_{RX}	50nJ
E_{amp}	0.0013Pj/bit/m^2
Efs	10pJ/bit/m^2
E_{DA}	5nJ/bit/signal
Message Size	4000Bits
d_o	70m
p_{opt}	0.1
E_{total}	124J
E_{nrm} (per node)	0.5J
E_{adv} (per node)	1.25J
E_{sup} (per node)	1.5J
E_{ultra} (per node)	1.75J
Number of rounds	10000

Radio parameters used in heterogeneous WSN are mentioned in Table 1.

IX. SIMULATION AND RESULTS

This section includes the implementation of EDEEC for 3-level and 4-level heterogeneous wireless sensor network. In this work the behaviour of EDEEC which is a three-level protocol which has three type of nodes such as normal, advanced and super nodes, is compared with the behaviour of EDEEC which is a four-level heterogeneous protocol (proposed work), which has four types of nodes such as normal, advanced, super nodes and ultra-super nodes.

For the simulation, a network is created of N=100 nodes which are randomly deployed in a field of dimension 100m* 100m with a centrally located sink. These nodes are divided into four types based on their energy. Based on the equation 13, 14 and 15 using the fraction of advanced nodes (m) be 0.8, super nodes (m_o) be 0.5 and ultra-super (m_1) be 0.4, the number of normal, advance, super and ultra-super nodes come out to be 20, 40, 24 and 16 respectively.

Normal nodes contain initial energy of E_o, the advanced nodes of fraction m are having a times extra energy than normal nodes equal to E_o (1+a) whereas, super nodes of fraction m_o are having a factor of b times more energy than normal nodes so their energy is equal to E_o (1+b) and ultra-super nodes of fraction m_1 are having a factor of c times more energy than normal nodes so their energy is equal to E_o (1+c).

The time interval of the network until the death of the first node is called stability period. Figure 3 depicts the number of dead nodes during each round. The first node for

EDEEC and EDEEC for four-level heterogeneous wireless sensor network dies in 941 and 1401 respectively. At this stage the number of nodes alive in EDEEC for four-level heterogeneous nodes is quite larger than EDEEC.

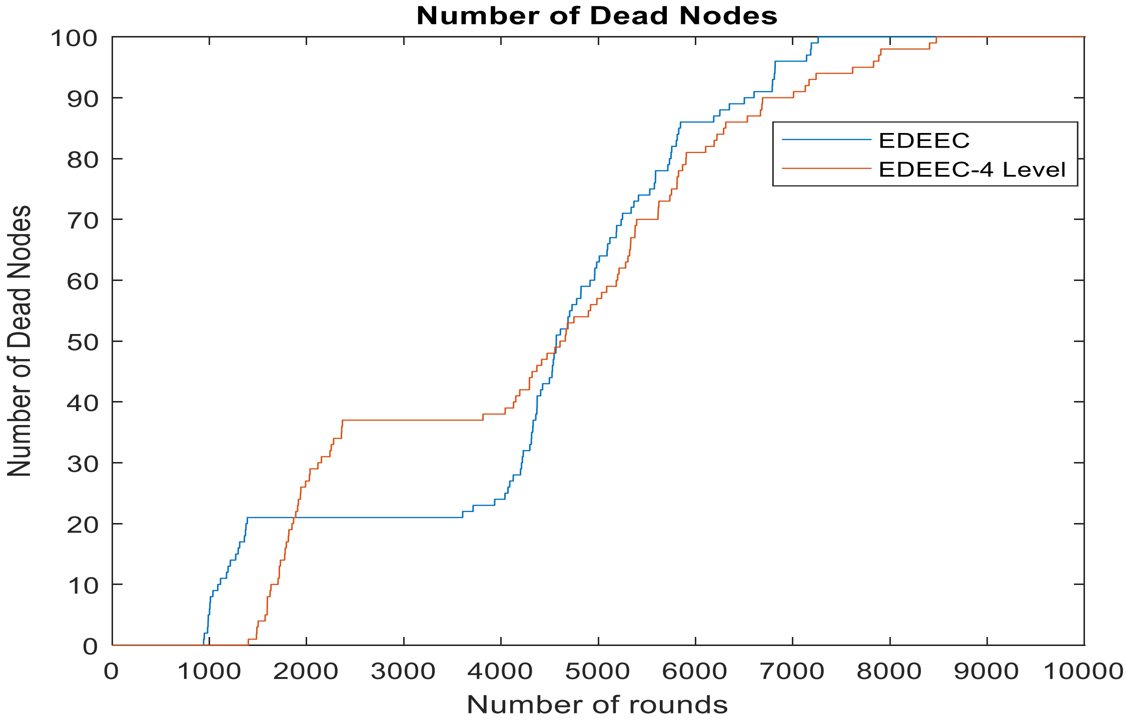

Figure.3. Performance Comparison for Stability Period

As the nodes communicate with cluster heads and sink, some of the energy associated with those particular nodes utilized. After some number of nodes, as the nodes lose their energy, nodes start to die out. The measure of total number of all types of nodes that have not yet dissipated all of their energy is termed as number of nodes alive.

The Figure 4 depicts the number of alive nodes during each round.

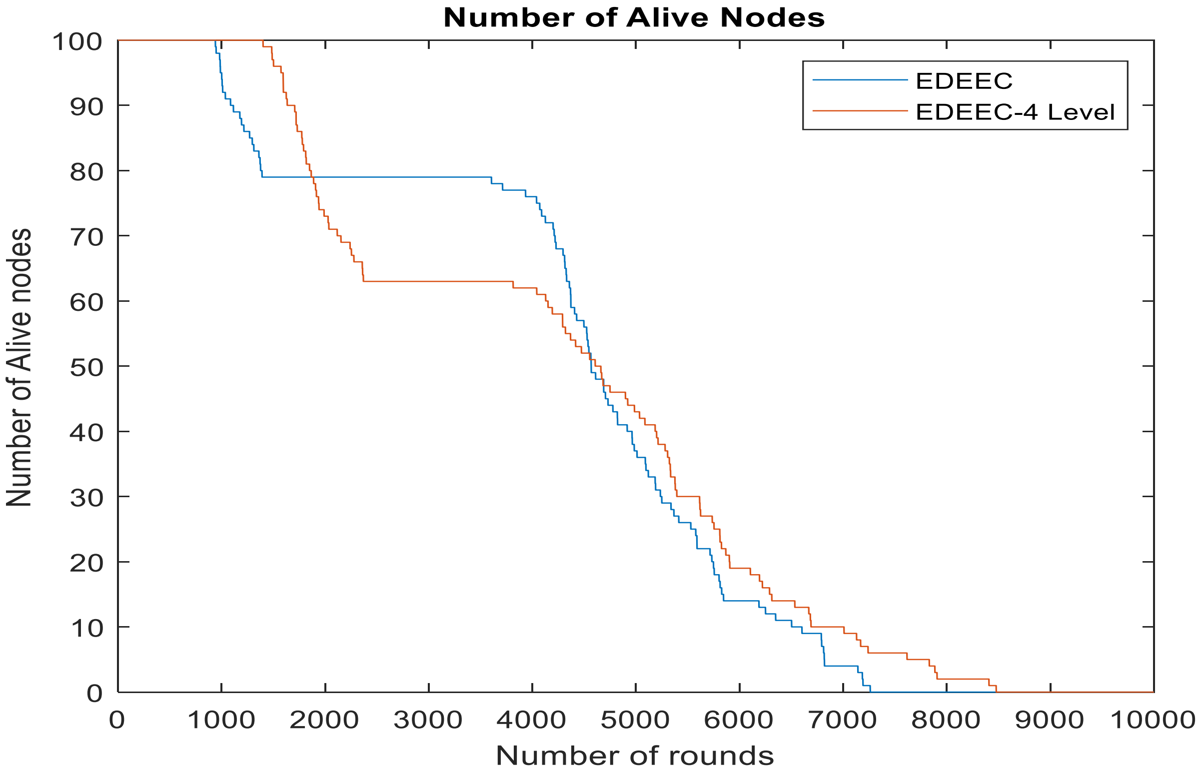

Figure.4. Performance Comparison for Number of Alive Nodes

All the nodes are alive till round number 940 and 1400 for EDEEC for four-level heterogeneous nodes respectively. Figure 5 depicts the total number of the number of packets transmitted in a particular round. The number of packets transmitted to base-station (sink) in EDEEC and EDEEC for four-level heterogeneous wireless sensor network is 393738 and 423115 respectively.

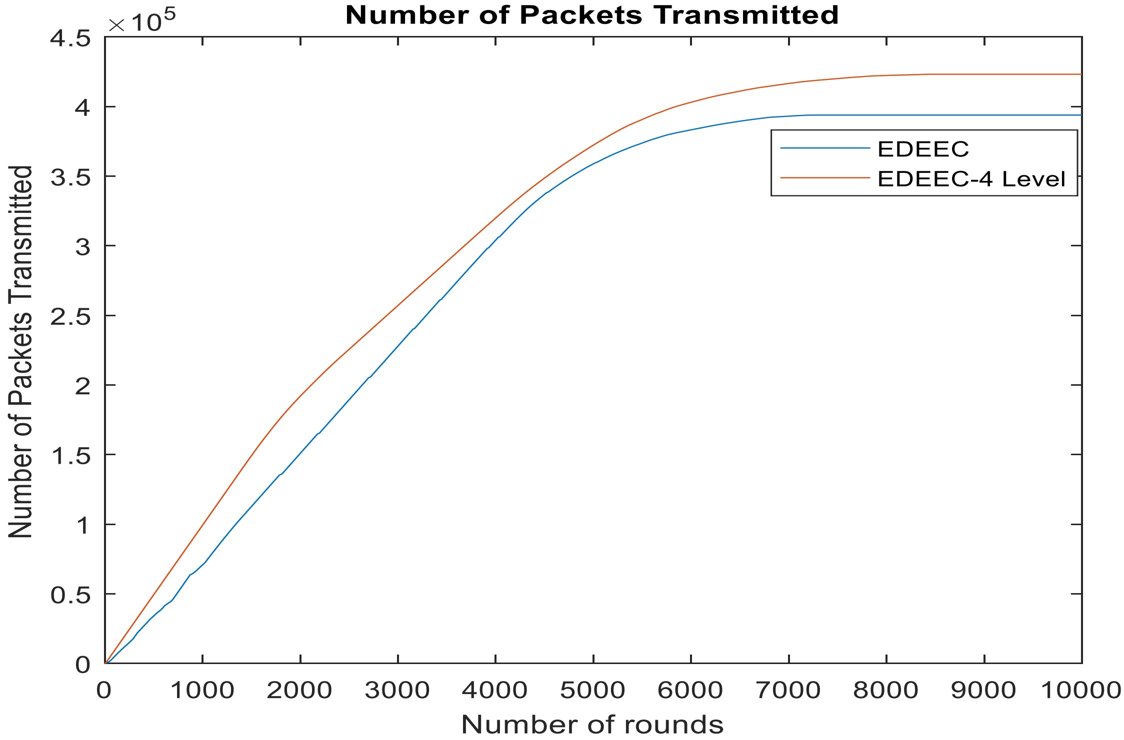

Figure.5. Performance Comparison for Number of Packets transmitted

X. CONCLUSION

The main conclusion of presenting this paper is that the life time and stability of the Wireless Sensor Network can be improved by increasing the heterogeneity of nodes in the network by using clustering algorithms.

During the implementation of the EDEEC for 3-Level and 4-Level heterogeneous wireless sensor networks, it is observed that the WSN using EDEEC protocol for 4types of nodes consumes the 3.33% more energy than the EDEEC protocol for 3 types of nodes but it is clearly shown that the minimal increase in the energy consumption, increase the stability of network using 4-Level heterogeneity by 48% than 4-Level heterogeneous network. Thus to improve the life-time of the network can enhanced if the level of heterogeneity in the network increased because in real world there can exist more than three or four types of nodes in the network.

REFERENCES

[1] S. Tamilarasan, P.K. Sharma, "*A Survey on Dynamic Resource* G. Anastasi, M. Conti, "*Energy conservation in wireless sensor networks: A survey*", Elsevier, Vol.**7,** No.**3**, pp.**537-568**, **2009**.

[2] J. Yick, B. Mukherjee, and D. Ghosal, *"Wireless sensor network survey,"* Comput. Networks, vol. **52**, no. 12, pp. **2292–2330, 2008.**

[3] K. Akkaya and M. Younis, *"A survey on routing protocols for wireless sensor networks"*, Ad Hoc Networks, vol. **3**, no. 3, pp. **325–349, 2005.**

[4] W.B. Heinzelman, A.P. Chandrakasan, and H. Balakrishnan, "*An application-specific protocol architecture for wireless microsensor networks*", IEEE Trans. Wirel. Commun., Vol.1, Issue.4, pp.**660–670, 2002**

[5] G. Smaragdakis, I. Matta and A. Bestavros, *"SEP: A stable election protocol for clustered heterogeneous wireless sensor networks"*, Second Int. Work. Sens. Actor Netw. Protoc. Appl. (SANPA 2004), pp.**1–11, 2004.**

[6] L. Qing, Q. Zhu, and M. Wang, "*Design of a distributed energy-efficient clustering algorithm for heterogeneous wireless sensor networks*", Comput. Commun., Vol.**29**, Issue.**12**, pp.**2230–2237, 2006.**

[7] B. Elbhiri, S. Rachid, S. Fkihi, and D. Aboutajdine, "*Developed Distributed Energy-Efficient Clustering (DDEEC) for heterogeneous wireless sensor networks*", 2010 5th Int. Symp. I/V Commun. Mob. Networks, ISIVC 2010, pp.**1–4, 2010.**

[8] P. Saini and A. K. Sharma, "*E-DEEC - Enhanced distributed energy efficient clustering scheme for heterogeneous WSN*", 2010 1st Int. Conf. Parallel, Distrib. Grid Comput. PDGC - 2010, pp.**205–210, 2010.**

[9] J. Yick, B. Mukherjee, and D. Ghosal, "*Wireless sensor network survey*", Computer Networks, Vo**l.52**, Issue.**12**, pp.**2292–2330, 2008.**

[10] J. Yan, M. Zhou, and Z. Ding, "*Recent Advances in Energy-Efficient Routing Protocols for Wireless Sensor Networks*", Middle-East J. Sci. Res., Vol.**4**, pp.**5673–5686, 2016.**

AUTHORS PROFILE

Harjit Kaur received Bachelors in Computer Science and Engineering (2016) from Guru Nanak Dev Engineering College, Ludhiana in India. She is currently a Masters in Computer Science and Engineering candidate in the Department of Computer Science at Baba Banda Singh Bahadur Engineering College, Fatehgarh Sahib, India. Her current research interests include energy conservation, clustering, and network stability in wireless sensor networks.

Sukhwinder Sharma received Masters in Computer Engineering (2011) from Punjabi University, Patiala and Bachelors in Information Technology (2005) with honors from Kurukshetra University, Kurukshetra in India. He is currently a PhD research scholar in Computer Engineering at Punjab Technical University, Jalandhar, India. He is also an Assistant Professor at Baba Banda Singh Bahadur Engineering College, Fatehgarh Sahib, India. He is teaching UG and PG computer engineering students from the last over 12-years. His current areas of interest are wireless sensor networks and computer networks. He has contributed more than 15 research papers in various international journals. He is available at sukhwinder.sharma@bbsbec.ac.in

.

