International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-6, Issue-6, June 2018 E-ISSN: 2347-2693

# iEDDEEC: Improved Enhanced Developed Distributed Energy Efficient Clustering Protocol for Heterogeneous Wireless Sensor Networks

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

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

**Corresponding author: gurwinderrajarh95@gmail.com*

**Available online at: www.ijcseonline.org**

Accepted: 03/Jun/2018, Published: 30/Jun/2018

***Abstract—*** Wireless sensor networks have large number of sensor nodes, which sense and transmit data to the sink. Network lifetime is one of the key challenge for these networks due to limited capacity batteries of sensor nodes. Clustering techniques, being the prominent way to prolong network lifetime through data aggregation, are taken up in this work. DEEC and its variants improve network performance up to certain extent, still have scope for further improvement. EDDEEC, being the recent variant of DEEC, dynamically adjusts the CHs selection probability and selects the suitable CHs. Stability period, duration for which all network nodes are alive, is a more concrete performance parameter than network lifetime for reliable communication over the network. In this paper, an improved dynamic clustering technique, improved Enhanced Developed Distributed Energy Efficient Clustering protocol, is proposed and evaluated for various performance parameters. The results are analyzed and compared with relevant protocols, EDEEC and EDDEEC. Proposed technique iEDDEEC dynamically elects cluster-heads based on selection probability and threshold value of different nodes. The probability of a node to become cluster-head is decided with the ratio between residual energy of each node and average energy of the network, while threshold depends upon the current network state. Simulation results shows that iEDDEEC protocol extends the stability period of underlying network with improved throughput and energy dissipation.

***Keywords—*** Clustering; Energy; heterogeneous; stability period; wireless sensor networks.

## I. Introduction

Wireless Sensor Network consists of spatially distributed autonomous devices using sensors where all nodes sense data and send it to base station which is usually called sink. Due to huge range of applications like military, critical infrastructure protection, healthcare, etc. recent scientific developments have been done on wireless sensing element network [1]. Many applications require energy efficient networks as exchange or restoration of batteries of deployed nodes is not realistic. Routing protocols are useful to achieve energy efficiency in WSNs by using clustering.s

Many of the protocols have been proposed since many years that prolongs the lifetime of the network. This paper proposed and implemented an energy efficient clustering protocol for heterogeneous WSN that extends the stability period, as it is more concrete parameter than network lifetime, with improved energy dissipation and throughput.

Rest of the paper is organized as follows, section I contains the introduction of WSN with its applications, importance of energy conservation to prolong network lifetime in WSN and motivation for proposed protocol, section II explains the energy consumption in various phases of WSN and most energy consumed phase comes out to be communication phase, section III contain the related work of energy efficient protocols that has need for clustering in heterogeneous WSN and some protocols developed for it, section IV contain the motivation of proposing iEDDEEC protocol, section V explains the radio energy dissipation model that how the energy is consumed in sending and receiving the data packet , section VI explains the heterogeneous WSN model and introduced to the various levels in corresponding models, section VII contains the assumptions and properties of the network that are considered while doing simulation, section VIII explains the cluster-head selection algorithm, section IX explains the performance criteria used in simulation, section X describes results and discussion, section XI concludes research work.

## II. Energy Consumption in WSN

The lifetime of WSNs is influenced by energy consumption of sensor nodes in the network. Energy consumption of a typical sensor node during communication is higher than sensing and processing operations (Fig.1) [2].

 

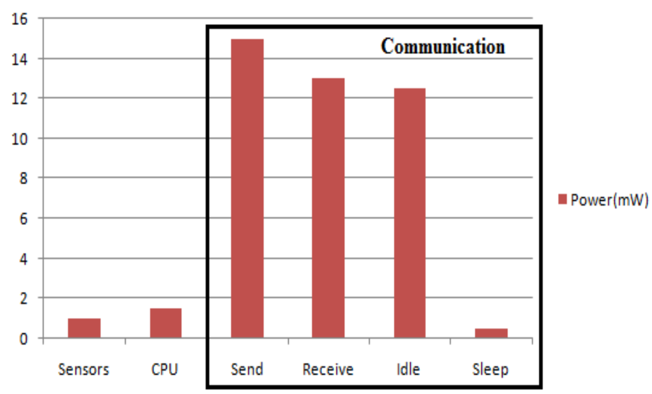


Figure 1. Energy Consumption of a Sensor Node [2]

The wireless communication module has four states: send, receive, idle and sleep. Amongst these four, send and receive i.e. transmitting signals takes two third of the total energy consumption by communication module. But the number of data packet transmission depends on the routing strategy. Therefore, to balance the energy consumption levels among WSN nodes, an efficient routing protocol should be used. This can improve the quality of data transmission along with the network lifetime [2].

As the energy consumption is minimal at sleep and idle states, researchers often consider the energy consumption of sending and receiving states only. In order to minimize energy consumption, clustering is used where group of nodes in a cluster select a cluster-head and send data to cluster-head. Cluster-head further send the data to base station by aggregating the data from various nodes [3].

## III. Related Work

Two kinds of clustering schemes are there. First is homogeneous scheme in which the clustering algorithm is applicable on homogeneous networks and other is heterogeneous scheme in which clustering algorithm is applicable on heterogeneous networks. Due to complicated energy configure and network operation, it becomes difficult to devise an energy-efficient heterogeneous clustering scheme.

Heinzelman, *et al.* [4] introduced clustering-based protocol, known as LEACH, for homogeneous WSNs to minimize the energy dissipation in sensor networks by randomly selecting the sensor nodes as cluster-heads. Among the two phases of LEACH, one is setup phase in which cluster-heads assign the time at which, the sensor nodes can send data to the cluster-heads based on a TDMA approach. The other phase is steady phase in which the sensor nodes can begin sensing and transmitting data to the cluster-heads. Also the cluster-heads aggregate data from the nodes in their cluster before sending these data to the base station.

To overcome the limitation of LEACH, G. Smaragdakis, *et al.* [5] proposed a protocol for two-level heterogeneous WSNs, in which nodes are categorized based on the initial energy. At beginning, the advanced nodes has more energy than normal nodes. SEP prolongs the stability period, which is defined as the time interval before the death of the first node.

As SEP is not fit for the widely used multi-level heterogeneous WSNs, L .Qing, *et al.* [6] proposed a protocol DEEC which is also fit for the multilevel heterogeneous networks and performs well. Based on the residual energy of each node and average energy of network, it selects the cluster-heads.

Further DEEC starts to penalize advanced nodes even when residual energy of advanced nodes comes under the range of normal nodes after depletion. B. Elbhiri, *et al.* [7] proposed a protocol, DDEEC, which balance residual energy for CH selection over the entire network. So, when their energy decreases, advanced 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, categorized as normal, advanced, and super nodes.

EDEEC protocol provides network stability, energy consumption and improved network lifetime in three level heterogeneous WSN. But with better use of resources, N. Javaid, *et al.* [9] proposed a routing technique which is based on changing the Cluster-head (CH) dynamically. EDDEEC shields the super and advance nodes from being over depletion. EDDEEC succeeds extensive stability period, system lifetime, and throughput than the other traditional clustering algorithms in heterogeneous environments.

## IV. Motivation

Many routing protocols such as DEEC, EDEEC and EDDEEC etc. have been proposed for WSN to prolong the network lifetime through efficient utilization of available energy. In SEP, clusters are formed in each round and new cluster heads are selected in every round. The probability is higher for advanced nodes to become cluster head than normal nodes. However, in SEP, it is assumed that the energy of advanced nodes has not been utilized effectively and there exist a scope of further improvement which is overcome by DEEC. In DEEC, CHs selection probability for advanced nodes is higher than that of the normal ones, and in EDEEC, CHs selection probability for super and advanced nodes is higher than that of the normal nodes. DEEC continues to punish just advanced nodes, and EDEEC continues to punish super and advanced nodes even when these have the same energy level as the normal nodes. Thus, in EDEEC, both super and advanced nodes lose their energy more quickly as compared to the normal ones. This is not the optimal way for energy distribution throughout the network. Therefore, EDDEEC suggested some changes in the probability function for the selection of CHs which improves stability period and network lifetime. Still there is a scope to further prolong the effective lifetime of heterogeneous WSNs through better CH selection as compared to EDDEEC. This thesis work aims to propose and implement improved Enhanced Developed Distributed Energy-Efficient Clustering (iEDDEEC) protocol for heterogeneous WSNs to extend the stability period through efficient clustering.

## V. Radio Energy Dissipation Model

Radio Energy Model used is similar energy model and analysis as proposed in [4].

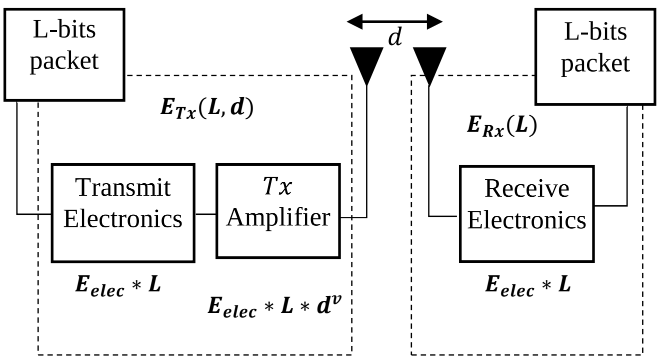


Figure 2. Radio Energy Dissipation Model [4].

The figure 2 depicts the energy model for radio hardware energy dissipation where radio electronics are made to run by the energy dissipated by receiver and both radio electronics and power amplifier are made to run by energy dissipated by transmitter.

Depending on the distance between transmitter and receiver, two channel models are used. Those are free for $d^2$ power loss and multipath fading for $d^4$ power loss. Power amplifier is used to invert this loss by power control. Free space model is used when distance is less than threshold $d_o$otherwise, multipath model is used [10]. Thus, the energy expended by the radio to achieve an acceptable Signal-to-Noise Ratio (SNR) in transmitting $L-bit$ message over a distance $d$, is given by:

$$E_{Tx}(L,d) = \begin{cases} L.E_{elec} + L.E_{fs}.d^2 \;\; if\ d < d_o \\ L.E_{elec} + L.E_{amp}.d^4 \;\; if\ d \geq d_o \end{cases} \quad (1)$$

Where, $E_{elec}$ is the energy dissipated per bit to run the transmitter $E_{Tx}$ or the receiver circuit $E_{Rx}$ [4].The $E_{elec}$ depends on many factors such as the digital coding, the modulation, the filtering, and the spreading of the signal. Also, $E_{fs}$ and $E_{amp}$ depend on the transmitter amplifier model used, and $d$ is the distance between the sender and the receiver. The value of threshold distance do is given by

$$d_o = \frac{E_{fs}}{E_{amp}} \quad (2)$$

Total energy dissipated in the network during a round is given as

$$E_{round} = L\left(2NE_{elec} + NE_{DA} + k \in_{mp} d_{toBS}^4 + N \in_{fs} d_{toCH}^2\right) \quad (3)$$

Where, $K$= number of clusters
$E_{DA}$= Data aggregation cost expended in CH $d_{toBS}$= Average distance between the CH and BS
$d_{toCH}$= Average distance between the cluster members and the CH

$$d_{toCH} = \frac{M}{\sqrt{2\pi k}}, d_{toBS} = 0.765\frac{M}{2} \quad (4)$$

$$k_{opt} = \frac{\sqrt{N}}{\sqrt{2\pi k}}\sqrt{\frac{E_{fs}}{E_{amp}}}\frac{M}{d_{toBS}^2} \quad (5)$$

## VI. Heterogeneous WSN Model

With respect to their energy levels, heterogeneous WSNs include two, three or multi types of nodes and are known as two, three and multilevel heterogeneous WSNs respectively.

### *A. Two Level Heterogeneous WSN*

There are two energy levels of nodes in two level heterogeneous WSNs termed as normal and advanced nodes. The normal node is associated with energy level $E_o$ and advanced nodes containing $a$ times more energy as compared to normal nodes which is $E_o(1 + a)$. For total number of nodes to be $N$, there are $N.m$ number of advanced nodes where $m$ refers to the fraction of advanced nodes and $N(1 - m)$ is the number of normal nodes. The sum of energies of normal and advanced nodes gives the total initial energy of the network.

$$N_{adv} = N.m \quad (6)$$

$$N_{nrm} = N.(1-m) \quad (7)$$

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

$$E_{adv} = N.m.(1+a).E_o \quad (8)$$

$$E_{nrm} = N.(1-m).E_o \quad (9)$$

The total initial energy of the two level heterogeneous WSN is the sum of energies of normal and advanced nodes:

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

$$= N.E_o.(1 - m + m + am)$$
$$= N.E_o.(1 + am) \quad (10)$$

The two level heterogeneous WSNs contain $am$ times more energy as compared to homogeneous WSNs [6].

*B. Three Level Heterogeneous WSN*

Three different energy levels of nodes are contained in three level heterogeneous WSNs called as normal, advanced and super nodes. Normal nodes are associated with energy of $E_o$, advanced nodes of fraction $m$ are having a factor of $a$ times more energy than normal nodes so their energy is equal to $E_o(1 + a)$ whereas, the super nodes of fraction $m_o$ are having $b$ times extra energy than normal nodes equal to $E_o(1 + b)$. [11]. The total number of normal, advanced and super nodes in network are therefore given by:

$$N_{nrm} = N.(1 - m) \quad (11)$$
$$N_{adv} = N.m.(1 - m_o) \quad (12)$$
$$N_{sup} = N.m.m_o \quad (13)$$

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

$$E_{adv} = N.m.(1 - m_o).(1 + a).E_o \quad (14)$$
$$E_{nrm} = N.(1 - m).E_o \quad (15)$$
$$E_{sup} = N.m.m_o.(1 + b).E_o \quad (16)$$

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

$$E_{total} = N.E_o.(1 + m.(a + m_o.b)) \quad (17)$$

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

*C. Multilevel Heterogeneous WSN Model*

Nodes of multiple energy levels are contained in multilevel heterogeneous WSN. The initial energy of nodes in multilevel heterogeneous WSN is distributed over the close set $[E_o, E_o(1 + a_{max})]$, where the value of maximal energy is $a_{max}$ and lower bound is $E_o$. Initially, node $S_i$ is associated with initial energy of $E_o(1 + a_i)$, which is $a_i$ times more energy than the lower bound $E_o$. The total initial energy of multi-level heterogeneous networks is given by:

$$E_{total} = \sum_{i=1}^{N} E_o(1 + a_i)$$
$$= E_o\left(N + \sum_{i=1}^{N} a_i\right) \quad (18)$$

After some rounds energy level of all the nodes becomes different from each other because CH nodes consume more energy as compared to member nodes. Therefore, heterogeneity is introduced in homogeneous WSNs and the networks that contain heterogeneity are more important than homogeneous networks [6].

## VII. Assumptions and Properties of the Network

Some assumptions have been made for the network as well as sensor nodes in the network model described above. Those assumptions are

- Sensor nodes are uniformly distributed and randomly deployed in WSN.
- At the centre of sensing field, there is a base station also called as sink.
- Nodes are always provided with data to transmit to sink.
- Nodes are not aware about 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.

The WSN is heterogeneous in nature i.e. provided with different energy levels. Some nodes have more energy than the normal nodes at the time of initialization.

## VIII. Cluster-head Selection Method

This section describes the detailed steps of proposed iEDDEEC protocol.

- Compute total no. of alive nodes
- Calculate optimal probability $(p_{opt})$ of node to become CH.

$$p_{opt} = \frac{1}{k_{opt}} \quad (19)$$

- Determine the initial energy $E_i$ and residual energy $E_r$ of every alive node.
- If total rounds of system lifetime be $R$ then, it can be calculated as

$$R = \frac{E_{total}}{E_{round}} \quad (20)$$

Where, $E_{total}$ is total power of the system and $E_{round}$ is energy expenditure throughout each round.

 

- Compute average energy of network by the side of current round

$$\bar{E}(r) = \frac{1}{N} E_{total}\left(1 - \frac{r}{R}\right) \quad (21)$$

- On the basis of threshold, nodes will decide whether to become cluster-heads or not. The threshold will be calculated as

$$temp = \frac{p_i}{1 - p_i.\left(1 - r \bmod \frac{1}{p_i}\right)} * \frac{E_r(r) * k_{opt}}{\bar{E}(r)}$$

$$T(s_i) = \begin{cases} temp, & if\ s_i \in G < 0 \\ 0, & otherwise \end{cases} \quad (22)$$

Where $r$ represents the round number and $G$ is the set of nodes that are eligible to become cluster-heads for that round having $p$ as the desired probability.

As there are more than two levels of heterogeneity in real scenarios. Therefore, three-level heterogeneity concept is being used, having nodes characterized as: normal, advanced and super. Their probabilities are described as

$$p_i = \begin{cases} \frac{p_{opt}\ .E_i(r)}{\left(1+m(a+m_o b)\right)\bar{E}(r)}, \\ for\ N_{ml}\ if(E_i(r) > T_{absolute}) \\ \frac{p_{opt}\ .(1+a).E_i(r)}{\left(1+m(a+m_o b)\right)\bar{E}(r)}, \\ for\ Adv\ if(E_i(r) > T_{absolute}) \\ \frac{p_{opt}\ .(1+b).E_i(r)}{\left(1+m(a+m_o b)\right)\bar{E}(r)}, \\ for\ Sup\ if(E_i(r) > T_{absolute}) \\ c\frac{p_{opt}\ .(1+b).E_i(r)}{\left(1+m(a+m_o b)\right)\bar{E}(r)}, \\ for\ N_{ml}, Adv, Sup\ \ if(E_i(r) \le T_{absolute}) \end{cases} \quad (23)$$

The probability is based on the absolute residual energy level $T_{absolute}$, which specifies that under $T_{absolute}$, all normal, advanced, and super nodes have the same probability for CH selection. The absolute residual energy level $T_{absolute}$ can be calculated as

$$T_{absolute} = zE_o \quad (24)$$

Where $z$ ranges as $z(0,1)$. $z = 0$ Indicates EDEEC and through various rounds of simulation using random topologies, EDDEEC gives a nearest value of $z$ to be $z = 0.7$. Thus $T_{absolute}$ comes out to be $T_{absolute} = (0.7)E_o$. Also the probability function in Eq. 23 has a variable $c$ which control the clusters in number. For $c$ to be higher means that there are more cluster-heads transmitting to sink. For $c = 0$, there is no cluster-head which means that all the nodes transmit directly to sink. For the better network performance, the value needs to be accurate. Therefore EDDEEC gave the best possible solution to be $c = 0.025$ to enhance network efficiency.

## IX. Performance Criteria Used

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

- Data Packets received at base station: The total number of messages or data packets that sink receives are termed as data packets received at base station.
- Data Packets received at cluster-head: The total number of messages or data packets that cluster-head receives from other cluster members are termed as data packets received at cluster-head.
- Throughput: The sum of data packets received at BS and at CH is termed as throughput.
- Number of alive nodes: The measure of total number of all type of nodes that has not yet dissipated all of their energy are the alive nodes.
- Stability Period: The time interval of the network until the death of first node.
- Energy Dissipation: The energy consumed in the network, measured at each transmission round.

Table 1. Simulation Parameters

| Parameters | Value |
|---|---|
| Network Field | (100,100) |
| Number of Nodes | 100 |
| $E_o$(Initial energy of normal nodes) | 0.5 J |
| Message Size | 4000 Bits |
| $E_{elec}$ | 50nJ/bit |
| $E_{fs}$ | 10nJ/bit/m$^2$ |
| $E_{amp}$ | 0.0013pJ/bit/m$^4$ |
| $E_{DA}$ | 5nJ/bit/signal |
| $d_o$(Threshold Distance) | 70m |
| $p_{opt}$ | 0.1 |

Radio parameters used in heterogeneous WSN are mentioned in Table 1 for different protocols deployed in WSN and to estimate the performance for three level heterogeneous WSNs.

## X. Simulation and Results

This simulation results for EDEEC, EDDEEC and iEDDEEC (proposed protocol) in three-level heterogeneous WSNs using MATLAB are described in this section. WSN consists of $N = 100$ nodes which are randomly deployed in a field of dimension $100m \times 100m$ with a centrally located sink. A network is assumed with 20 normal nodes with $E_o$ initial energy, 32 advanced nodes with two times more energy than normal nodes and 48 super nodes having 3.5 times more energy than normal nodes such that $a = 2.0\ and\ b = 3.5$ and the fraction of advanced nodes be $m = 0.8$ and super node is $m_o = 0.6$. The simulation of EDEEC, EDDEEC, iEDDEEC for three level heterogeneous WSN is done for 10000 rounds.

Figure 3 depicts the number of alive nodes during each round. As the nodes communicate with cluster-heads and sink, some of the energy associated with that particular nodes gets used. After some number of rounds, as the nodes loses their energy, nodes starts to die out. The first node for EDEEC, EDDEEC and iEDDEEC dies at 1223, 1458 and 1567 respectively. At this stage, the number of nodes alive in iEDDEEC is quite larger than EDEEC because in iEDDEEC, the threshold function used by nodes for CH selection includes residual and average energy of that round. So nodes having high energy will become CHs and nodes survive to be alive longer than traditional protocols. Therefore iEDDEEC comes out to have better network stability.

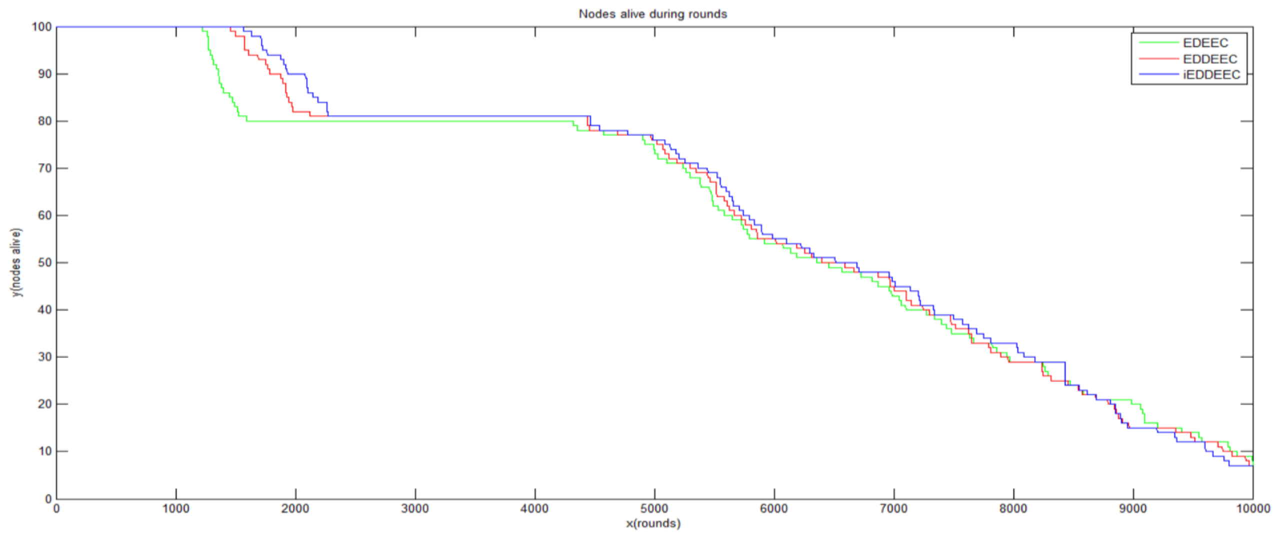


Figure 3. Number of nodes alive during rounds.

Figure 4.

Normal nodes have least energy amongst all other types. Even if clustering scheme follows the criteria that nodes with higher energy will become CHs more often because energy dissipation at CH includes the energy dissipation for both, while sending and receiving data packet. But still, the normal node will die first because instead of having least energy, it dissipate some energy while sending data packet to its respective CH. This protocol extends the number of rounds in which first normal node dies. Figure 4 shows that out of 20 number of normal nodes alive in each round. The first normal node dies for EDEEC, EDDEEC and iEDDEEC at 1223, 1308 and 1317 respectively. EDEEC causes all the normal nodes to die earlier than EDDEEC and iEDDEEC.

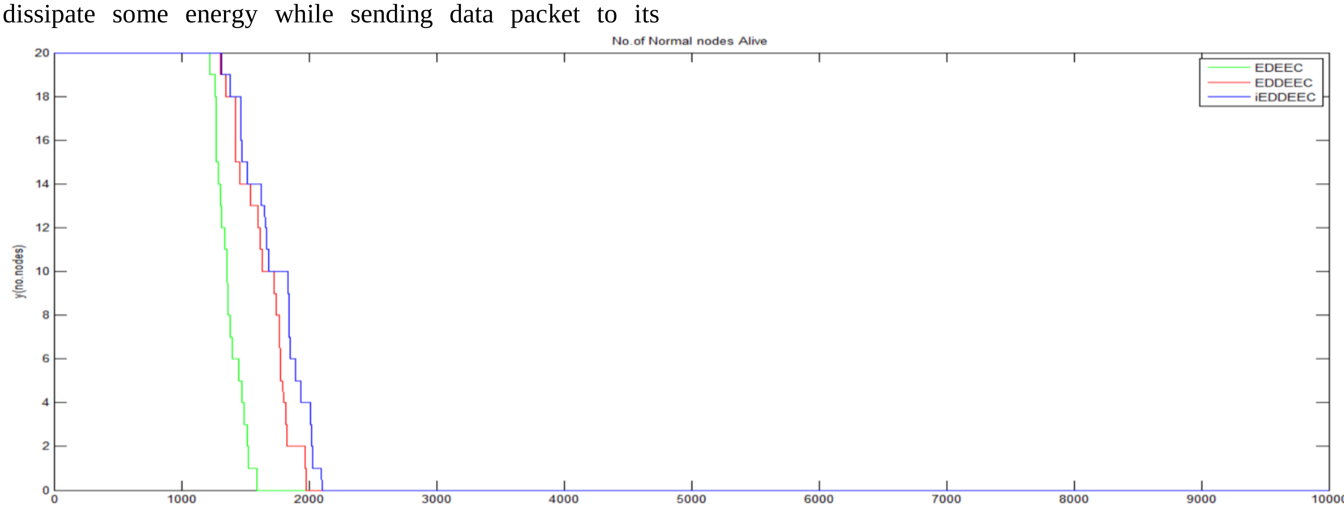


Figure 5. Number of normal nodes alive during rounds.

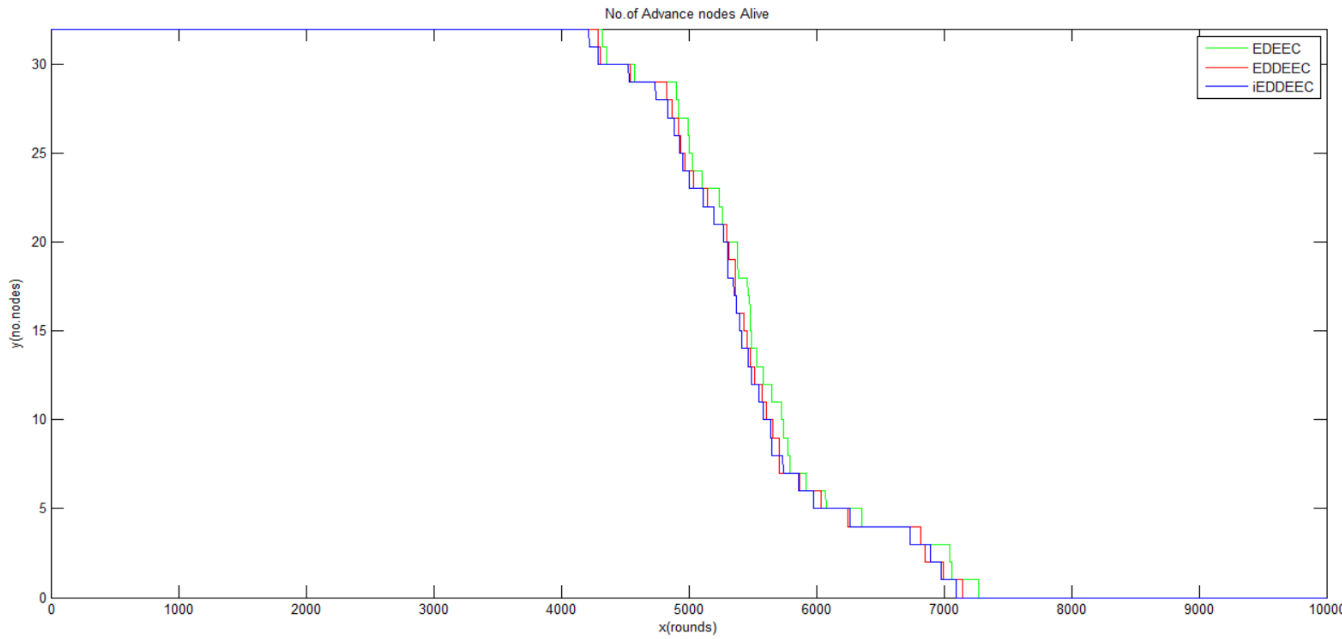


Figure 6. Number of advance nodes alive during rounds.

Figure 5 and 6 shows the number of advanced and super nodes alive during the network lifetime respectively. The first node, amongst 32 advanced nodes, dies for EDEEC, EDDEEC and iEDDEEC at 4326, 4294 and 4220 round respectively. The first node, out of 48 super nodes, dies for EDEEC, EDDEEC and iEDDEEC at round number 6139, 6106 and 6050 respectively. As iEDDEEC protocol causes super and advanced nodes to become CHs more frequently, so these nodes loses their energy at a faster rate than traditional protocols to improve the network stability period.

Figure 7 depicts that the data sent to the BS is slightly more for iEDDEEC as compared to EDEEC and EDDEEC protocols because of the better CH selection.

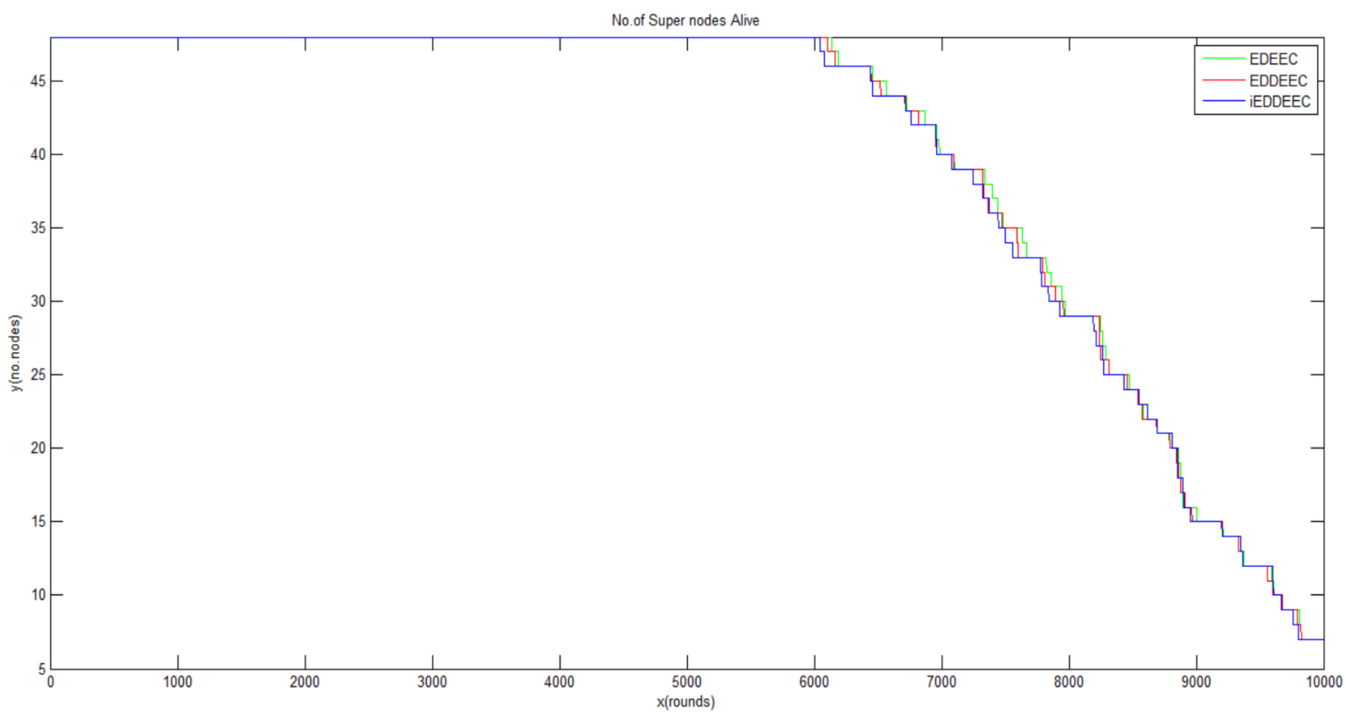


Figure 7. Number of super nodes alive during rounds.

 

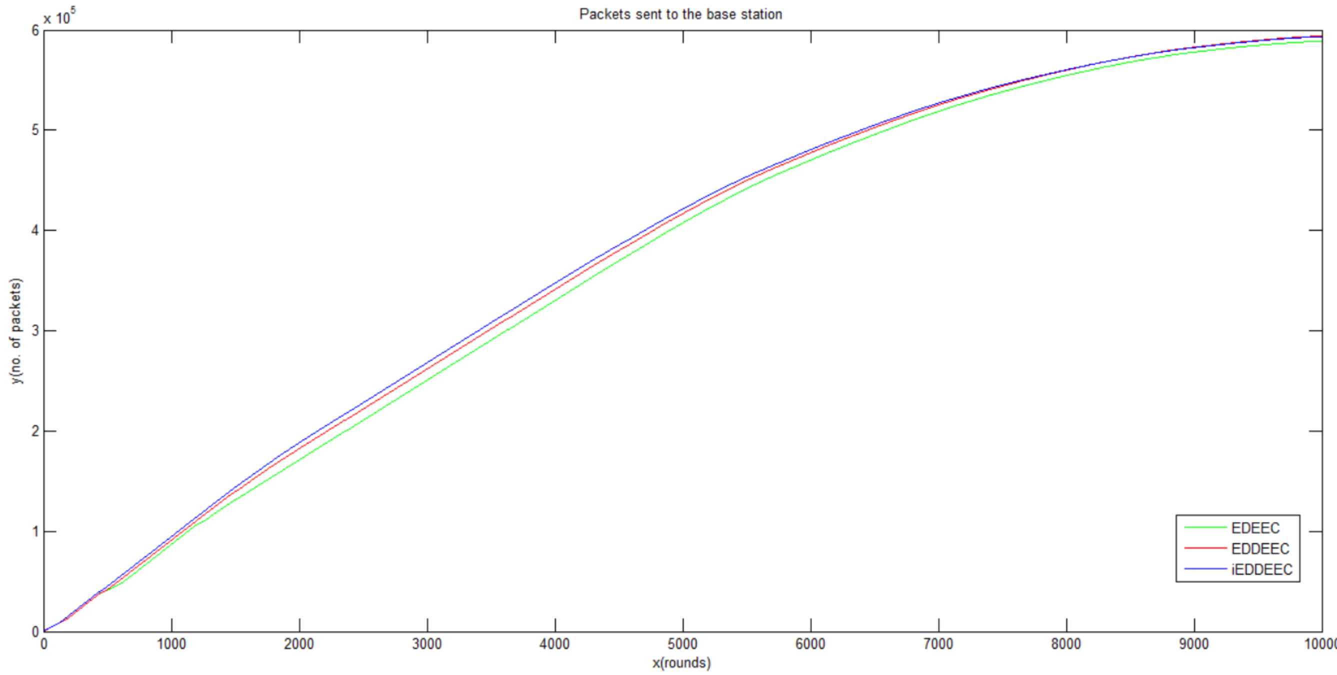


Figure 8. Number of packets sent to base station during rounds.

Figure 8 shows the data sent to the CH for EDEEC, EDDEEC and iEDDEEC protocols. Due to poor CH selection, the number of CHs formed in EDEEC are more in former rounds. But EDDEEC and iEDDEEC manage to form more optimal CHs that gives lesser data packets at former rounds which increases as the rounds increase. iEDDEEC shows more optimal results for CH selection.

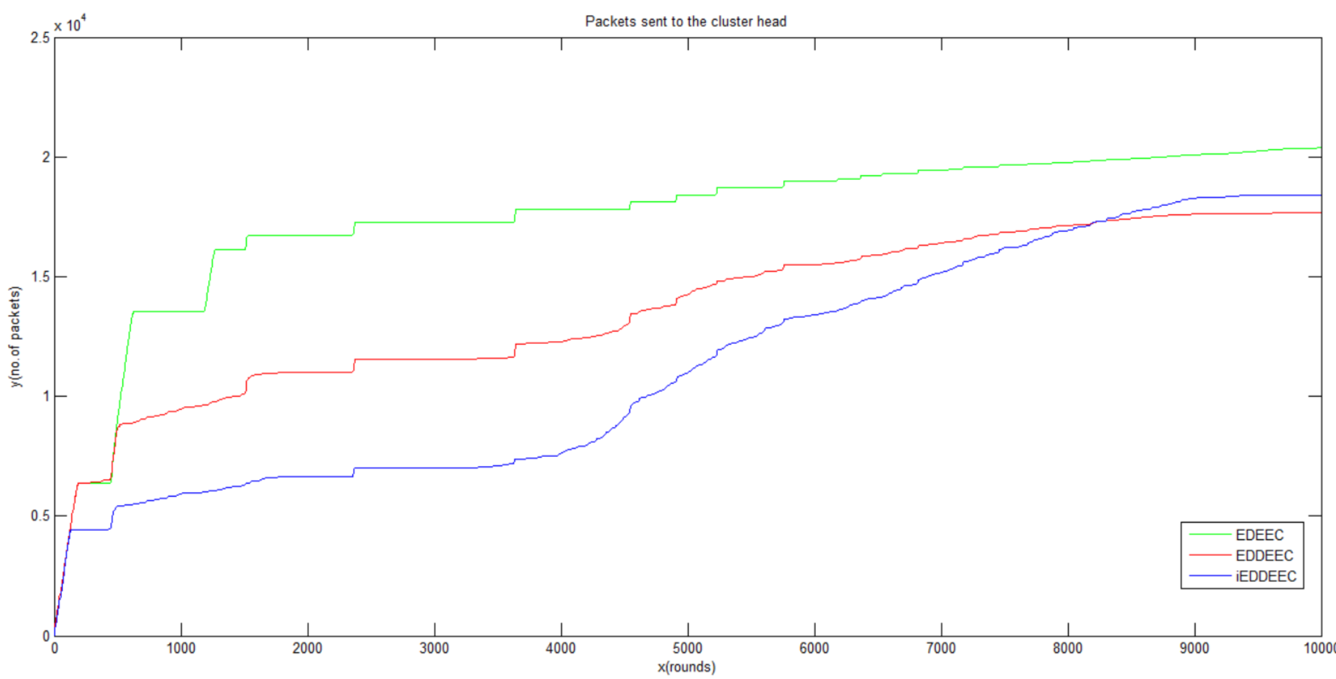


Figure 9. Number of packets sent to cluster-heads during rounds.

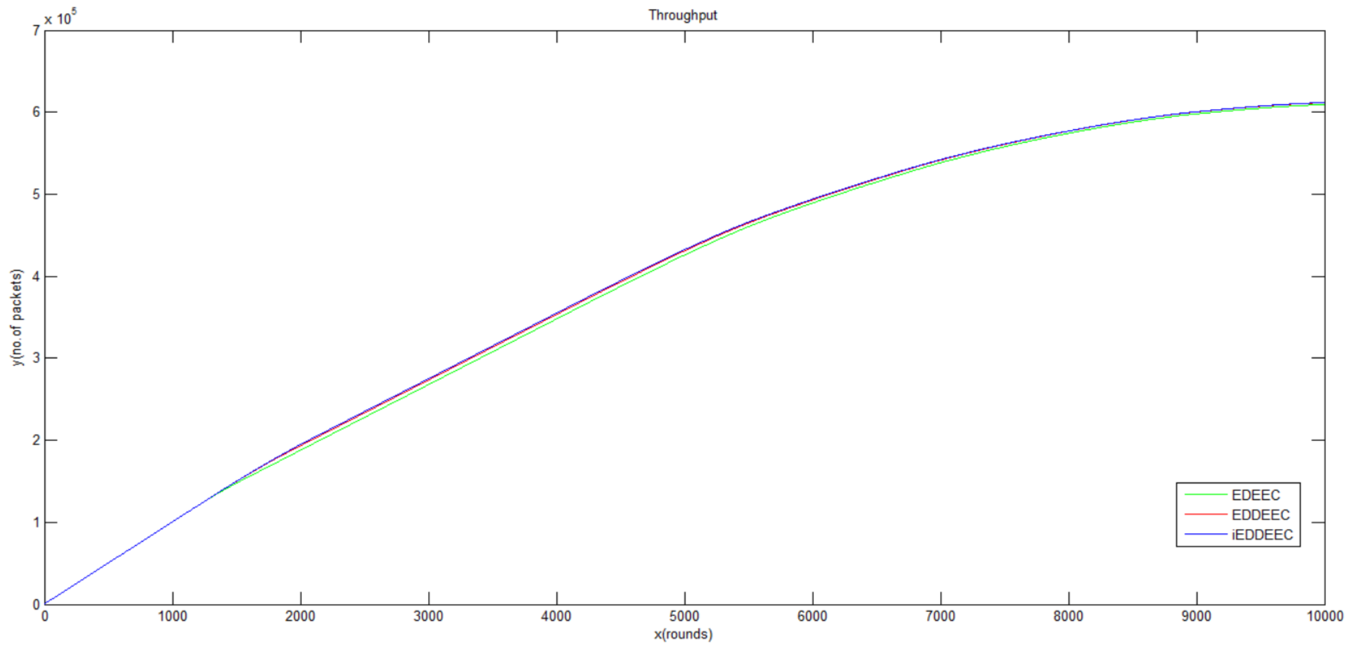


Figure 10. Throughput during rounds.

Instead of change in CH selection method and lesser number of packets sent to cluster-heads, iEDDEEC gives same throughput as that of EDDEEC as depicted in figure 9, because it sends more data packets to base station.

Figure 10 shows the energy dissipated for EDEEC, EDDEEC and iEDDEEC protocol for the network lifetime. The CH selection algorithm used in iEDDEEC results in selecting optimal number of cluster-heads because of which energy dissipation is lesser as compared to EDEEC and EDDEEC.

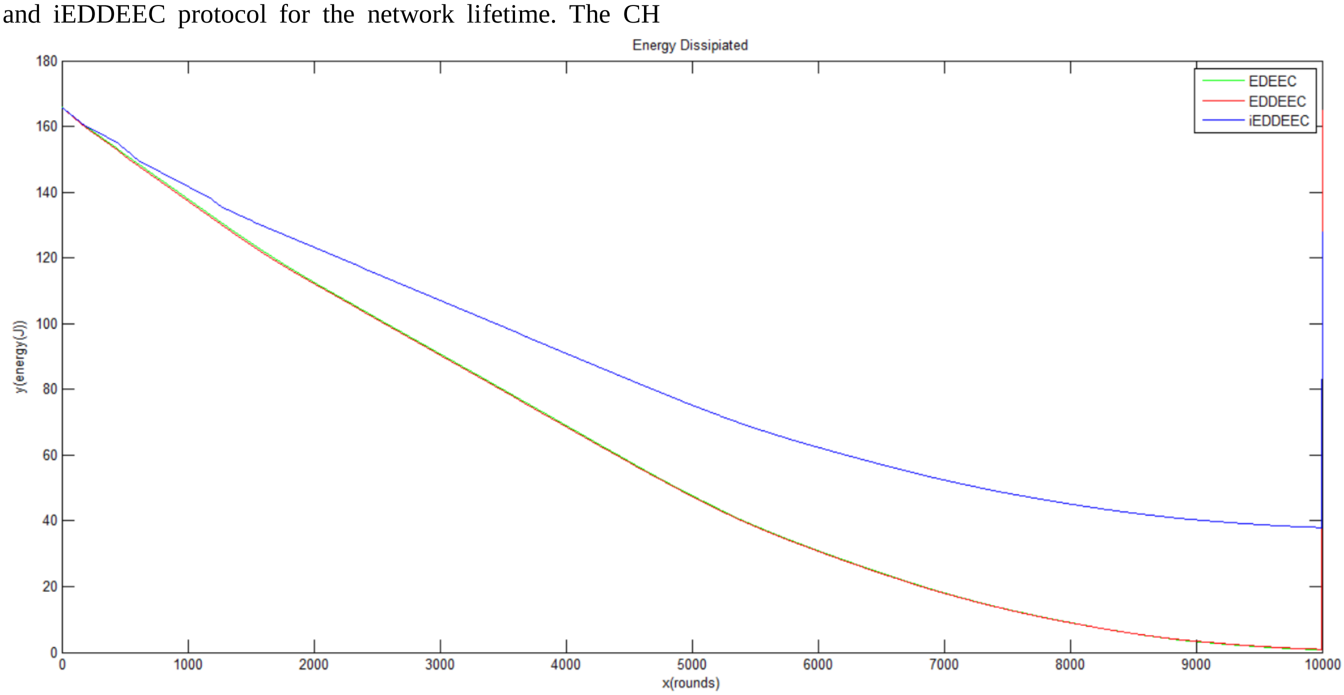


Figure 11. Energy dissipation during rounds.

 

## II. CONCLUSION

During protocol operations, EDEEC independently elect cluster-heads based on initial energy and residual energy of nodes and does not require any global knowledge of energy at every election round. EDDEEC dynamically adjusts the CHs selection probability and selects the fittest CHs. iEDDEEC modifies the threshold value of a node based on which it decides to be a cluster-head or not along with dynamic CHs selection probability. Thus, iEDDEEC consumes relatively less energy which leads to prolong stability period in comparison to the other protocols; thereby, the number of packets sent to BS are more in comparison to the other selected protocols. It has been observed that stability period of iEDDEEC is 7% and 28% improved than EDDEEC and EDEEC respectively. iEDDEEC maintains average number of cluster-heads equivalent to optimal desired value, therefore, reduces number of direct communications to sink resulting improved stability period. As optimal cluster-heads are elected, the energy dissipation in each round will also be lesser than EDEEC and EDDEEC.

## REFERENCES


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

[2] 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.

[3] K. Akkaya and M. Younis, "*A survey on routing protocols for wireless sensor networks*", Ad Hoc Networks, Vol.3, Issue.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] N. Javaid *et al.*, "*An energy-efficient distributed clustering algorithm for heterogeneous WSNs*", Eurasip J. Wirel. Commun. Netw., Vol.15, Issue.1, pp.1–11, 2015.

[10] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "*Energy-efficient communication protocol for wireless microsensor networks*", Proc. 33rd Annu. Hawaii Int. Conf. Syst. Sci., Vol.1, Issue.11, pp.10-15, 2000.

[11] D. Kumar, T. C. Aseri, and R. B. Patel, "*EEHC: Energy efficient heterogeneous clustered scheme for wireless sensor networks*", Comput. Commun., Vol.32, Issue.4, pp.662–667, 2009.


### Authors Profile

*Gurwinder Kaur* received Bachelors in Information Technology (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

 