THRESHOLD SENSITIVE HETEROGENOUS ROUTING PROTOCOL FOR BETTER ENERGY UTILIZATION IN WSN

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ABSTRACT

Advancements in WSN have led to the wide applicability of sensor network in various fields. WSNs basic classification is Reactive and Proactive network. Reactive networks responds to the very immediate changes in its environment in required parameters of interest, as opposed to the Proactive network, due to continuous sensing nature of WSN. To make it more efficient and improved in terms of Energy in network's lifetime, we need to reduce the energy expense in the network model, which is one of the most significant issues in wireless sensor networks (WSNs) [1, 2]. In this paper, we proposed an efficient version of TSEP Protocol, which prolongs the networks lifetime by efficient utilization of sensor energy, as we have simulated. We evaluated the performance of our protocol and compared the results with the TSEP. And from the results of simulation, it can be concluded easily that our proposed efficient routing protocol performs better in terms of network lifetime and stability period.

KEYWORDS

Wireless sensor network, Stable Election Protocol, Threshold sensitive stable election protocol.

1. INTRODUCTION

Advances in technology have led to the development of wireless network domain. Each sensor node in WSN is a small sized and low powered electro-mechanical sensing device [3, 4]. These sensing nodes have many applications like monitoring physical or environmental conditions, such as temperature monitoring, humidity monitoring, sound monitoring, motion monitoring etc. Functionality of wireless sensor devices purely depends upon the battery life time which is very limited in case of wireless sensor. Wireless Sensor Networks allows us to use the collection of these small sensor nodes for enormous real live applications.

WSN made up of few to thousands of small sensor, which continuously sense the application environment for the relevant data information and send information to sink node as data packets.Sensor nodes can be either stationary or mobile depends on the application and can be deployed in the environment randomly or by using proper deployment mechanisms. Sensor's energy gets consumed in continuous sensing the target environment and some of it is reduced during the transmission and reception of data. It is practically not possible to replace or recharge sensor node's batteries once deployed. The objective of our proposed protocol is to prolonged the network lifetime by utilization of sensor node's energy, for this purpose an improved version of TSEP and also Evaluated the Performance of TSEP Protocol in WSN.

2. BACKGROUND

2.1 LEACH PROTOCOL (Low Energy Adaptive Clustering Hierarchy):

It is a clustering based routing protocol, proposed in [5] where CH is always elected randomly and uniformly out of all the nodes in the network, based on some probability. Each node generates a random number ‘r’ between 0 to 1, if generated random value i.e. ‘r’ is less than threshold value of that cluster, computed by the formula given below, then this one node will become the Cluster Head for this round.

$$T = \begin{cases} \frac{p}{1-p[r.mod1/p]} & if \;\; p_{nrm} \in G \\ 0 & otherwise \end{cases} \tag{1}$$

Where, G is set of sensor nodes which have not become CH in 1/P rounds and r is the current round. LEACH works in iterations, where each iteration or round includes the CH set up followed by aggregation of data packet and the transmission of that aggregated data packet to the Base Station (sink). Clusters set up phase will takes place in every round. The network in case of LEACH is homogeneous and energy constrained. After the formation of cluster, sensor nodes sense and transmit data to the CH of corresponding cluster.

2.2 SEP(Stable Election Protocol):

A Stable Election Protocol (SEP)[6], is a heterogeneous routing protocol, having the two different levels of discrimination of nodes using parameters like additional energy factor ‘α’ between the advance sensor node and the normal sensor nodes and the fraction ‘m’ of advance sensor nodes which enhance the network stability period which is critical in many real world applications. The probabilities used by the normal nodes and advance nodes to be chosen as a cluster head will be computed by using the formulas shown below:

$$p_{nrm} = \frac{p}{1 + m.\alpha} \tag{2}$$

$$p_{adv} = \frac{p(1+\alpha)}{1 + m.\alpha} \tag{3}$$

Where, p represents probability of each sensor node to be chosen as Cluster Head.

2.3 TSEP(Threshold Sensitive Stable Election Protocol)[7]:

This protocol comprises of two parts:

• Its a reactive based routing protocol:

– Transmission dissipates more energy than sensing.

– Will takes place when it reaches to specified threshold.

• Three different levels of energy discrimination in sensor nodes.
1. Normal Nodes
2. Intermediate Nodes
3. Advance Nodes

Energy for Normal nodes = E_o (4)

Energy for Intermediate nodes= $E_{int} = E_o(1+\mu)$ (5)

Energy for Advance nodes = $E_{ADV} = E_o(1+\alpha)$ (6)

The optimal probability of nodes:

$$p_{nrm} = \frac{p_{opt}}{1+m.\alpha+b.\mu} \quad (7)$$

$$p_{int} = \frac{p_{opt}.(1+\mu)}{1+m.\alpha+b.\mu} \quad (8)$$

$$p_{adv} = \frac{p_{opt}.(1+\alpha)}{1+m.\alpha+b.\mu} \quad (9)$$

For calculation of threshold depending on their probabilities:

$$T_{nrm} = \begin{cases} \frac{p_{nrm}}{1-p_{nrm}[r.mod1/p_{nrm}]} & if\ p_{nrm} \in G' \\ 0 & otherwise \end{cases} \quad (10)$$

$$T_{int} = \begin{cases} \frac{p_{int}}{1-p_{int}\left[r.\frac{mod1}{p_{int}}\right]} & if\ p_{int} \in G'' \\ 0 & otherwise \end{cases} \quad (11)$$

$$T_{adv} = \begin{cases} \frac{p_{adv}}{1-p_{adv}[r.mod1/p_{adv}]} & if\ p_{adv} \in G''' \\ 0 & otherwise \end{cases} \quad (12)$$

Where G', G'', G''' are the set of normal, intermediate and advance nodes respectively. In case of original TSEP, at the moment of cluster change, the elected CH broadcasts the parameters listed below-

• Report Time (TR)
• Attributes (A)
• Hard Threshold (HT)
• Soft Threshold (ST)

2.3.1 Energy Analysis of TSEP:

Total Energy of Normal Nodes, Intermediate nodes, Advance nodes are:

$E_0(1-m-b.n)$, $E_0.n.b(1+\mu)$ and $m.n.E_0(1+\alpha)$.

Total Energy will be $n.E_0(1+m.\alpha+b.\mu)$ (13)

Energy Dissipation:

Energy Dissipation of Cluster is

$$E_{cluster} = E_{CH} + E_{nonCH} \tag{14}$$

Where

$$\mathrm{E_{CH}} = \mathrm{L.E_{elec}}\left(\frac{\mathrm{n}}{\mathrm{k}}-1\right) + \mathrm{L.}\frac{\mathrm{E_{DA}n}}{\mathrm{k}} + \mathrm{L.E_{elec}} + \mathrm{L.}\epsilon_{\mathrm{fs}}.\mathrm{d_{toBS}^2} \tag{15}$$

$$E_{nonCH} = L.E_{elec} + L.\epsilon_{fs}.d_{toCH}^2 \tag{16}$$

Where ϵ_{fs} depends on the transmitter amplifier model we use and d_{toCH} is the distance between the non-CH node and its CH. Assuming that nodes distribution is purely uniform, it can be shown as

$$E[d_{toCH}^2] = \iint (x^2+y^2)\rho(x,y)dxdy = \frac{M^2}{2.\pi.k} \tag{17}$$

Where ρ(x, y) is nodes distribution.

3. PROPOSED ALGORITHM

To propose an energy efficient routing algorithm, which can reduces the energy consumption inside the network, by selecting a sensor node having higher residual energy as CH. It also includes concept hard threshold and soft threshold to reduce the loss of energy during the transmission to CH by sensor node, as most of energy of a sensor gets consumed in data transmission. Energy for Normal nodes = E_o

Energy for Intermediate nodes = E_{int} = $E_o(1+\mu)$ (18)

Energy for Advance nodes = E_{ADV} = $E_o(1+\alpha)$ (19)

The optimal probability of nodes:

$$p_{nrm} = \frac{E_o}{1+m.\alpha+b.\mu} \tag{20}$$

$$p_{int} = \frac{E_o.(1+\mu)}{1+m.\alpha+b.\mu} \tag{21}$$

$$p_{adv} = \frac{E_o.(1+\alpha)}{1+m.\alpha+b.\mu} \tag{22}$$

Calculation of threshold values depending on the residual energy rather than probabilities:

$$T_{nrm} = \begin{cases} \frac{p_{nrm}}{1-p_{nrm}[r.mod1/p_{nrm}]} * \frac{RE_{nrm}}{E_{AVG}} & if \;\; p_{nrm} \epsilon \, G' \\ 0 & otherwise \end{cases} \tag{23}$$

$$T_{int} = \begin{cases} \frac{p_{int}}{1-p_{int}\left[r.\frac{mod1}{p_{int}}\right]} * \frac{RE_{int}}{E_{AVG}} & if \;\; p_{int} \epsilon \, G'' \\ 0 & otherwise \end{cases} \tag{24}$$

$$T_{adv} = \begin{cases} \frac{p_{adv}}{1-p_{adv}[r.mod1/p_{adv}]} * \frac{RE_{adv}}{E_{AVG}} & if \;\; p_{adv} \epsilon \, G''' \\ 0 & otherwise \end{cases} \tag{25}$$

Where RE_{nrm} , RE_{int}, RE_{adv} are the residual energy of normal, intermediate and advance node respectively and E_{AVG} is the Average Energy of the all the nodes in WSN and p_{nrm}, p_{int} , p_{adv} are the probabilities of normal ,intermediate and advance node respectively , which depends on the energy of the node. Where G', G'', G''' are the set of normal nodes, intermediate and advance nodes respectively. In TSEP, at the time of changing in cluster, the Cluster Head (CH) broadcasts same parameters as TSEP does. Thus, trying to reduce probabilistic behaviour of the TSEP, to make it depends on the residual energy.

3.1 CH selection Phase:

In our protocol, we select the CH based on the weighted election probabilities of the nodes, which basically depends on the residual energy. In our proposed network election probabilities are different based on the three different levels of heterogeneity in the network. The probabilities of election of the CH for normal nodes, intermediate nodes and advanced nodes can be calculated as given in equation (20), (21) and (22). CH selection is done based on the thresholds. Each node generates a random value between 0 and 1 and if this value is less than its particular threshold then the node can become the CH. Calculation of thresholds based on the probabilities of the nodes and can be obtained as shown in equation (23), (24) and (25). And then again we check the all the member node, if any member node is having more energy than the CH, so the transmission will be done by that node only i.e. shown in the pseudo code given below

Pseudocode of CH selection:

```
newCH=CH;
for (c=0, cluster =0: c < clustersize: c++, cluster++ )
{
If ( newCH.Energy < cluster(c).Energy)
newCH=cluster(c)
}
```

Now the transmission will takes place from the newCH. All sensor nodes in WSN keep sensing the application environment continuously. As parameters out of attribute set reaches to hard threshold, transmitter will be turned on and data will be transmitted to Cluster Head, however this is for the first iteration when this condition becomes true or met. This sensed value will be stored in an internal local sense variable, called its Sensed Value (SV). Then for second time onward, sensor nodes will transmits the data if sensed value is greater over the hard threshold value (TH) or if difference of current sensed value and SV variable value is equal to or greater over soft threshold. So, by considering these both thresholds, number of data transmissions rounds can be controlled to save or control the energy of sensor node, as transmission will done only when sensed value reaches hard threshold(HT). While the further transmissions of sensed data packets are led by soft threshold, as it will reduce transmissions rounds when there is a very small changes in values, even smaller than interests. Some of significant features along with the features of TSEP are described below:

1) Selection of Node to become CH purely depend upon the Residual Energy of sensor node using the equation (23), (24) and (25).
2) Strictly focusing on the higher residual energy node by checking all the neighbour nodes in the cluster, which have the greater residual energy.
3) Nodes sense the environment continuously but transmission is not done frequently.
4) The users can change the attributes as per requirements, as attributes set always broadcasted at the time of cluster change.
5) Still it is a probabilistic algorithm, but works specifically based on the Energy of nodes and finally selects the nodes based on the residual energy rather than probabilities.
6) Still the only main adjustments of this protocol is that, if threshold value is not reached, user will not be able to get any information, even if one or all the sensor nodes dies, system will never came to know about that. In nutshell, this approach is useless for the applications where a data is required continuously.

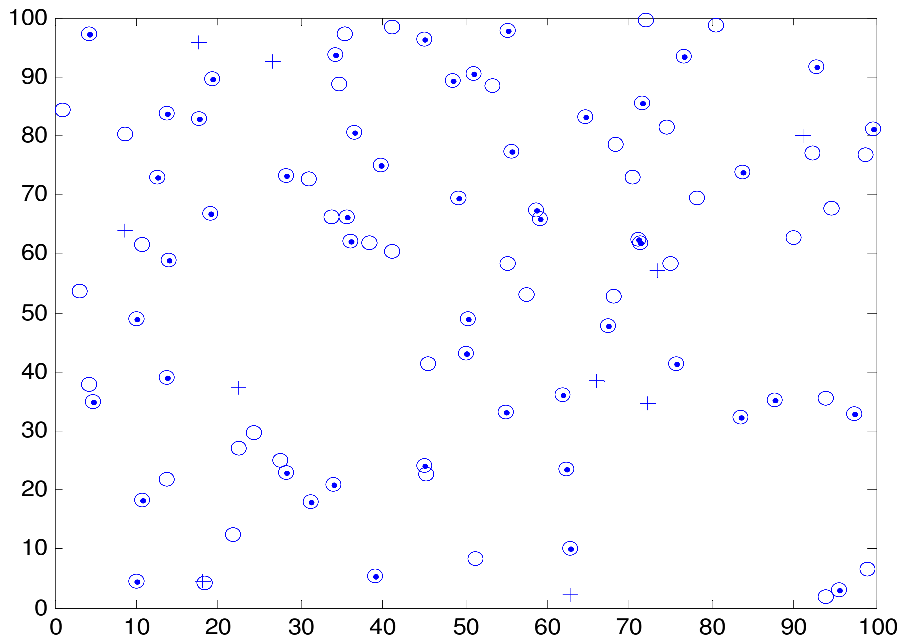
4. SIMULATION RESULTS

we have used the MATLAB simulation tool to evaluate the performance of TSEP and also of the proposed protocol. The performance of our proposed protocol is compared with TSEP based on energy dissipation and longevity of wireless network. Our demonstrated network field have 100 sensor nodes deployed randomly in a region of 100×100 area (in meters). With the value of m = 0.1, $\alpha = 1$ for the various locations of BS in simulated environment. For the first and all iteration or round of simulation, we have considered the BS at the centre of the network area that is (50, 50) i.e. sink is static. This has to be done to observe change in stability of network and network's life about at various BS positions or locations.

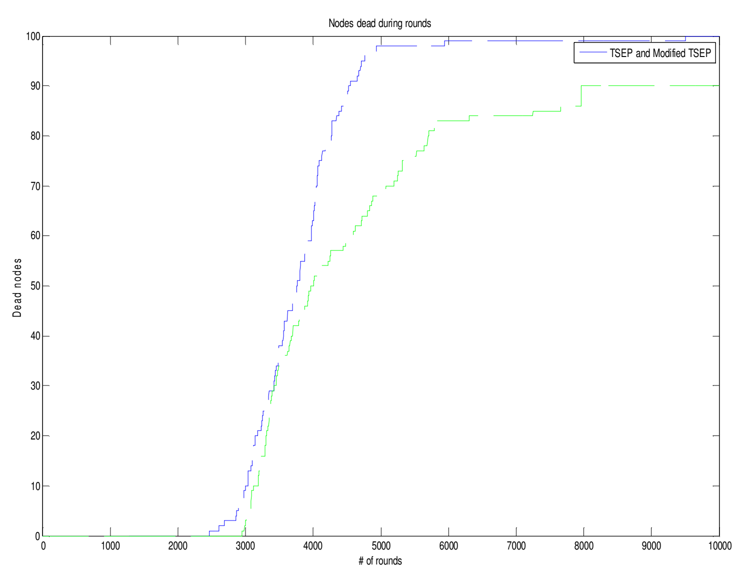
The used parameters in simulations are listed below in Table 1

Parameters	Value
E_{elec}	60nJ/bit
E_{DA}	4nJ/bit/message
ϵ_{fs}	8pJ/bit/m4
ϵ_{mp}	0.0013pJ/bit/m4
E_o	0.6J

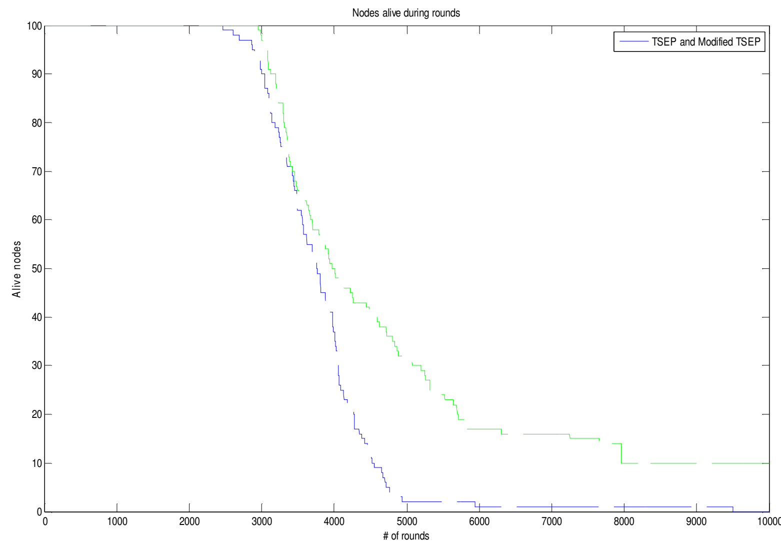
Message size	5000bits



Figure(1): Nodes Distribution.



Figure(2): Dead Nodes Representation.



Figure(3): Alive Node Representation.

Figure (1) represents the pure random deployment of the Sensor nodes in the Wireless sensor Network. Figure (2) represents the number of Dead node with respect to the number of rounds, as well as figure (3) represents the number of Alive node with respect to the number of rounds. Where yellow marked line shows the better performance of the Extended TSEP and the blue marked line shows the performance of TSEP.

By demonstrating simulations in MATLAB Tool, it has been observed that:

• Extended TSEP has enhanced stability period than TSEP protocols, as shown in Figure (2) and Figure (3).

• The network life for Extended TSEP was increased as compared to others.

• Increased and decreased in number of alive and dead nodes with respect to the time respectively.

5. CONCLUSION

We dedicated out work to the cause of finding better solutions for the known problems in the threshold sensitive routing protocols in WSNs. In the course of our study we dissected the problems and investigated their genesis based on which we proposed a novel technique for tackling the problem of maximizing the network lifetime of a sensor network. The proposed algorithm is a threshold sensitive routing protocol which elects the node with highest residual energy as the CH, for this we introduced an additional parameter in the CH election procedure of TSEP.

The results of the simulations substantiate our claims on the efficiency of our proposed algorithm when gauged in terms of the residual energy of the nodes in the sensor network and stability period of the network. Our algorithm is seen to outperform its contemporary algorithms namely

TSEP , which can be attributed to the changes that were suggested by us , hence we can undoubtedly conclude that our proposed algorithm can cater to a wider range of real time applications and is successful in achieving the objectives of our study.

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