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## SIMULATION AND ANALYSIS OF A PROTOCOL BASED ON ENERGY LEVEL SELECTION OF CLUSTER HEAD

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## ABSTRACT

In Wireless Sensor Network, the vitality effectiveness is the key issue for planning the convention since sensor hubs have one time battery reinforcement. There are numerous current conventions which develop the lifetime of the remote sensor system by proficiently utilizing battery force of the sensor hub. In this paper, we propose another system and convention Protocol Based on Energy Level Selection of Cluster Head (PBELSCH) in Wireless Sensor Network. We investigate and look at the execution and consequences of present day conventions like PLEACH, DEEC, SEARCH, TEEN and TSEP with PBELSCH. The re-enactment result demonstrates that execution and throughput of our proposed convention gives the compelling and critical vitality proficiency and in addition more system lifetime contrasted with different conventions.

Key words:  Wireless Sensor Networks, Clustering, Energy Efficiency, Stable Election, Network Lifetime, SEARCH.

## INTRODUCTION

Wireless sensor networks (WSNs) [1][2] are group of sensor nodes that sense the environment and send the data to the users. Each sensor node in WSN is an electromechanical sensing device. The microelectronic mechanical systems (MEMS) is a modern advanced technology today and MEMS with wireless communication technologies have developed small sized, low-power andlow-cost multifunctional smart sensor nodes in a wireless sensor network (WSN) [9][10]. For monitoring physical and environmental conditions such as temperature, humidity, radiation, sound, vibration, motion, light and pressure the sensor nodes cooperate together to collect environmental information and data.

 Earlier, the developments, application and usage of wireless sensor networks were initiated by military such as battlefield surveillance; today the modern sensor [9][10] networks are bi-directional and have self-controlling ability. Modern sensor networks are used in many industrial, commercial and consumer applications, such as industrial process control and monitoring, instrument health monitoring, healthcare applications, traffic control system, home automation and so on. The WSN [1] consists of hundreds to thousands sensor nodes, where each sensor node is connected to several sensorexternal antenna, a microcontroller, an electronic circuit for interfacing to the

sensors and a power source, typically a battery or an embedded form of energy source. The cost of sensor nodes may vary, according to the type, size, functionality, applications and complexity of the individual sensor nodes. The cost of the multifunctional sensor is usually higher than the normal single functional sensor node. Size and cost limitations on sensor nodes result in corresponding limits on resources such as power backup, memory, computational speed, processing speed, durability, efficiency, accuracy and communications bandwidth. The network layout and topology of the WSNs may differ from a simple star network to an advanced multi-hop wireless mesh and hybrid network. The information propagation technique among the multiple hops of the sensor network may be routing or flooding. To resolve the scalability and expandability issues the cluster based techniques and protocols have been originally proposed for the wire line networks. Now, the cluster based protocols are used in WSNs to minimize the energy consumption [3].Once WSN is deployed, then the battery recharge or replacement of sensor nodes are not possible practically. Therefore, WSN must operate without human manipulation or involvement so our main focus is to enhance the lifetime of the network in any way and for this purpose many protocols and techniques were introduced and proposed.

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## II. BACKGROUND

In this paper we reviewed, explored and analyzed some modern energy efficient protocols [19]likePLEACH, DEEC, SEARCH, TEEN and TSEP.

*A. PLEACH (Low Energy Adaptive Clustering Hierarchy)*

PLEACH [4] is a proactive and cluster based routing protocol. In PLEACH clustering reduces the energy consumption in sensor nodes. In a wireless sensor network, to distribute the load evenly among all sensor nodes the hundreds and thousands of sensor nodes are dispersed randomly. These sensor nodes continuously sense data, transmit it to their associated cluster heads (CHs) which receive, aggregate and send this data packets to the Base Station (BS) or sink. In PLEACH, all the sensor nodes deployed in the environment are homogeneous and each node has limited battery power. To distribute the work load among all nodes and to improve the lifetime of the network clusters are formed. In this network, each sensor node is made to become CHs on their turns [4]. Each node randomly elect itself as a CH(cluster head) and this process is done in a way that each node becomes a CH once in the time period of 1/ round. Once a node becomes cluster head (CH) then again the same node will become CH after all other nodes get a chance to become a CH. The cluster heads (CHs) selection procedure is done on the probabilistic basis [4], each node generates a random number in the rage of 0
and 1, if generated value is less than threshold value computed by the equation given below [4], and then that node becomes a CH.

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

where,
*TN*= Threshold

*P* = Probability or change of node to become a
CH *r* = Current round number

*G* = Set of nodes which are not became a CH in 1/P round.By using this threshold value, each sensor node will become a CH in 1/P rounds, thus probability of becoming CH among remaining nodes must be increased, and however there are fewer nodes that are eligible to become CH.

*Advantages of PLEACH:*

The strategy of PLEACH [4] protocol is completely distributed, it minimizes energy consumption 4 to 8 times lower in case of multi-hop data packets transmission.
All the sensor nodes in the network die at about the same time due to even distribution of CH work in PLEACH protocol.
The control information from base station is not required for sensor nodesinPLEACH [4]protocol.
PLEACH [4][6] minimizes 7 to 8 times low overall energy consumption as compared to direct transmission and minimum transmission energy (MTE) [6]routing protocol.
Sensor nodes do not require knowledge of global network or identificationin completely distributed wireless sensor network.

*Limitation of PLEACH:*

Nodes have different energy level, but CH is selected unreasonably.
The performance of PLEACH protocol is not ideal for large geographical areas.

*B. DEEC*(*Stable Election Protocol* )

DEEC [7] protocol is an improvement and enhancement of PLEACH [4] protocol which uses clustering based routing strategy based on the node heterogeneity of the sensor node in the networks. In this protocol and technique, some of the sensor nodes have high energy they are referred to as the advanced nodes and the probability of the advanced nodes to become CHs is more as compared to the normal nodes and the normal nodes have lower energy as compared to the advanced nodes in the network. DEEC strategy uses a distributed method to select a CH in WSNs. It is heterogeneity-aware protocol and CH selection probabilities of nodes are weighted by initial energy of each node compared to the other nodes in WSN. So basically, DEEC protocol is based on two levels of node heterogeneity as normal nodes and advanced nodes.
Let, mis the fraction of total number of nodes n, which are deployed with α times more energy than the others nodes.
These powerful nodes are as advanced nodes.

The remaining$(1 - m) \times n$ nodes are as normal nodes.

Probability of normal nodes to become CHs is calculated as

$$P_{nor} = \frac{P_{opt}}{1 + m.\alpha}$$

Probability of advanced nodes to become CHs is

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calculated as

$$P_{adv} = \frac{P_{opt}}{1 + m.\alpha}(1 + \alpha)$$

$P_{opt}$is the optimal probability of each node to become CH in the network. In DEEC [7][8]strategy, selection of CH is done randomly on probability basis for each node. Sensor nodes continuously sense data and transmit it to their associated CH and CH transmit that data it to the sink or base station (BS). This system can be further improved by increasing the value of or P . Due to advance nodes with two level of node hetero geneity, DEEC [7] strategy results in high stable time period, high network lifetime and high throughput.

*Advantage of DEEC:*

Any identification or global knowledge of energy of sensor node is not required in DEEC [7] technique at each selection round of cluster head.

*Limitations of DEEC:*

The cluster head (CH) selection among sensor nodes are not dynamic, which results that nodes that are far away from the powerful nodes will die first.

*C. SEARCH(Enhanced Stable Election Protocol)*

SEARCH [7][11] is improvement and enhancement of DEEC technique. Three type of sensor nodes are considered in SEARCH method, as normal, advance and intermediate nodes on the basis of their energy levels. The purpose of SEARCH is to build a self-configured WSN which enhances network lifetime and stability period. Each sensor node in a network, continuously sense environment and transmits data to their associated CH, whereas, CH aggregates data to reduce data redundancy and sends that data to base station. In SEARCH, advance nodes are some of total nodes having additional energy as in DEEC. Intermediate nodes are some nodes having some extra energy greater than normal nodes but less than advance nodes, and normal nodes are the remaining nodes. In SEARCH, CHs are selected on probability based method for each type of node.

*Advantage of SEARCH:*

Due to three levels of heterogeneity in SEARCH [7][11], the power saving advantage is little enhanced as compared to DEEC.
The limitation of SEARCH is same as DEEC.
*D. TEEN (Threshold Sensitive Energy Efficient sensor Network protocol)*

TEEN [13] is a reactive network routing protocol which is basically used for time critical applications. In TEEN [13] protocol, nodes continuously sense the medium, but the data packets are transmitted less frequently. In TEEN [13] strategy, data packets are transmitted only when there is any change occurs in the environment. TEEN [13] is basically threshold sensitive protocol which is based on two levels of threshold value, first hard threshold and second soft threshold. In hard threshold mode, the nodes transmit data packets if the sensed data value exceeds the limited range and thus it reduces the number of data packet transmissions or frequent data transmission. In soft threshold mode, the nodes transmit data packets if there is any little variation in the sensed data value. The sensor nodes continuously sense the environment and store the sensed data value for transmission up to the hard threshold limit exceeds. Whenever the sensed data value equals or exceeds the hard threshold value, then sensor nodes transmit their data packets to associated CHs. Next time, data packets are transmitted if there is any difference between the sensed data value and previously saved data value is equals or exceeds the soft threshold value. So, in TEEN [13] routing strategy, energy consumption is reduced as well as great throughput is achieved, network lifetime is increased and stability time period is improved than proactive based protocols.

*Advantages of TEEN:*

TEEN [13] is well suited for the time critical applications. In terms of energy consumption and response time TEEN

protocol is quite efficient.
According to the applications and criteria, soft threshold [14] value can be varied.
Smaller value of soft threshold produces more precise result of the WSN.

*Limitations of TEEN:*

The sensor nodes will never communicate, if the threshold value is not reached. No data will be achieved from the sensor network at all and it will be unknown even if all the sensor nodes die.
Cluster heads (CHs) will always wait for data from their nodes and keep their transmitter on.

*E. TSEP (Threshold-Sensitive Stable Election Protocol)*

TSEP [12] combines the features of SEARCH and TEEN protocols. TSEP is also a reactive routing protocol and it has three different levels of energies. Cluster head (CH)selection is done by threshold value, due to three levels of node heterogeneity and being reactive network routing protocol, it produces increased stability period and

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network lifetime. By comparing TSEP with DEEC, PLEACH, SEARCH and TEEN it is concluded that TSEP protocol performs well in small as well as large geographical networks.

*Advantages of TSEP:*

TSEP [12] combines the best features of SEARCH and TEEN protocols.
The performance of TSEP is better than PLEACH, DEEC, SEARCH and TEEN protocols.

*Limitation of TSEP:*

There is no calculation of energy levels for cluster head (CH) selection, CH is still probability based in TSEP protocol.

PLEACH, DEEC, SEARCH, TEEN and TSEP protocols still use probability based cluster head (CH) selection. On 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. PLEACH, DEEC and SEARCH are proactive network routing protocols where nodes continuously transmit data to base station and transmission consumes more energy compared to sensing. DEEC and SEARCH are node heterogeneity aware protocols which improve network lifetime but the limitation of node heterogeneity is this that throughput is also increased which decrease lifetime of WSN. TEEN and TSEP are reactive network routing protocols where frequent data transmission is limited by threshold value. To improve energy efficiency, and network lifetime, our proposed protocol PBELSCH is observed to be better than these protocols.

## III. PROPOSED PROTOCOL

In this section we discuss our new proposed protocol PBELSCH (Energy Level Based Stable Election Protocol) which is based on energy level calculation as well as three levels of node heterogeneity and threshold estimation. Cluster head (CH)selection is based on energy level of nodes in our proposed protocol PBELSCH unlike PLEACH, DEEC, SEARCH, TEEN and TSEP as cluster head is selected on probability bases.

Clustering method [17] provides an efficient and effective way to increase the network lifetime of a WSN. The clustering algorithms discussed in literature review basically utilize two techniques, first the selection of cluster head (CH) with more residual energy and second the rotation of cluster heads (CHs) on the probability basis periodically, for equal distribution of energy consumption among sensor nodes in each cluster and enhance the lifetime of the WSN. To forward data packets to the base

station, cluster heads cooperate with other cluster heads, on the probability bases the cluster heads is selected and high residual energy node may not be selected as cluster head (CH) and low residual energy node may be selected as cluster head (CH).

To address this problem, we propose an Energy Level Based Stable Election Protocol (PBELSCH) which 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 [16] in the WSN, the base station (BS) broadcasts a signal at a fixed energy level. Each node

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

$R_{ci}$ =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

The competition radius of the sensor node is estimated by

$$R_a = 2R_{ci}$$

$d_i$.If$d_i$is bigger, then$R_{ci}$will be smaller. The diameter of the cluster in the WSN dominated by node i is
*Cluster heads formation of the network:*
After cluster formation based on the distance from the base station, cluster head is selection process is conducted. Before cluster head selection, sensor nodes are categorized according to the energy levels in the network. PBELSCH is a reactive network routing protocol, as we know the transmission of data consumes more energy than sensing so data transmission is done only when a specific threshold limit is exceeded and it has three levels of node heterogeneity. For three levels of node heterogeneity [20], sensor nodes with different energy levels are:
[25]    Advanced Nodes
[26]    Intermediate Nodes
[27]    Normal Nodes

Advance nodes are some of total nodes which contain additional energy (advance nodes have energy greater than all other nodes). Intermediate nodes are some nodes which contain some extra energy greater than normal nodes and less energy than advance nodes, while normal nodes are the remaining nodes. In the energy model of PBELSCH, we consider following:
Energy of normal nodes = $E_0$

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Energy for advance nodes $E_{adv} = E_0 (1 + \alpha)$
Energy for intermediate nodes $Eint = E_0 (1+\alpha)$

where,     $\mu = \dfrac{\alpha}{2}$,

The total energy of normal nodes $= n.b\,(1+\alpha)$

The total energy of advance nodes $= n.E_0\,(1 - m - b.n)$ The total energy of intermediate nodes $= n.m.E_0\,(1+\alpha)$

And finally the total Energy of all the nodes $= n.E_0(1 - m - b.n) + n.m.E_0(1+\alpha) + n.b(1+\mu) = n.E_0(1+m.\alpha+b.\mu)$

n =total number of sensor nodes, m=proportion of advanced nodes,

b=proportion of intermediate nodes,

Optimal probability of normal nodes to be selected as cluster head (CH) is calculated by this equation:

$$P_{nor} = \frac{P_{opt}}{1 + m.\alpha + b.\mu}$$

Optimal probability for intermediatenodes to be selected as cluster head (CH) is calculated by this equation:

$$P_{int} = \frac{P_{opt}}{1 + m.\alpha + b.\mu}(1 + \mu)$$

Optimal probability for advanced nodes to be selected as cluster head (CH) is calculated by this equation:

$$P_{adv} = \frac{P_{opt}}{1 + m.\alpha + b.\mu}(1 + \alpha)$$

$P_{opt}$ = Optimal Probability.

For cluster head (CH) selection in our proposed protocol PBELSCH, we improved over TSEP method. In PBELSCH, We have taken threshold levels as the parameters for consideration. Each node generates a random number between 0 and 1, if generated value is less than these threshold then that node becomes a cluster head (CH).
The threshold levels for normal nodes are calculated as

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

G' =Set of those normal nodes that have not became cluster head in previous round.
Ecurrent= Residual energy of the node at current time.
Einitial= Residual energy of the node at initial time.
The threshold levels for intermediate nodes are calculated as

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

The threshold levels for advanced nodes are calculated as

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

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

Here is modification and improvement in our proposed protocol PBELSCH by estimating the ratio of energy levels of node at current time to energy of node at initial time.
Total average number of cluster heads per round =
$n(1 - m - b)P_{nor} + n.b.P_{int} + n.m.P_{adv} = n.P_{opt}$

*Functioning of network:*

In PBELSCH, at the beginning of each round, node by node cluster head (CH) changes take place. At the time of cluster change, the cluster head (CH) transmits the following parameters [18]:

*Report Time:* The time period during which each sensornode successfully transmits the reports.
*Attributes:* The set of physical parameters about whichinformation data is being sent.
*Hard Threshold:* The upper limit of the value for thesensed attribute beyond which the nodes switch their transmitter on and send reports to their cluster head.
*Soft Threshold:* The lowest limit of the value below whichthe nodes switch their transmitters on and transmit data to
their cluster head (CH).
All sensor nodes continuously sense their environment continuously. As the parameters value from attributes equals or exceeds hard threshold limit, transmitter is turned on and the data packets are transmitted to their cluster heads (CHs), however this is for the first time when hard threshold condition is taken place [18]. The

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sensed parameter value is stored by the sensor node is called the "Sensed Value". The next time, sensor nodes transmit data if the sensed value equals or exceeds the upper limit of the hard threshold or if currently sensed value and the previously sensed value equals or exceeds the limit of soft threshold value. So, by estimating hard threshold and soft threshold, the frequent data packet transmissions can be reduced, as the data transmission will only take place when sensed value equals or exceeds the hard threshold [18]. Further data transmissions is taken place by soft threshold, as it minimize transmissions when there is a small changes in value. Some of important functions and features of our proposed protocol PBELSCH are summarized below:

1.PBELSCH is applicable in time critical applications in which data is sent to the user almost instantaneously.
[20]     Sensor nodes continuously keep on sensing but data transmission is not continuous as data transmission consumes more energy than sensing and processing, so energy consumption is much less than that of other networks.

[21]     When the cluster head changes, the threshold value is calculated byratio of current energy to initial energy of the sensor node, so it is a better strategy for cluster head selection in PBELSCH protocol and values of hard threshold, soft threshold, report time and attributes are transmitted, so user can predict the occurrence of sensed values and parameters according to applications. The attributes value can be varied by the user depending on applications and requirement, as attribute values are broadcasted at the time of cluster head changes.

[22]     As PBELSCH use ratio of current residual energy to initial residual energy so it balances the energy consumption among sensor nodes and enhances the network lifetime.

The limitation of PBELSCH 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, PBELSCH is not useful for those types of applications where a sensed data is required frequently and continuously.

## IV. SIMULATION AND PERFORMANCE EVALUATION

We used MATLAB as a simulator for our implementation and performance evaluation of our proposed protocol PBELSCH. Our purpose of estimating simulations is to compare the performance of PBELSCH with DEEC, SEARCH, PLEACH, TEEN and TSEP protocols on the basis of energy consumption, lifetime of the sensor

network and throughput.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).
For simulation of PLEACH, DEEC, SEARCH, TEEN and TSEP, we have taken some initial parameter values as well as the same parameter values for our proposed protocol PBELSCH.

*Table 1: Initial Parameter Settings*

| Parameters | Values |
|---|---|
| Einitial | 0.60 Joule |
| Ecurrent | 0.55 Joule |
| $P_{opt}$ | 0.10 |
| α | 1.30 |
| n | 200 |
| m | 0.20 |
| b | 0.80 |
| $E_0$ | 0.60 Joule |

We are considering that initially our WSN consists of 200 sensor nodes, all sensor nodes are placed randomly in a region and a base station (BS) is located at the outside of that region.

For MATLAB simulation, we initialized some parameterslike$E_{initial}$as 0.60 Joule,$E_{current}$as 0.55 Joule,$P_{opt}$as 0.1, α as 1, n as 200, m as 0.20, bas 0.80 and $E_0$as 0.60 Joule.

On the next MATLAB simulation, we changed the parameters setting to different values. Figure 1 plots the graph of nodes dead during each round. In figure 1, PLEACH protocol is shown as the green curve, DEEC protocol is shown as the red curve, SEARCH protocol is shown as the cyan curve, TEEN protocol is shown as the magenta curve, TSEP is shown as blue curve and our proposed protocol PBELSCH is shown as dashed blue curve. As shown in the figure 1
proposed protocol PBELSCH has better performance as sensor nodes dies later as compared to other protocol.

In figure 2, same colored curves have been used as in figure 1 for PLEACH, DEEC, SEARCH, TEEN, TSEP and PBELSCH. The graph of nodes alive during each

Nodes dead during rounds
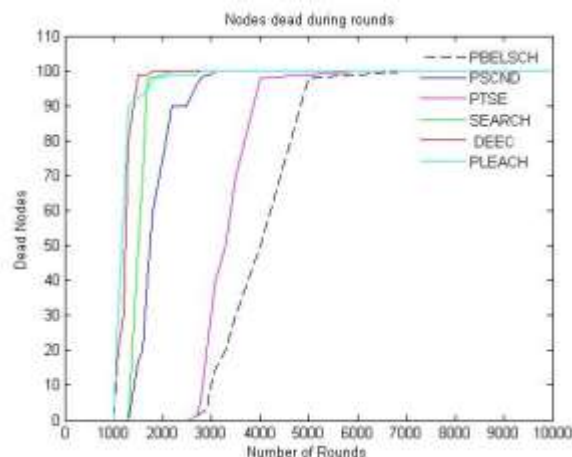
round in figure 2 is the complementary of the graph of nodes dead during each round. Again our proposed protocol PBELSCH performs better as compared to other protocol as shown in the graph. The graph plotted for nodes alive during each round of PBELSCH is shown as again dashed blue curve in figure

Figure 1: Nodes dead during each round

2.protocolPBELSCH performs better than PLEACH, DEEC, SEARCH, TEEN and TSEP as less nodes die after each rounds as compared to these

protocols.

As shown in figure 2, the graph plotted for nodes alive during each round in PBELSCH curve shows that our proposed protocol PBELSCH performs better than PLEACH, DEEC, SEARCH, TEEN and TSEP as more nodes alive after each rounds as compared to these protocols.

The graph of figure 3 plots the data packets send to the base station or throughput. Again the same colored curve are used for PLEACH, DEEC, SEARCH, TEEN, TSEP and PBELSCH protocols.
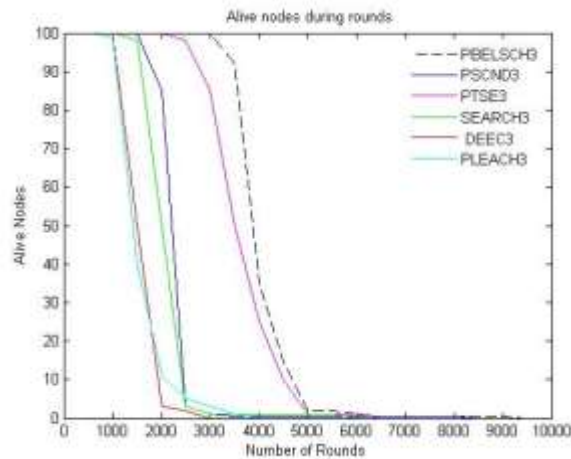


Figure 2: :Nodes alive during each round

For performance evaluation of PBELSCH in MATLAB, we considered the same initial parameter values and the next parameter values as used in PLEACH, DEEC, SEARCH, TEEN and TSEP. As shown in figure 1, the graph plotted for nodes dead during each round in PBELSCH curve shows that our proposed

In our MATLAB simulation, we considered the same parameter setting to compare PBELSCH with PLEACH, DEEC, SEARCH, TEEN and TSEP. The throughput of PBELSCH as the graph of data packet sent to the base station is around double as compared to TSEP, as shown in figure 3which is better than PLEACH, DEEC, SEARCH,

TEEN and TSEP. The curve of PBELSCH throughput shows our proposed protocol sends more data packets to the base station (around 50 % more) as compared to other
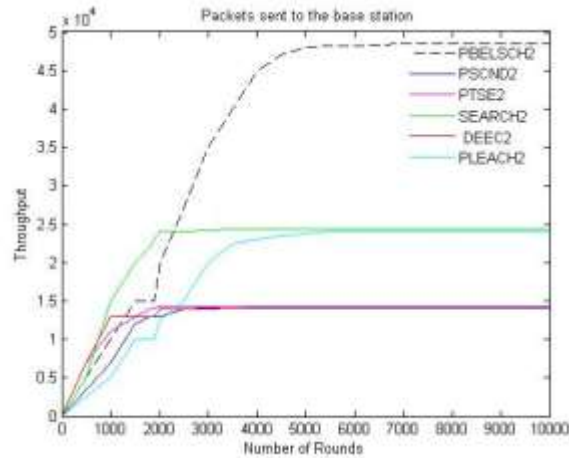


protocols discussed above.

Figure 3: Throughput (Packet sent to base station)

After comparison of PBELSCH with PLEACH, DEEC, SEARCH, TEEN and TSEP, we evaluated that using our proposed protocol PBELSCH, better energy efficiency, enhanced network lifetime and greater throughput.

## V. CONCLUSION AND FUTURE WORK

In this paper, we proposed PBELSCH as a receptive system directing convention with three distinctive levels of hub heterogeneity. PBELSCH consolidates the best elements of TSEP and vitality level estimation technique. Because of the idea of vitality level based group head choice, hard and delicate edge esteem, three levels of hub heterogeneity and being receptive directing system convention PBELSCH produces increment in vitality proficiency, upgraded lifetime of system and most extreme throughput as appeared in the reenactment result. In examination with DEEC, PLEACH, SEARCH, TEEN and TSEP it can be inferred that our convention PBELSCH will perform well in little and additionally huge topographical systems and most appropriate for time basic applications.

However PBELSCH is not reasonable where regular data is gotten from remote sensor system. Ourfuture bearing will be to defeat this restriction in this convention. At long last, in future, the idea and usage of versatile base station can be acquainted in PBELSCH with perform the following level of innovation of remote sensor system.

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