International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 06 | June-2016 www.irjet.net p-ISSN: 2395-0072

Energy Level Based Stable Election Protocol for Periodic Data Transmission

Neha Saini[1], Dr. Preeti Sethi[2], Dr. Naresh Chauhan[3]

[1]*Department of Computer Engineering, YMCAUST, Faridabad (HR), India*
[2] *Asst. Prof., Department of Computer Engineering, YMCAUST, Faridabad (HR), India*
[3] *Chairman, Department of Computer Engineering, YMCAUST, Faridabad (HR), India*

---***---

Abstract - *Wireless Sensor Networks (WSNs) are the networks which are characterized by severely constrained computational and energy resources. Residual energy is the key factor which determines the network lifetime in WSNs, therefore, conserving the residual energy of the networks is the major issue while designing the routing protocols. Clustering based routing techniques are best opted for this purpose. In these techniques, different nodes play different roles and thus there is no uneven load on nodes. Clustering protocols enhances the network lifetime. This work presents a brief review of various energy efficient clustering protocols in WSNs. The work concludes by proposing a framework for a novel protocol which meets the deficiencies of the surveyed protocols*.

***Key Words*: Wireless Sensor Networks; Routing protocols; Clustering; Hierarchical; Energy-efficient; network lifetime.**

1. INTRODUCTION

A wireless sensor network (WSN)[1][10] consists of randomly deployed autonomous sensors to monitor the physical or environmental conditions, such as temperature, sound, pressure, humidity etc. and to collect and pass their data through the network to a specific destination for further processing. WSNs were initially used for military applications. But now, the area of applications of WSN is widely increasing ranging from traffic control, home automation, to health applications. Efficient routing of the data in these networks plays a vital role in WSNs. Routing at the network layer can be classified into two broader categories namely Flat-based Routing and Hierarchical-based Routing. In flat-based routing, all nodes are assigned equal roles or functionality. In hierarchical-based routing, nodes play different roles in the network. It is also called cluster-based routing. Sensor nodes have limited energy which is a major challenge. Once the nodes are deployed, the replacement of these nodes is not possible practically. Therefore, while designing the protocols for WSN, the main focus is to efficiently utilize the available energy with the nodes for enhancement of network lifetime. Hierarchical-based routing is the most accepted routing technique for this purpose. Nodes are organized into clusters in which higher energy nodes are used to process and forward the information, while lower energy nodes are used to sense the target. In this paper, we present a brief review of existing energy-efficient routing protocols in WSNs and propose a framework to improve the existing protocols.

This paper consists of four sections. The Section I gave an introduction about the WSN and Routing. Section II gives the review of the various hierarchical protocols designed in this area. Section III presents the proposed framework. Section IV shows the simulated results of the proposed framework and Section V concludes the work.

2. RELATED WORK

To utilize the available energy of the nodes efficiently, various techniques have been proposed in the literature. In this work, we give a brief review of the various clustering based protocols.

2.1 LEACH (Low Energy Adaptive Clustering Hierarchy)

The first hierarchical routing protocol for WSN is Low Energy Adaptive Clustering Hierarchy (LEACH) [2]. Ningbo Wang and HaoZhu stated that LEACH randomly selects a few sensor nodes as cluster heads (CHs) and rotates this role to evenly distribute the energy load among the nodes in the network [2]. Each node randomly elects itself as a CH. This process is done in a way that each node becomes a CH once in the time period of 1/P round. The CH selection procedure is done on the probabilistic basis. Each node generates a random number *R* in the range of 0 and 1.If this value is less than threshold value computed by the equation given below, and then that node becomes a CH.

$$T_N = \begin{cases} \dfrac{P}{1 - P\left[r.mod\frac{1}{P}\right]} & if\ n \in G \\ 0 & otherwise \end{cases} \tag{1}$$

where, T_N = Threshold value,
P = Optimal Probability
r = current round number

G = Set of nodes which have not become a CH in 1/P round

This protocol is most appropriate when there is a need for constant monitoring by the sensor network. However, LEACH is not applicable for networks with large geographical areas.

2.2 SEP (Stable Election Protocol)

SEP (Stable Election Protocol), an enhancement of LEACH, is a heterogeneous-aware protocol [3] [9]. In [9], Smaragdakis et al. assumed that a certain proportion of population of nodes is equipped with more energy as compared to other nodes. The nodes with higher energy are referred to as advanced nodes and rest are called normal nodes. Hence, in SEP, two-level of node heterogeneity is introduced : advanced nodes and normal nodes. CH selection is done on probabilistic basis for each node.

Let m be the fraction of total population of sensor nodes (n) with α times more energy than the other nodes. The remaining (1-m)*n nodes are normal nodes. Let us define as P_{nrm} the weighted election probability for normal nodes, and P_{adv} the weighted election probability for the advanced nodes, which can be calculated as:

$$P_{nrm} = P/(1+m*\alpha) \quad (2)$$
$$P_{adv} = P(1+\alpha)/(1+m*\alpha) \quad (3)$$

In Equation (1), we replace P by the weighted probabilities to obtain the threshold that is used to elect the cluster head in each round. SEP provides longer stability period (time period between the start of operation and death of first node) and higher average throughput than clustering protocols like LEACH and FAIR.

But the CH selection among sensor nodes is not dynamic, due to which the nodes that are far away from the powerful nodes will die first.

2.3 ESEP (Enhanced Stable Election Protocol)

Enhanced Stable Election Protocol (ESEP) is the improvement and enhancement of SEP. In [3][5],authors considered three types of sensor nodes, as advanced nodes, normal nodes and intermediate nodes. Intermediate nodes are the nodes which have energy less than the advanced nodes and slightly more than the normal nodes.

Let m is the proportion of advanced nodes to the total number of nodes n with α times more energy than the rest of the nodes and b is the proportion of intermediate nodes with μ times more energy than the normal nodes. We proceed with the similar assumptions as used in SEP. Let P_{nrm}, P_{int} and P_{adv} be the probabilities of becoming normal, intermediate and advanced nodes respectively.

$$P_{nrm}=P / (1 + m*\alpha + b*\mu) \quad (4)$$
$$P_{int} = P * (1 + b) / (1 + m*\alpha + b*\mu) \quad (5)$$
$$P_{adv} = P * (1 + \alpha) / (1 + m*\alpha + b*\mu) \quad (6)$$

For the sensor nodes to become cluster heads, a new threshold for the election processes is defined. The threshold $T(n_{nrm})$, $T(n_{int})$, $T(n_{adv})$ for normal, intermediate and advanced respectively becomes:

$$T(n_{nrm}) = \begin{cases} \frac{P_{nrm}}{1-P_{nrm}\,[r \times mod\,(1/P_{nrm})]} & if\ n_{nrm} \in G' \\ 0 & otherwise, \end{cases} \quad (7)$$

where, G' is the set of normal nodes that has not become cluster head in the past $1/P_{nrm}$ round r

$$T(n_{int}) = \begin{cases} \frac{P_{int}}{1-P_{int}\,[r \times mod\,(1/P_{int})]} & if\ n_{int} \in G'' \\ 0 & otherwise, \end{cases} \quad (8)$$

where, G'' is the set of intermediate nodes that has not become cluster head in the past $1/P_{int}$ round r.

$$T(n_{adv}) = \begin{cases} \frac{P_{adv}}{1-P_{adv}\,[r \times mod\,(1/P_{adv})]} & if\ n_{adv} \in G''' \\ 0 & otherwise, \end{cases} \quad (9)$$

where, G''' is the set of advanced nodes that has not become cluster head in the past $1/P_{adv}$ round r.

Due to three levels of heterogeneity in ESEP, the power saving advantage is little enhanced as compared to SEP. The limitation of ESEP is same as SEP.

2.4 TEEN (Threshold Sensitive Energy Efficient sensor Network protocol)

Threshold sensitive Energy Efficient sensor Network protocol (TEEN) is the first reactive protocol in the field of sensor networks [7]. This protocol is used for time-critical applications. The nodes continuously sense the environment. But the data is transmitted less frequently. As this protocol is threshold sensitive, so, there are two threshold values: hard threshold and soft threshold. The first time a parameter from the attribute set reaches its hard threshold value, the node switches on its transmitter and sends the sensed data. The sensed value is stored in an internal variable in the node, called the sensed value (SV). Next time, data packets are transmitted if there is any difference between the sensed data value and previously saved data value or it equals or exceeds the soft threshold value. Whenever a node transmits data, SV is set equal to the current value of the sensed attribute.

The main features of this scheme are that the time critical data is transmitted instantaneously. Data transmission is not frequent, hence, energy consumption is less because sensing consumes less energy as compared to the data transmission. The main drawback of this scheme is that, if the thresholds are not reached, the nodes will never communicate, the user at the destination will not get any data from the network at all and will not come to know even if all the nodes die. Thus, this scheme is not well suited for applications where the user needs to get data on a regular basis.

2.5APTEEN (Adaptive Periodic Threshold Sensitive Energy Efficient sensor Network protocol)

APTEEN is an enhancement of TEEN and it allows periodic transmission in the network. In [11], authors combined the best features of proactive and reactive protocols by creating a Hybrid protocol that sends data periodically, as well as responds to sudden changes in attribute values. A TDMA schedule was introduced such that each node in the cluster is assigned a transmission slot. They assumed that two nodes close enough in a cluster work in pairs. One node from each pair respond to a query. The other node can go to a "sleep" mode and need not receive the query. Thus, two nodes can alternately take the role of handling queries. Hence, TDMA schedule was such modified that that sleeping nodes transmit the non-critical data without waiting for idle node's next slot.

The main drawback of this scheme is the additional complexity required to implement the threshold functions and the count time. However, this is a reasonable trade-off and provides additional flexibility and versatility.

2.6 TSEP (Threshold-Sensitive Stable Election Protocol)

To control trade-off between energy efficiency, accuracy and response time dynamically, Threshold-Sensitive Stable Election Protocol (TSEP) was introduced in [8]. TSEP combines the features of ESEP and TEEN protocols. TSEP is also a reactive routing protocol and it has three different levels of energies. Like ESEP, it calculates the probabilities for normal nodes, intermediate nodes and advanced nodes to become the cluster-heads(CHs) by equations (4), (5) & (6). Using these probability values in equations (7), (8) & (9), nodes become the cluster heads. Like TEEN, all nodes keep on sensing environment continuously and data is transmitted when threshold is reached.

But, in TSEP, there is no calculation of energy levels for cluster head (CH) selection, CH is still probability based. In probability based cluster head selection, low energy nodes may be selected as cluster head and high energy nodes may not be selected as cluster head.

2.7 ELBSEP (Energy Level Based Stable Election Protocol)

To address the problem of probability based CH selection in above protocols, Yogesh Mishra, Ashish Singhadia, Rashmi Pandey proposed Energy Level Based Stable Election Protocol (ELBSEP) in [8]. It is based on residual energy level estimation of sensor nodes as well as it combines the best feature TSEP protocol and also provides mechanism for periodical data packet gathering in WSN. For cluster formation in the WSN, the base station (BS) broadcasts a signal at a fixed energy level. Each node in the network computes its approximate distance from base station based on received signal strength. It provides the sensor nodes to estimate the proper power strength level to communicate with base station. Clusters are produced by this clustering formula given below:

$$R_{ci} = \left(1 - c\,\frac{d_i - d_{min}}{d_{max} - d_{min}}\right) R_{max} \tag{10}$$

where, R_{ci} = the range of radius in the network for cluster formation,
d_{max} = maximum distance from sensor node to base station,
d_{min} = minimum distance from sensor node to base station,
d_i = distance from node i to base station in WSN,
c = weighted factor (value is between 0 to 1),
R_{max} = maximum competition radius.

The competition radius of the sensor node is estimated by d_i. If d_i is bigger, then R_{ci} will be smaller. The diameter of the cluster in the WSN dominated by node i is

$$R_a = 2R_{ci} \tag{11}$$

Optimal probability for normal, intermediate and advanced nodes can be calculated using equations (4), (5) & (6).

The total energy of normal nodes = n.b (1+α)
The total energy of advance nodes = $n.E_0$ (1 - m - b.n)
The total energy of intermediate nodes = $n.m.E_0$ (1+α)
And finally the total Energy of all the nodes =
$n.E_0(1-m-b.n)+n.m.E_0(1+\alpha)+n.b(1+\mu) = n.E_0(1+m.\alpha+b.\mu)$
where, E_0 = Energy of normal nodes.

The threshold levels for normal nodes are calculated as

$$T_{nor} = \begin{cases} \dfrac{P_{nor}}{1 - P_{nor}\left[r.\,mod\,\frac{1}{P_{nor}}\right]} \times \dfrac{E_{current}}{E_{initial}} & if\ P_{nor} \in G' \\ 0 & otherwise \end{cases} \tag{12}$$

where, G' = Set of those normal nodes that have not became cluster head in previous round.
$E_{current}$ = Residual energy of the node at current time.
$E_{initial}$ = Residual energy of the node at initial time.

The threshold levels for intermediate nodes are calculated as

$$T_{int} = \begin{cases} \dfrac{P_{int}}{1 - P_{int}\left[r.\,mod\,\frac{1}{P_{int}}\right]} \times \dfrac{E_{current}}{E_{initial}} & if\ P_{int} \in G'' \\ 0 & otherwise \end{cases} \tag{13}$$

where, G'' = Set of those intermediate nodes that have not became cluster head in previous round.

The threshold levels for advanced nodes are calculated as

$$T_{adv} = \begin{cases} \dfrac{P_{adv}}{1 - P_{adv}\left[r.\,mod\,\dfrac{1}{P_{adv}}\right]} \times \dfrac{E_{current}}{E_{initial}} & if\ P_{adv} \in G''' \\ 0 & otherwise \end{cases} \quad (14)$$

where, G''' = Set of those advanced nodes that have not became cluster head in previous round.

ELBSEP has better aspect of energy consumption and improved lifetime of the WSN and this improvement is due to node heterogeneity and ratio of current energy to initial energy of the nodes. The limitation of ELBSEP is that if threshold value is not reached, the base station will not receive any information or data from sensor network and even all the sensor nodes of the network become dead, system will be unknown about this limitations. So, ELBSEP is not useful for those types of applications where a sensed data is required frequently and continuously.

3. PROPOSED PROTOCOL

In this Section, we introduce a new protocol which is an improvement on ELBSEP. This protocol meets the limitations of existing ELBSEP by allowing periodic transmissions for non-critical data in the networks by combining the features of existing ELBSEP with APTEEN.
In a sensor network, close-by nodes fall in the same cluster, hence they sense similar data and try to send their data simultaneously which causes possible collisions. We introduce a TDMA schedule such that each node in the cluster is assigned a transmission slot, as shown in Fig. 1.

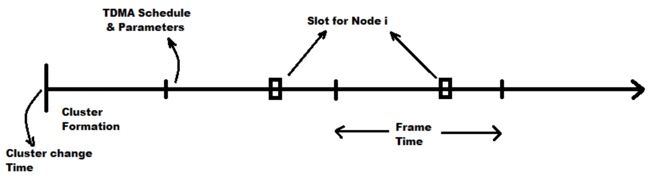

Fig.1 TimeLine of the protocol

If we assume that adjacent nodes can sense similar data, we can form pairs of two nodes and make only one node from each pair respond to a query. The other node can go to a "idle" mode and need not receive the query. Thus, two nodes can alternately take the role of handling queries if there are nodes close enough to form pairs.

3.1 Modified TDMA Schedule

A best possible pairing of active and idle nodes can be found by the BS using simulated annealing. BS sends queries to the nodes. The nodes which listen to the queries have to be always awake (i.e., in active state ready to receive any query). Also, these active nodes will have more data to send if they receive queries, since they might have to send data as well as the queries. Hence, the slots for these active nodes have to be larger than the slots for the idle nodes. By modifying the TDMA schedule, we can have the idle nodes send their data first and then the active nodes. For example, if adjacent node a and node b constitute idle/active pair, they will have their slots at an average distance of half the frame time. So, even though the interval between two successive slots of node a is larger because of larger slots for active nodes, the critical data can still be sensed and transmitted by node b without having to wait for node a's next slot. The nodes can change their roles midway between cluster change times, so that sleeping nodes now go into idle mode to handle queries and the idle nodes now go into sleep mode.

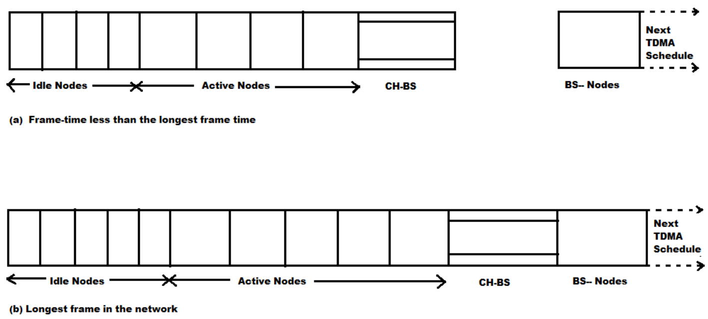

Fig. 2 Different Frame lengths in a network

The CH aggregates all the data and sends it to its higher level CH (or the BS). Once the BS receives the data from all the CHs, it extracts the queries and the answers from the data.

4. PERFORMANCE EVALUATION

4.1 Simulation Environment

We used MATLAB as a simulator for our implementation and performance evaluation of our proposed protocol. Performance attributes used in our MATLAB simulations are as follows:

1. The number of alive nodes during each round.
2. The number of dead nodes during each round.
3. The number of packets sent from cluster heads to the base station,(throughput).

A network consisting of 100 nodes, placed randomly in a region of MxM and a BS located in the center is considered. The area of the network is randomly assigned a temperature between 0˚F to 200˚F. The hard threshold is set at the average value of the lowest and the highest possible temperatures,100˚F. The soft threshold is set at 2˚F for our experiments.

Table -1: Initial Parameters

Parameters	Values
$E_{initial}$	0.60 J
$E_{current}$	0.55 J
P_{opt}	0.1
α	1.30
n	100
m	0.20
B	0.80
E_0	0.60 J

Our evaluation compares the results of proposed protocol with the existing Energy Level Based Stable Election Protocol (ELBSEP).

4.2 Results

In fig.4(a), the curve of graph represents the number of nodes dead during rounds in ELBSEP and fig.4(b) shows the number of dead nodes during rounds in our proposed protocol. As shown in figure, our proposed protocol has better performance as sensor nodes dies later as compared to ELBSEP.
As shown in fig. 5(a) and 5(b), the graph plotted for nodes alive during each round in ELBSEP curve and proposed protocol curve shows that our proposed protocol performs better than ELBSEP as more nodes are alive after each rounds.

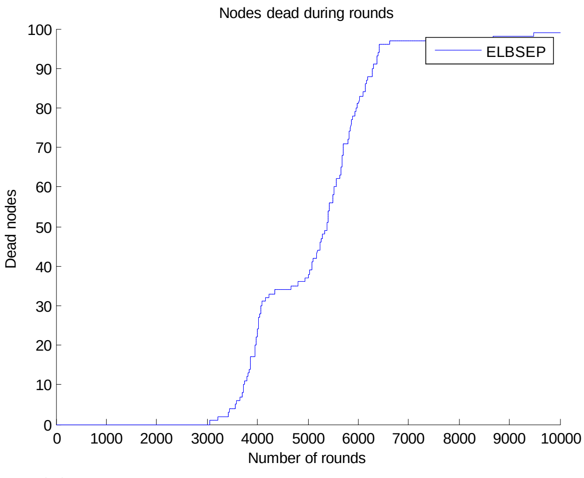

Fig. 4(a) Nodes dead during rounds in ELBSEP

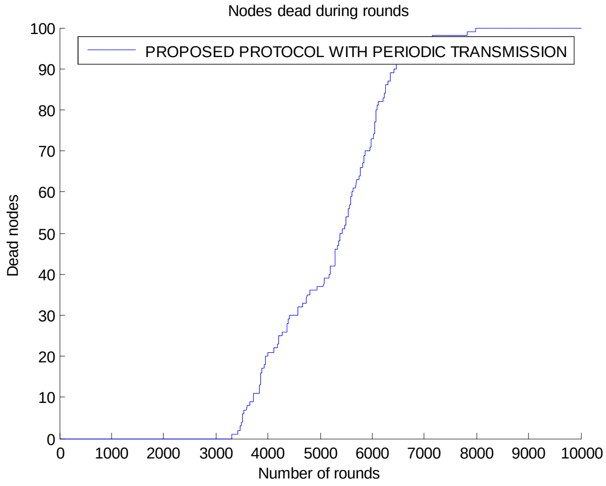

Fig.4(b) Nodes dead during rounds in proposed protocol

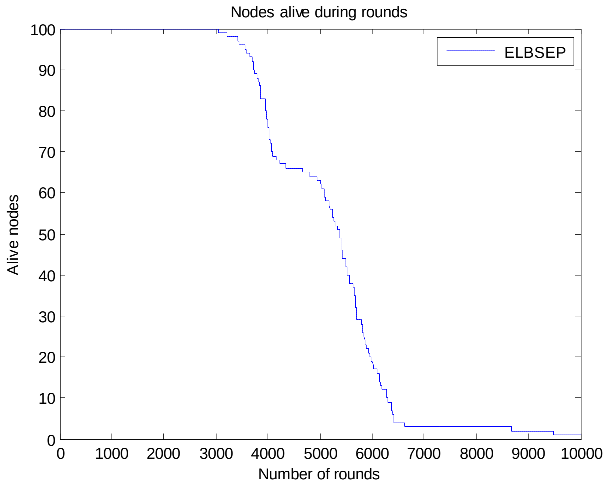

Fig.5(a) Nodes dead during round in ELBSEP

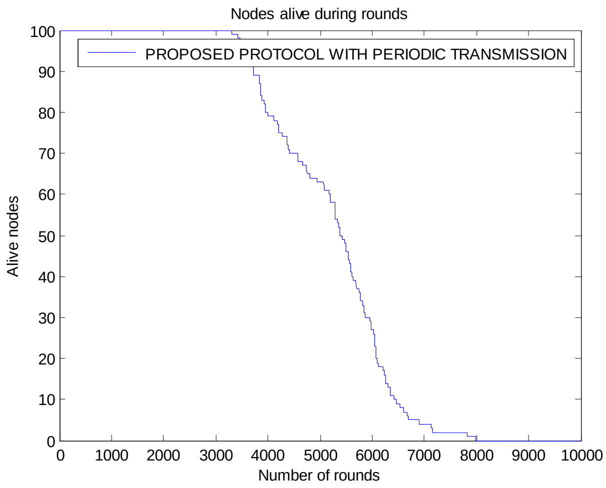

Fig.5(b) Nodes dead during round in proposed protocol

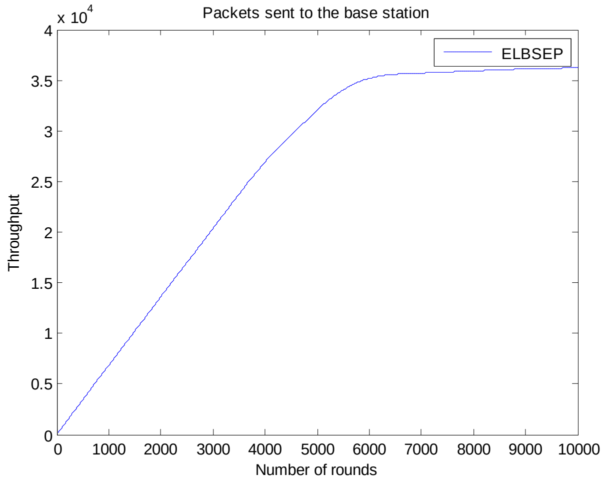

Fig.6(a) Throughput in ELBSEP

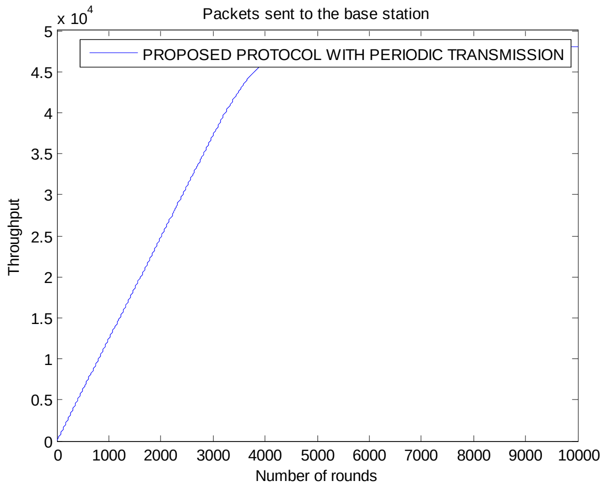

Fig.6(b) Throughput in proposed protocol

In fig. 6(a) and 6(b), the curve for throughput i.e. packets sent during the rounds shows that the throughput for proposed protocol is about 33% more as compared to the throughput in ELBSEP.

After comparison of our proposed protocol with ELBSEP, we evaluated that using our proposed protocol gives better energy efficiency, enhanced network lifetime and greater throughput.

5. CONCLUSION AND FUTURE WORK

In this paper, we proposed a protocol which combines the features of proactive and reactive routing with three different levels of node heterogeneity. Due to the concept of energy level based cluster head selection, hard and soft threshold value, three levels of node heterogeneity, the proposed protocol produces increase in energy efficiency, enhanced lifetime of network and maximum throughput as shown in the simulation result. Our proposed protocol is well suited for both time critical and non-time critical data transmissions. This protocol is suitable for fixed BS and in future, the concept and implementation of mobile base station can be introduced in the protocol to perform the next level of technology of wireless sensor network.

REFERENCES

[1] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A Survey on Sensor Network", IEEE Communication Magazine, 2004, pp. 102-114M.

[2] Ningbo Wang, HaoZhu, "An Energy Efficient Algorithm Based on LEACH Protocol", International Conference on Computer Science and Electronics Engineering (ICCSEE), 2012, pp. 339-342.

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

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

[5] Raju Pal, RituSindhu, Ajay K Sharma, "SEP-E (RCH): Enhanced Stable Election Protocol Based on Redundant Cluster Head Selection for HWSNs", 9th International Conference on Quality, Reliability, Security and Robustness in Heterogeneous Networks, 2013, Vol. 115, pp. 104-114.

[6] Kashaf, A, Javaid, N., Khan, Z.A, Khan, I.A., "TSEP: Threshold Sensitive Stable Election Protocol for WSNs", IEEE 10th International Conference on Frontiers of Information Technology, 2012, pp. 164 -168.

[7] Arati Manjeshwar, Agrawal, D.P., "TEEN: a routing protocol for enhanced efficiency in wireless sensor networks", Proceedings 15th International conference on Parallel and Distributed Processing Symposium 2001, pp. 2009 – 2015.

[8] Yogesh Mishra, Ashish Singhadia, Rashmi Pandey, "Energy Level Based Stable Election Protocol in Wireless Sensor Network", International Journal of Engineering Trends and Technology (IJETT) – Volume 17 Number 1 – Nov 2014.

[9] Georgios Smaragdakis, Ibrahim Matta, Azer Bestavros, "SEP: A Stable Election Protocol for clustered heterogeneous wireless sensor networks" This work was supported in part by NSF grants ITR ANI-0205294, EIA-0202067, ANI-0095988, and ANI-9986397.

[10] Mittal, R. Bhatia, M.P.S., " Wireless sensor networks for monitoring the environmental activities", IEEE International Conference on Computational Intelligence and Computing Research(ICCIC), 2010, pp. 1-5.

[11] Arati Manjeshwar, Dharma P. Agrawal, "APTEEN: A Hybrid Protocol for Efficient Routing and Comprehensive Information Retrieval in Wireless Sensor Networks", IEEE Proceedings of the International Parallel and Distributed Processing Symposium (IPDPSí02).