Volume 4, Issue 7, July 2014 ISSN: 2277 128X

International Journal of Advanced Research in Computer Science and Software Engineering

Research Paper

Available online at: www.ijarcsse.com

Performance Evaluation of Variants of Stable Election Based WSN protocols

Shobti Saini*
Department of Computer Science and Engineering,
Sri Sai Collegeof Engineering and Technology,
Badhani, Pathankot, 145001, India

Prof. Meenakshi Sharma
Department of Computer Science and Engineering,
Sri Sai Collegeof Engineering and Technology,
Badhani, Pathankot, 145001, India

Abstract - Wireless Sensor Networks (WSNs) contain a large number of sensor nodes that sense the environment they are employed in; and gather the data and forward it to the Base Station (BS). The sensing and transmission of data involves a huge amount of energy. While WSNs are equipped to handle complex functionalities, the network processing may require the sensors to use the constrained energy level to enhance the network lifetime. Many protocols have been proposed for achieving energy efficiency in heterogeneous structure of the network. In this paper, the performance of SEP, ECRSEP and ESEP have been evaluated for different WSNs scenarios. The outcomes of the same have been then analysed for stability, network lifetime and throughput. It has been shown that the ESEP and ECRSEP performs well in differing heterogeneous scenarios, however ESEP has best results in stability period among others. This study has shown that the ESEP is quite effective over the available protocols.

Index terms: WSNs, Energy consumption, Cluster head, Heterogeneity, Stability, Network lifetime.

I. INTRODUCTION

Recent advances in hardware technology have made possible the deployment of small, low-cost devices that are battery-powered and have limited processing and wireless communication capabilities. As the time passed by, the researchers found new and critical applications of WSNs. WSNs are continuously used in many critical applications like environment monitoring, battlefield surveillance in military and detection of attacks. Other applications involving the use of WSNs include industrial control and monitoring, home automation and consumer electronics and health care. Wireless communication technologies are continuously growing in diverse areas and provide new and better opportunities for different business environments. The latest wireless micro sensor networks present a new standard for obtaining data from the surrounding environment and also allow the reliable examining of a number of environments for various applications.

WSNs are among the most widely used ad-hoc wireless networks. These consist of sensors that consume less power and can be deployed at a cost much less than those traditional wired systems. Wireless sensor network is a small system that is able to communicate over short distances. This small system is made up of sensor nodes. Sensor nodes can be imagined as small computers, extremely basic in terms of their interfaces and their components. They usually consist of a processing unit with limited computational power and limited memory, sensors or MEMS, a communication device, and a power source usually in the form of a battery

These nodes are adaptive and self-organized and integrate the functions of collecting data, processing it and then communicating it to the other nodes in the network. The sensing elements sense data from the environment, the processing system performs computation on the sensed data and the communication or radio system exchange the information with other nodes in the system. This information can then be transmitted to a base station (BS) or sink.

Nodes can be stationary or mobile.. In most of the cases, sensor nodes have non-rechargeable battery that cannot be replaced. The energy of the nodes is consumed during sensing phase first and later during the transmission and reception of data. WSNs are based on energy-constrained, battery-powered devices and in case large networks are needed to function for a longer period of time, balanced energy consumption is a critical issue.

To extend the lifetime of the network, efficient use of available energy is the subject to be considered. Many protocols have been proposed to enhance the network lifetime. But routing protocols have the capability to reduce the energy consumption of WSNs by choosing minimal routes. Among many routing protocols, the most effective is the cluster-based technique.

In cluster-based routing, the sensor nodes are grouped together into a number of clusters and the nodes of the cluster send their data to a specific node called cluster head (CH). The cluster head (CH) is present in each cluster and is responsible for collecting the data from the other nodes. After gathering all the data from sensor nodes, the CH then transmits it to the sink or Base station (BS) and these local Base Stations transmit the data to the global BS, where it is accessed by the end user. The base stations are one or more components of the WSN with much more computational, energy and communication resources. Clustering reduces the number of packets sent to the base station and also the number of nodes passing data is few. So the energy of the network is saved to a great extent and thus the overall network lifetime is improved. Since CHs are an important part of cluster-based routing protocols, the CH selection affects the network lifetime, energy consumption rate and the delay occurred in the delivery of packets.

Clustering may be used in two types of networks- homogeneous and heterogeneous. Nodes that have same amount of initial energy constitute homogeneous network and those with different energy levels are heterogeneous. Many protocols are proposed such different network conditions. Protocols such as Low-Energy Adaptive Clustering Hierarchy (LEACH), Hybrid Energy- Efficient Distributed clustering (HEED) are suitable for homogenous networks but they cannot be used in heterogeneous environments. So, other advance protocols such as Stable Election Protocol (SEP), Energy Consumption Rate based Stable Election Protocol (ECRSEP) and Extended Stable Election Protocol (ESEP) are designed for heterogeneous networks. These may also be used in homogeneous networks.

In this paper, we study the performance of these heterogeneous WSN protocols under two and three levels of heterogeneity. Three level heterogeneous networks contain normal, intermediate and advance nodes where advance nodes have highest amount of energy and the energy of intermediate nodes lie between those of advance and normal nodes. We differentiate each protocol on the basis of stability period and network lifetime of the nodes that are alive during various rounds for different energy levels.

It is found that each protocol behaves different from the other in terms of number of packets sent to BS and CH, number of nodes dead and alive as per the reading of the first dead and last dead node. ECRSEP and ESEP perform well under heterogeneous conditions enhancing network lifetime. SEP gets highly affected due to varying values of performance variables but the stability factor in SEP is seen to be better than ECRSEP and ESEP.

Performance Measures:

Following are the measures that are used to evaluate the performance of clustering protocols:

Stability period: time interval from start of operation until death of first node

Instability period: time interval from death of first node until death of last node

Network lifetime: time interval from start of operation to death of last alive node

Number of CHs per round

Number of alive nodes per round

II. RELATED WORK

Heinzelman, *et al.* [11] proposed a clustering- based protocol LEACH for homogenous networks that utilizes random rotation of cluster heads to distribute the energy load equally among the other nodes in the sensor field. The nodes randomly organize themselves into local clusters out of which a cluster head is selected. Each node decides independently whether to be a cluster head for the current round. The decision to become a CH depends upon the energy left with the node. G.

Smaragdakis, *et al.* [9] has proposed a protocol for heterogenous environment in which nodes differ in the initial amount of energy. The nodes elect themselves to be CH depending upon the initial energy levels. The election probabilities of nodes are weighted by the initial energy of each node relative to the other nodes in the network. It has normal ad advance nodes. The stability period is enhanced due to heterogeneity.

A.A. Khan, *et al.* [3] has proposed a hierarchical protocol that is also heterogeneity aware. In this, the transmission energy from the CH to BS is reduced by introducing secondary CHs in the network. These secondary CHs are selected from the existing primary CHs on the basis of some probability in each round. The primary CHs transmit the aggregated data to those CHs which are at a minimum distance from them (secondary CHs). The secondary CHs further send data to BS thus minimizing the transmission distance.

M.M.Islam, *et al.* [7] introduced three levels of heterogeneity in the proposed algorithm ESEP. The nodes are distinguished as normal, intermediate and advance based upon their initial energies. The CH election is based on the battery power and the remaining energy of the node.

O. Rehman, *et al.* [1] has considered the energy consumption rate of the nodes in the proposed protocol ECRSEP. A node that has less consumption rate in the previous round is selected the CH in the current round.

III. HETEROGENEOUS PROTOCOLS

A. Stable Cluster Head Election (SCHE) Protocol

Its goal is to reduce the energy consumption of each sensor node and thus minimizing the overall energy dissipation of the network. SCHE is a source driven protocol based on timely reporting. So the sensor node will always have some data to transmit to the Base station. It also makes use of data aggregation to avoid information overload.

SCHE was proposed where this mechanism was applied by obtaining the optimum value of probability for a node to become a CH and consumes significantly less energy compared to LEACH. It also reduces consumption by minimizing distance between CH and BS. 7

B. Stable Election Protocol (SEP)

There are some drawbacks associated with LEACH such as: single hop routing is used where each node can transmit directly to CH and sink. CHs are elected randomly. The protocol also assumes that all nodes have amount of energy for each node.

But recent protocols like SEP is opposite to that of LEACH as it considers energy heterogeneity. The nodes also differ in initial amount of energy and also in depletion rate. This leads to the heterogeneous networks where we consider two or more types of nodes. The nodes that have higher amount of energy than the other nodes are called advance nodes and the other nodes are the normal nodes.

In SEP the election probabilities of nodes are weighted by the initial energy of each node to become the cluster-head relative to the other nodes in a network. This prolongs the time period before the death of first node in the system. SEP approach makes sure that CH election is done randomly and is distributed based on the energy of each node assuring the uniform utilization of the nodes energy. SEP consists of advance nodes that carry more energy than the normal nodes at the beginning, so it enhances the stability period of the network.

Normal nodes have initial energyE_0, and advance nodes have initial energy (1+a)E_0.Where (a) is the percentage of energy higher than normal nodes. Each node has a probability to become a CH and each node generates a random number between 0 and 1 just like in LEACH. If the number is less than threshold T(s), then that node becomes CH in the current round. With increase in number of rounds, the T(s) also increases and reaches 1 only in the last round.

Let p_{nrm} be the weighted election probability of normal nodes and p_{adv} be the weighted election probability of advance nodes. Optimum probability of each node to become CH can be calculated by:

$$p_{nrm} = \frac{p_{opt}}{1+am} \quad (1)$$

$$p_{adv} = \frac{p_{opt}}{1+am} * (1+a) \quad (2)$$

'm' denotes the fraction of advance nodes and 'a' is the additional energy factor between advance and normal nodes.

The threshold is given by the formula:

$$T_{nrm} = \begin{cases} \frac{p_{nrm}}{1-p_{nrm}\left[r.mod\frac{1}{p_{nrm}}\right]}, & n_{nrm} \in G \\ 0 & otherwise \end{cases} \quad (3)$$

$$T_{adv} = \begin{cases} \frac{p_{adv}}{1-p_{adv}\left[r.mod\frac{1}{p_{adv}}\right]}, & n_{adv} \in G \\ 0 & otherwise \end{cases} \quad (4)$$

The total energy of new heterogeneous setting will be:

$$\text{n. }(1-m).\ E_0 + \text{n.}m.\ E_0.(1+a) = \text{n. } E_0.\ (1+a.m) \quad (5)$$

So the total energy of the system is increased by (1+*a.m*) times.

In order to optimize the stable region of the system the new epoch must become $\frac{1}{p_{opt}}$.(1+a.m) as the system has *a.m* times more energy and *a.m* times more nodes.

C. Extended Stable Election Protocol (ESEP)

It is a modified SEP protocol. Instead of two types of nodes, it considers three nodes based on their energy levels. These nodes are: normal, moderate and advance nodes. The goal of ESEP is to achieve a WSN that maximizes the network lifetime and stability period. Also it must reduce the communication cost and deployment cost. The operation to become a CH is same as in SEP by generating a random number and then comparing it with the threshold. In ESEP the moderate or intermediate nodes are selected in two ways either by the relative distance of advance nodes to normal nodes or by the threshold of energy level between advance nodes and normal nodes.

The weighted election probabilities are given by:

$$p_{nrm} = \frac{p_{opt}}{1+p.a+k.b} \quad (6)$$

$$p_{mod} = \frac{p_{opt}}{1+p.a+k.b}.\ (1+a) \quad (7)$$

$$p_{adv} = \frac{p_{opt}}{1+p.a+k.b}.\ (1+b) \quad (8)$$

And the total initial energy of heterogeneous network is given by:

$$E_t = \text{n. } E_0.(1-p-k) + \text{n. p. } E_0.(1+a) + \text{n. k. } E_0.(1+b) \quad (9)$$

$$E_t = \text{n. } E_0.(1+p.a+k.b) \quad (10)$$

The results show that ESEP outperforms SEP and LEACH in terms of stability because of three levels of heterogeneity.

D. Threshold-sensitive Stable Election Protocol (TSEP)

It is a reactive routing protocol that senses data continuously over the network but transmits only when there is a drastic change in the value of sensed attributes. The transmission takes place only when a specific level of threshold is reached. It uses three types of nodes: normal, intermediate and advance nodes. The intermediate nodes are selected by using a fraction *b* of intermediate nodes. The energy of intermediate nodes is assumed to be μ times more than that of normal nodes. So, the energy of intermediate nodes is calculated as:

$$E_{INT} = E_0(1+\mu) \text{ where } \mu = \frac{\alpha}{2} \quad (11)$$

So, total energy of normal, advance and intermediate nodes is *n.b(1+α), n* E_0 *.(1-m-bn),* and *n.m.* E_0 *(1+ α)* respectively. So total energy of all nodes becomes $nE_0.(1-m-bn) + n.m.\ E_0.(1+\alpha) + n.b.(1+\mu) = n.\ E_0.(1+ m\alpha + b\mu)$. (12)

The optimum probability of nodes to be elected CHs is calculated by:

$$p_{nrm} = \frac{p_{opt}}{1+m\alpha+b\mu} \quad (13)$$

$$p_{int} = \frac{p_{opt}}{1+m.a+b\mu}.(1+\mu) \quad (14)$$

$$p_{adv} = \frac{p_{opt}}{1+m.a+b.\mu}.(1+\alpha) \quad (15)$$

To make sure that the CH is selected in the assumed way, a new parameter threshold, is considered. If the generated random number by the nodes is less than the threshold then that node becomes the CH for the current round. The threshold is calculated by the following formulae:

$$T_{nrm} = \begin{cases} \frac{p_{nrm}}{1-p_{nrm}\left[r.mod\ \frac{1}{p_{nrm}}\right]} & \text{if } n_{nrm} \in G' \\ 0 & otherwise \end{cases} \quad (16)$$

$$T_{int} = \begin{cases} \frac{p_{int}}{1-p_{int}\left[r.mod\ \frac{1}{p_{int}}\right]} & \text{if } n_{int} \in G'' \\ 0 & otherwise \end{cases} \quad (17)$$

$$T_{adv} = \begin{cases} \frac{p_{adv}}{1-p_{adv}\left[r.mod\ \frac{1}{p_{adv}}\right]} & \text{if } n_{adv} \in G''' \\ 0 & otherwise \end{cases} \quad (18)$$

Average number of CHs per round will be:

$$n.(1-m-b).\ p_{nrm} + n.b.\ p_{int} + n.m.\ p_{adv} = n.\ p_{opt} \quad (19)$$

This shows that due to energy heterogeneity, the energy dissipation is reduced in the network. At the start of each round, the process of cluster change takes place in which the CH broadcasts the parameters. The next time the nodes transmit data only when the sensed value is greater than the hard threshold or if the difference between the sensed value and the value in SV is equal to or greater than the soft threshold. So, these thresholds reduce the number of transmissions as the data will be transmitted only when it reaches hard threshold.

E. Hierarchical based stable election protocol (HSEP)

The increasing distance between the CH and the BS results in increasing the transmission energy because most of the energy is consumed in the transmission process. HSEP is proposed which aims at reducing the transmission energy between the CH and BS. It brings into consideration the clustering hierarchy which lowers the transmission cost and hence the energy. In this type of clustering we use two types of cluster-heads: primary CHs and secondary CHs. The secondary CHs can be selected from the primary CHs and are elected on the basis of probability from those nodes which had already become the primary CHs. The CHs that are at minimum distance from them are selected the secondary CHs. These primary CHs then aggregate data collected from other nodes and transmit it to the secondary CHs which further send it to the BS. Thus, minimizing the transmission distance between the secondary CHs and the BS results in less consumption of energy.

F. Energy Consumption Rate based Stable Election Protocol (ECRSEP)

Owing to static clustering in homogeneous networks, the CHs will be overloaded with long distance transmissions and need extra energy for processing. This results into the death of CHs before the other nodes. To make sure that all nodes die at the same time, a small part of residual energy gets wasted. A method to do this is to rotate the CH periodically and randomly over all nodes.

In ECRSEP, CH selection is based on the energy consumption rate (ECR). It is defined as the

$$\text{ECR} = \frac{E_{int} - E_r}{r-1}, \quad (20)$$

where E_{int} is the initial energy, E_r is the residual energy and *r* is the current round. The CH selection in the next round is based on the ECR of the previous round. A node with less ECR in the previous round is selected as CH in the next round.

Let *n* be the number of rounds to become CH for nodes S. we call it the rotating epoch. Let $p=\frac{1}{n}$ is average probability to become CH during n rounds.

We have, p = p_{opt} * ECR

Total number of CHs per epoch is $\sum_i^N P_i$ = N p_{opt}

In two level heterogonous networks, p_{opt} is replaced by weighted probabilities of advance and normal nodes

$$p_{adv} = \frac{p_{opt}\frac{E_i - E_r}{r-1}}{1+am} \quad (21)$$

$$p_{nrm} = \frac{p_{opt}\,(1+a)\frac{E_i - E_r}{r-1}}{1+am} \qquad (22)$$

The results show that ECRSEP has enhanced stability period and network life than other protocols. ECRSEP achieves maximum lifetime of the network. SEP extend the stability period by assigning probabilities of CH election weighted by relative initial energy. ESEP has three levels of heterogeneity so it has longer stability period than SEP. HSEP uses hierarchical clustering approach and thus reduces the transmission energy.

IV. GAPS IN LITERATURE

1) The survey on different WSNs has been done by considering the various stable election based protocols like SEP, ESEP, ECRSEP etc.

2) SEP, ESEP and ECRSEP continues to punish advance and intermediate nodes i.e. no special protection for over utilization of advance and intermediate nodes.

3) SEP, ECRSEP and ESEP has also neglected the use of thresholding to reduce the energy consumption.

4) It has been found that the most of the existing researchers have neglected the use of absolute residual energy level (ARL) value to avoid this unbalanced case in three-level heterogeneous network and to save intermediate and advance nodes from over penalized.

V. SIMULATIONS AND DISCUSSION

In this section, we implement different clustering protocols in heterogeneous network. The platform used in the simulation is MATLAB and the number of nodes is 100 spread in the network area with dimension $100m \times 100m$. The base station is positioned initially at the center of the network field. The assumption undertook in the implementation is that the energy loss due to signal collision and interference is ignored for simplicity. We implement the protocols SEP, ECRSEP and ESEP for different values of some specific parameters.

TABLE I: VALUES FOR PARAMETERS

Parameters	**Values**
Network Field	100m,100m
Base Station	50,50
N	100
P	0.1
E_o	0.1
T	2000
T_x (Transmitter energy)	$50*10^{-9}$
R_x (Receiver energy)	$50*10^{-9}$
Min_do	$10*10^{-12}$
Max_ do	$0.0013*10^{-12}$
M	0.2
A	1

The underlying scenario covers the description of values for the number of packets sent to BS, packets sent to CH, value of first dead and last dead node and also the total number of nodes dead at different values of parameters BS_x, BS_y, Eo and t. These values are analysed for SEP, ECRSEP and ESEP. The heterogeneous network for our protocols consists of the parameters defined in Table 1. Parameters *x* and *y* represent the position of base station in the network field. *Eo* denotes the initial energy of the nodes and *t* defines the maximum lifetime of the network.

In the first case, the values of parameters are specified as *x*=*y*=10, *Eo* = 0.1, and t=4000. The simulation results from fig1, 2 and 3 show that the first node for protocols SEP, ECRSEP and ESEP dies at 318, 397, 405 rounds respectively. All nodes are dead at 975, 2139 and 2353 rounds respectively. Similarly, the packets sent to the CHs by the nodes are 47128, 65062 and 90941. And the packets sent to BS by SEP, ECRSEP and ESEP are 1541, 2214 and 13084 respectively. The results show that the first node takes maximum time to die in ESEP. So, the stability period of ESEP is higher as compared to SEP and ECRSEP.

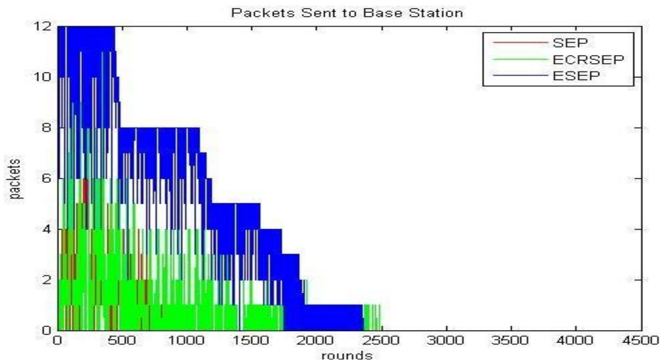

Fig. 1 Packets sent to base station

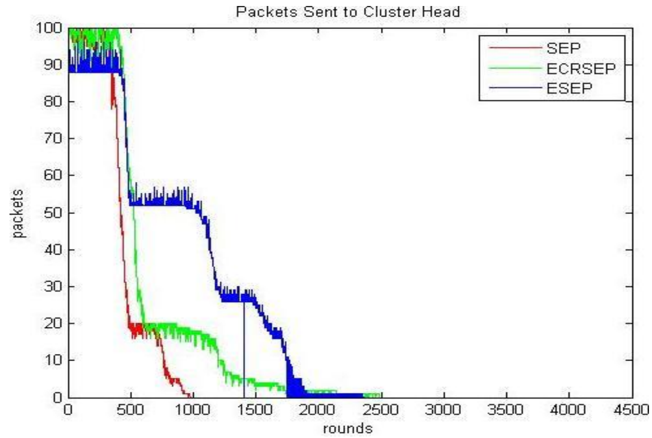

Fig. 2 Packets sent to cluster head

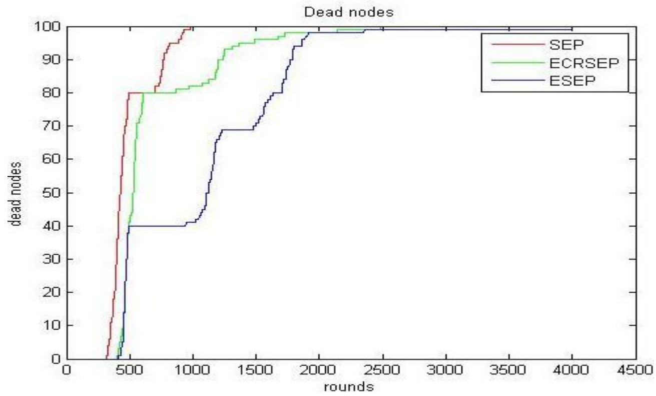

Fig. 3 Dead nodes

The network lifetime is depicted by the time interval between start of operation and the death of last alive node. As the last dead node in ESEP dies after maximum number of rounds, so its network lifetime is longer compared to SEP and ECRSEP.

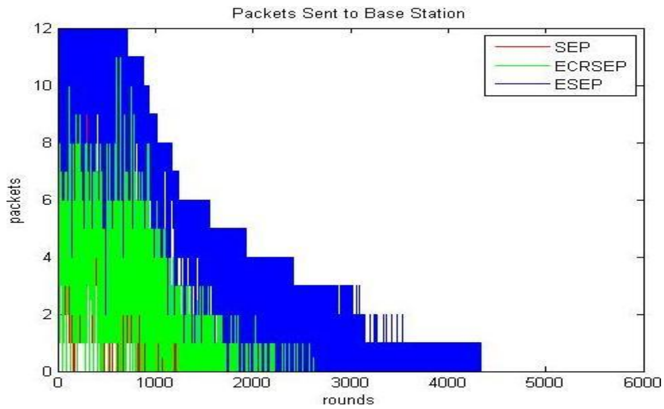

Fig. 4 Packets sent to base station

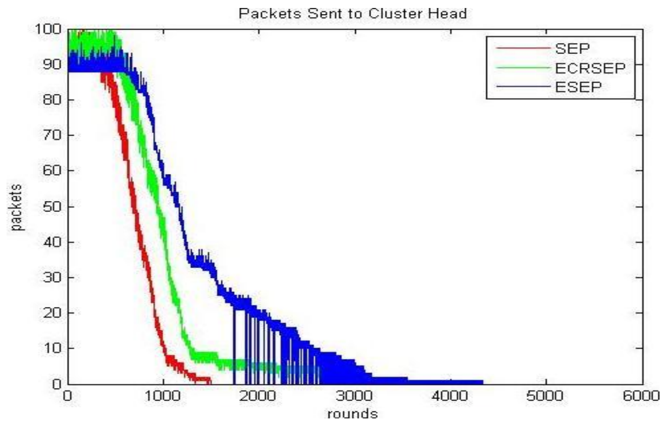

Fig. 5 Packets to cluster head

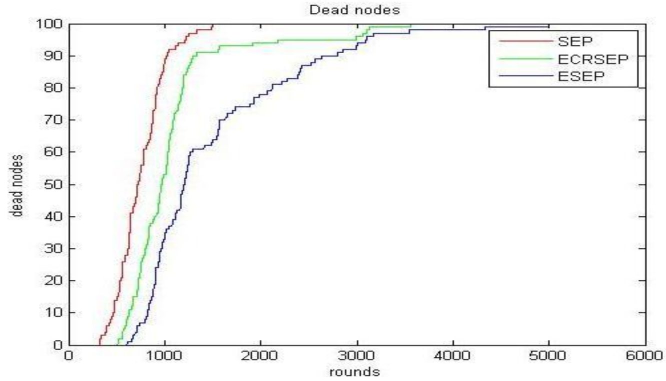

Fig. 6 Dead nodes

Now considering the second case in which values of parameters are increased to *x*=*y*=150, *Eo*= 0.3, and *t*=5000. The first dead node in SEP, ECRSEP and ESEP dies at 511, 608 and 324 rounds respectively. The number of packets sent to CH is 70431, 100104 and 128065 respectively. Also the packets that the BS receives from the CHs are 4605, 6805 and 18117. The energy factor is increased which allows a large number of nodes to be elected CH. The distance of the base station in increased from the nodes which results in early drainage of energy as more energy will be required to send the packets to the base station. The nodes in SEP, ECRSEP and ESEP are dead at 1496, 3132 and 4329 rounds respectively. Compared to the previous one, this simulation shows that the stability period of the network is increased due to the increased energy factor. Although the base station is at a great distance, but the network lifetime improves at the same time.

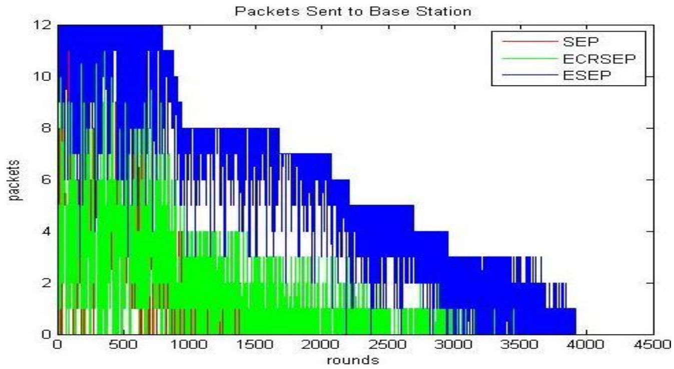

Fig. 7 Packets sent to base station

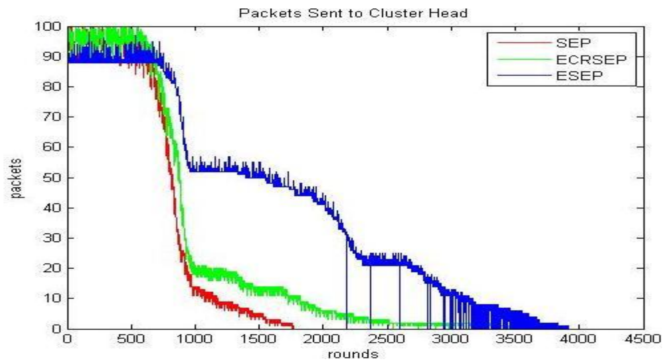

Fig. 8 Packets to cluster head

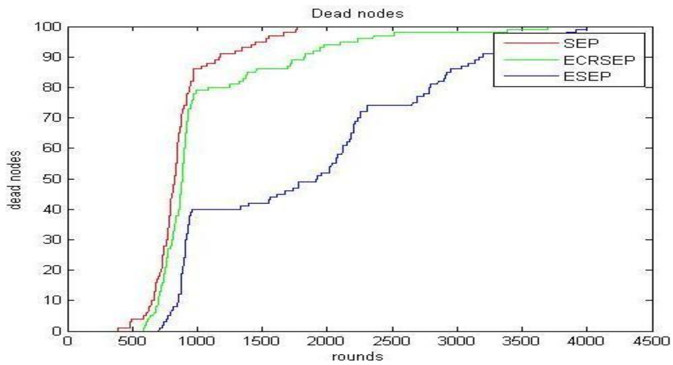

Fig. 9 Dead nodes

Let us consider the third case in which the values of parameters decrease to *x*=*y*= 100, *Eo*= 0.2, and *t*= 4000. The graphs for this simulation show that the values of the rounds for the death of first node for SEP, ECRSEP and ESEP reaches to 387, 588 and 705. Also the values of last dead nodes for the same are 1770, 3383 and 3916. The packets sent to CH and BS are 82635, 99850, 160024 and 4180, 5281, 23250 respectively for SEP, ECRSEP and ESEP. The last node dies at 1770, 3383 and 3916 in respective protocols.

The stability period is enhanced and also the network lifetime since the distance of the base station is decreased which results in less consumption of energy. ESEP is seen as very efficient compared to SEP and ECRSEP. But ECRSEP is better than SEP in terms of network lifetime. The stability period of SEP and ECRSEP differ by a small amount.

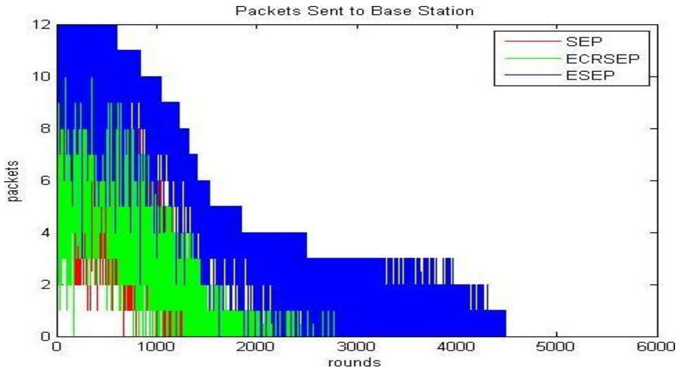

Fig. 10 Packets sent to base station

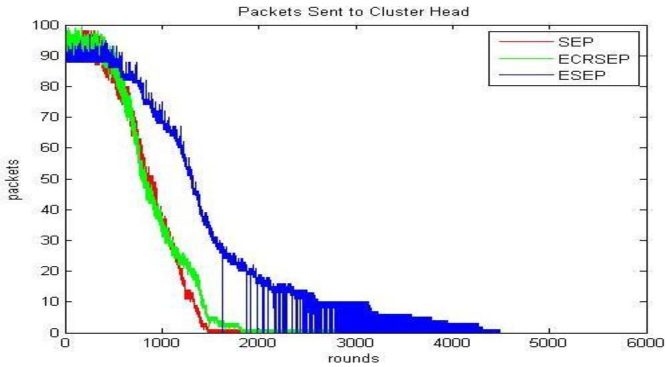

Fig. 11 Packets to cluster head

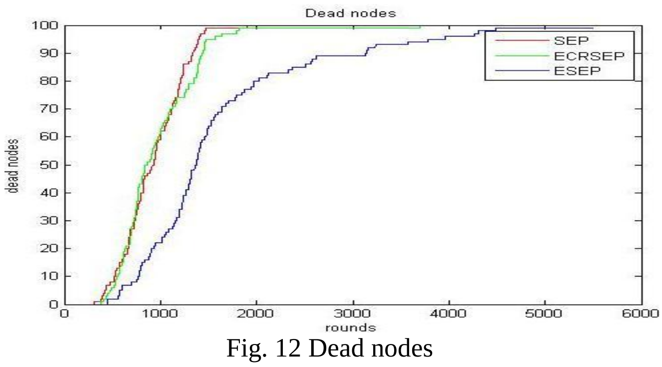

Fig. 12 Dead nodes

Consider the fourth case in which the values of parameters are increased to *x*=*y*= 175, *Eo*= 0.5, and *t*= 5500. The graphs for this simulation show that the values of the rounds for the death of first node for SEP, ECRSEP and ESEP reaches to 305, 377 and 446. Also the values of last dead nodes SEP, ECRSEP and ESEP are 1904, 1821 and 4482. The packets sent to CH and BS are 85158, 89388, 136894 and 7061, 7475, 19427 respectively for SEP, ECRSEP and ESEP. The last node dies at 1770, 3383 and 3916 in respective protocols. The stability period is reduced compared to the previous result and also the network lifetime since the distance of the base station is increased which results in early energy drain that results in the early death of first nodes. The number of rounds needed to complete the operation required to be increased since the energy factor is greatly increased and the nodes have higher amount of initial energy. ESEP is seen as not so efficient compared to SEP and ECRSEP as the stability period of all is very close to other.

From all the comparisons, it is seen that ESEP outperforms SEP and ECRSEP in enhancing the network lifetime. Although ESEP proved to be better than the other two, the stability period of ECRSEP and ESEP is almost the same in some scenarios. The instability can also be seen in ESEP as all the nodes do not die till the last round. And in order to make sure the nodes are dead at the end of the operation, the number of rounds has to be increased.

VI. CONCLUSION AND FUTURE WORK

Many protocols have been proposed for achieving the optimized the energy efficiency in heterogeneous structure of the network. This paper has evaluated the performance of SEP, ECRSEP and ESEP by considering different WSNs scenarios. The experimental results have shown that the there exists trade-off between SEP and ECRSEP. However it is also found that the ESEP outperforms over the SEP and ECRSEP in all scenarios. However no modification is done in this work to enhance the results further. In near future we will modify the cluster head selection criterion in such a way that it provides more efficient results.

REFERENCES

[1] Rehman, O., Javaid, N., Manzoor, B., Hafeez, A., Iqbal, A., & Ishfaq, M. (2013). Energy Consumption Rate based Stable Election Protocol (ECRSEP) for WSNs. Procedia Computer Science, 19, 932-937.

[2] Kashaf, A., Javaid, N., Khan, Z. A., & Khan, I. A. (2012, December). TSEP: Threshold-sensitive Stable Election Protocol for WSNs. In Frontiers of Information Technology (FIT), 2012 10th International Conference on (pp. 164-168). IEEE.

[3] Khan, A. A., Javaid, N., Qasim, U., Lu, Z., & Khan, Z. A. (2012). HSEP: Heterogeneity-aware Hierarchical Stable Election Protocol for WSNs. arXiv preprint arXiv:1208.2335.

[4] Li, Yuling, Luwei Ding, and Feng Liu. "The improvement of LEACH protocol in WSN." Computer Science and Network Technology (ICCSNT), 2011 International Conference on. Vol. 2. IEEE, 2011.

[5] Peng, J., Chengdong, W., Yunzhou, Z., & Fei, C. (2011, September). A Low-Energy Adaptive Clustering Routing Protocol of Wireless Sensor Networks. InWireless Communications, Networking and Mobile Computing (WiCOM), 2011 7th International Conference on (pp. 1-4). IEEE.

[6] Aderohunmu, Femi A., and Jeremiah D. Deng. "An Enhanced Stable Election Protocol (and Heterogeneous WSN." XH Wu, S. Wang," Performance comparison of LEACH on LEACH-C protocols by NS2," Proceedings of 9th International Symposium SEP) for Clustered Distributed Computing and Applications to Business, Engineering and Science. Hong Kong, China. 2010.

[7] Islam, M. M., Matin, M. A., & Mondol, T. K. (2012, June). Extended Stable Election Protocol (SEP) for three-level hierarchical clustered heterogeneous WSN. In Wireless Sensor Systems (WSS 2012), IET Conference on (pp. 1-4). IET.

[8] Muhamad, W. N. W., Dimyati, K., Mohamad, R., Haron, M. A., Sarnin, S., Wahab, N., & Aziz, N. H. A. (2008, December). Evaluation of Stable Cluster Head Election (SCHE) routing protocol for wireless sensor networks. In RF and Microwave Conference, 2008. RFM 2008. IEEE International (pp. 101-105). IEEE.

[9] Smaragdakis, Georgios, Ibrahim Matta, and AzerBestavros. SEP: A stable election protocol for clustered heterogeneous wireless sensor networks. Boston University Computer Science Department, 2004.

[10] Manjeshwar, Arati, and Dharma P. Agrawal. "TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks." IPDPS. Vol. 1. 2001.

[11] Heinzelman, Wendi Rabiner, AnanthaChandrakasan, and HariBalakrishnan. "Energy-efficient communication protocol for wireless microsensor networks." System Sciences, 2000. Proceedings of the 33rd Annual Hawaii International Conference on. IEEE, 2000.

