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Energy Efficient Stable Election Protocol for Clustered Heterogeneous Wireless Sensor Networks

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Abstract : *Wireless sensor networks are the networks with wireless sensors disseminated in a region which sense various types of information and then transmit this information to the other nodes or to the final destination. These nodes sense the changes in the physical parameters similar to – temperature, pressure, etc. The data sensed by these nodes are then approved to the Base Station (BS) for estimation. Wireless sensor networks are used for the variety of purposes like military surveillances, habitat monitoring, forest fire detections, landslide detections. This paper presents the new clustering algorithm by modifying SEP (Stable Election Protocol) for heterogeneous wireless sensor network, called EE-SEP. Energy Efficient -SEP protocol is used to increase the number of alive nodes and thereby increasing the energy efficiency, stability period and network lifetime and balancing the energy consumption. Simulation results show that proposed Energy Efficient SEP algorithm performs better as compared to SEP.*
***Keywords** - Energy consumption, Energy efficiency, Network life time, Stability period, SEP, EE-SEP, Wireless sensor network.*

I. Introduction

Wireless sensor networks are composed of tiny and miniaturized electronic devices which are recognized as sensors. Sensors can sense, compute, store, send out and collect data of interests from the environment in which they are deployed. appropriate to minute size of sensors, a large size battery supply cannot be embedded into them therefore sensors need efficient mechanism for energy utilization to improve the life time of the sensors in wireless sensor networks, communication protocols plays an important role. The design objective of these protocol is to avoid unnecessary data transmission and reception. For this purpose, switching the nodes into idle or sleep mode when there is no data to send or receive. For efficient utilization of energy resources, many routing protocols are defined. A Sensor Node (SN) is composed of processor, sensor, transceiver, and power units. In addition to performing these functionalities, a sensor node excessively has the ability of routing. sensor nodes face energy optimization and quick route discovery problems, different routing techniques have been proposed to address these issue. Clustering is individual of them and is used in WSNs, which handles these issues efficiently. Base Station (BS) and Cluster Head (CH) are the main components of a clustered network. In a cluster, SNs are located at minimum communication distance. Each cluster is headed by a CH. All the nodes in a cluster are in accessible range of the CH. Member nodes in a cluster send their data to their respective CH, and CH aggregates data and sends aggregated data to the BS.

II. Related Works

SEP[1] (Stable Election Protocol) provides longer stability period and higher average through put than current clustering heterogeneous-oblivious protocols. So every sensor node in a heterogeneous two-level hierarchical network independently elects itself as a cluster head based on its initial energy relative to that of other nodes.

D-SEP[2] (Deterministic-SEP) , for electing cluster heads in a distributed style in two, three, and multi-level hierarchical wireless sensor networks. The significant improvement has been using D-SEP in comparison with SEP in terms of energy consumption, data transmission and network lifetime to Base station.

D-SEP protocol goal is to enlarge the lifetime and stability of the network in the presence of heterogeneous nodes. Since cluster heads consume more energy than cluster members in receiving and sensing data from their component nodes, performing signal dispensation and transfer the aggregated data to next node or base station. D-SEP network lifetime is increased by 4.4 times over SEP. The results clearly show that the stability period of D-SEP is longer as compared to SEP.

Z-SEP[3] Zonal -Stable Election Protocol for heterogeneous environment: two level heterogeneity. The field is divided in to three zones: Zone 0, Head Zone 1 and Head Zone 2. Normal nodes are only deployed in zone 0 to reduce the energy consumption and they transmit data directly to base station. Half of advanced nodes are deployed in Head zone 1 and half in Head zone 2 and they use clustering technique to transmit data to base station. the stability period is increased approximately 50%, by altering the deployment of the different type of nodes in different zones according to their energy requirement. Z-SEP is also increased compared with LEACH and SEP.

H-HEED[4](Heterogeneous - Hybrid Energy Efficient Distributed Protocol) H-HEED for Wireless Sensor Network has been proposed to prolong the network lifetime. H-HEED protocol is proposed for heterogeneous wireless sensor network

DB-SEP[5], an energy-aware adaptive clustering protocol used in heterogeneous wireless sensor networks and compared it to the LEACH and SEP protocols. In DB-SEP, every sensor node independently elects itself as a cluster-head based on its initial energy and the distance separates it of the base station.
DB-SEP uses the low levels hierarchical concept which offers a better use and optimization of the energy dissipated in the network. Results from our simulations shows that DB-SEP provides better performance for energy efficiency and network lifetime.

TDEEC[6] (Threshold Distributed Energy Efficient Clustering) protocol which improves stability and energy efficient property of the heterogeneous wireless sensor network and hence increases the lifetime. TDEEC (Threshold Distributed Energy

OCEA[7]Optimal Cluster Energy Aware Protocol is a hierarchical cluster based technique in which random selection of cluster heads . The concept of threshold is not present in this protocol. Instead, the CHs are chosen by BS based upon the available energies of the nodes in the network. There is an extra overhead in OCEA to aware the BS about the available energies of the nodes at each round, after considering this extra overhead

H-SEP[8] Heterogeneous - SEP, A Stable Election Protocol for clustered heterogeneous for Wireless Sensor Network has been proposed to prolong the network lifetime. H-SEP achieves longer lifetime and more effective data packets in comparison with the SEP and LEACH protocol.

HSEP[9] Heterogeneity-aware Hierarchal Stable Election Protocol having two stage of energies. replication results show that HSEP prolongs stability period and network lifetime, as compared to conservative routing protocols and having higher normal throughput than preferred clustering protocols in WSNs.

Three protocols[10] TEEN, SEP and LEACH that are analyzed energy efficient and clustering algorithms for heterogeneous wireless sensor network. The results shows how the election criteria for cluster heads election such as preliminary Energy Eo, probability amid occurrence of advance nodes with different energy level and base station area concern the number of cluster head selected, and the network life, and provided to the comparative effectiveness of different clustering algorithm on network lifetime, cluster heads selection.

III. Sep Protocol

Existing SEP[1] is a heterogeneity-aware protocol and election probabilities of nodes are weighted by initial energy of each node relative to that of other nodes in a network.

A Stable Election Protocol for clustered heterogeneous wireless sensor networks (SEP) is developed for the two-level heterogeneous networks, which include two types of nodes, the advance nodes and normal nodes according to the initial energy. The revolving epoch with election probability is directly correlated with the initial energy of nodes.

The probability threshold, which each node s uses to determine whether itself to become a cluster-head in every one round, is as follow:

$$T(s) = \begin{cases} \dfrac{p}{1 - p * \mathrm{mod}(r, round(\frac{1}{p}))} & \text{if } s \in G \end{cases} \quad (1)$$

Where G is the set of nodes that are eligible to be cluster heads at round r. In each one round r, when node s find it is eligible to be a cluster head, it will decide a casual number between 0 and 1. If the number is less than threshold $T(s)$, the node si becomes a cluster head during the current round.
Also, for two-level heterogeneous networks, p is defined as follow:

$$pnrm = \frac{popt}{1 + \alpha . m} \quad (2)$$

if s is the normal node

$$padv = \frac{popt}{1+\alpha.m} \times (1+\alpha) \qquad (3)$$

if s is the advanced node

SEP, which improves the stable region of the clustering hierarchy process using the characteristic parameters of heterogeneity, namely the fraction of advanced nodes (m) and the additional energy factor between advanced and normal nodes (α). In order to prolong the stable region, SEP attempts to maintain the constraint of well balanced energy utilization. spontaneously, advanced nodes have to develop into cluster heads more often than the normal nodes, which is equivalent to a evenhandedness restraint on energy consumption. The new heterogeneous setting (with advanced and normal nodes) has no effect on the spatial density of the network so the a priori setting of *popt*, from Equation (1), does not modify. On the other hand, the total energy of the system changes. Assume that *Eo* is the initial energy of each normal sensor.

Now increase the stable region of the sensor network by $1+\alpha\cdot m$ times, if (i) each normal node becomes a cluster head once every 1 $popt \cdot (1+\alpha \cdot m)$ rounds per epoch; (ii) each advanced node becomes a cluster head exactly $1+\alpha$ times every 1 $popt$ $(1+\alpha\cdot m)$ rounds per epoch; and (iii) the average number of cluster heads per round per epoch is equal to $n \times popt$ (the spatial density does not change). Constraint is very strict—If at the end of each epoch the number of times that an advanced sensor has become a cluster head is not equal to $1 + \alpha$ then the energy is not well distributed and the average number of cluster heads per round per epoch will be less than $n\times popt$. This problem can be reduced to a problem of optimal threshold $T(s)$ setting , with the constraint that each node has to become a cluster head as many times as its initial energy divided by the energy of a normal node.

$$T(s_{nrm})\begin{cases} \dfrac{pnrm}{1-pnrm*\mathrm{mod}(r,round(\frac{1}{pnrm}))} & \text{if } s_{nrm}\in G^{l} \end{cases} \qquad (4)$$

$$T(s_{adv})=\begin{cases} \dfrac{padv}{1-padv*\mathrm{mod}(r,round(\frac{1}{padv}))} & \text{if } s_{adv}\in G^{ll} \end{cases} \qquad (5)$$

IV. Ee - Sep Protocol

EE-SEP protocol goal is to decrease the energy consumption, and increase the energy efficiency, stability and lifetime of network by using the initial energy(Eo).In the Existing SEP algorithm using weighted election probability of nodes (P),this weighted election probability can be reduced to the Optimal Threshold value T(s).But EE-SEP algorithm using with the Initial energy (Eo) for the calculation of optimal threshold value T(s).It can be reduced more amount of optimal Threshold value T(s).The Optimal Threshold value T(s) is also reduces the Cluster head selection. As a result of it increasing the amount of alive nodes, Alive nodes using their own energy at that time of data Aggregation and Data transmission. In this process using the minimum amount of energy consumption and EESEP Algorithm provide more energy efficiency, and prolongs the stability period and network life time than previous sep algorithm and improve the quality of the estimation of wireless clustered sensor networks, in the occurrence of heterogeneous nodes.

The heterogeneous network model has been exists. The number of nodes which are distribute randomly within a 200M $\times$ 200M square region.The Sensor Nodes are uniformly and randomly deployed in the network. The Base Station which is located at the centre of the sensing field.

Sensor Nodes introduce the sensors in the field after those sensor nodes should be clustering. Clustering means group of nodes each node have different levels of energy.

Epoch is calculated by using that new formula modulus of initial energy multiplies with current round divided by 2.And round of one is added with supplementary energy factor divided by (n*p^m).

$$Epoch = (\mathrm{mod}(Eo*r/2, round(1+a/n*p\wedge m))$$

Calculated the Energy by using the distance and transmit amplifier packet length, data aggregation energy. Distance is denoted by d1 ,The distance is greater than or equal to initial energy. The EDA is the energy required for data aggregation. Maximum round is denote rmax. Otherwise Energy degenerate By Associated

Cluster Heads. energy is calculated by using the minimum distance and ETX character packet length, Emp packet length and Efs character packet length, Efs packet length. The minimum distance is denote by min_dis.The min_dis is greater than initial energy.

cluster head formation of SEP protocol, nodes elect themselves as cluster heads based on their energy levels, retaining more uniformly distributed energy among sensor nodes. EE-SEP protocol goal is to increase the lifetime and stability of the network in the presence of heterogeneous nodes. Since cluster heads consume more energy than cluster members in receiving and sensing data from their member nodes, performing signal processing and sending the aggregated data to next node or base station, the role of cluster head must be rotated among sensor nodes. Therefore, EE-SEP works in rounds as SEP and also considers how to optimally select the cluster heads in the heterogonous network. At each round node decides whether to become a cluster head based on threshold calculated by the suggested percentage of cluster heads for the network (determined a priori) and the number of times the node has been a cluster-head so far. This decision is made by the nodes by choosing the random number between 0 and 1. If the number is less than a threshold *T(s)* the node becomes a cluster-head for the current round. In proposed EE-SEP algorithm, threshold value is calculated by using this formula.

$$T(S)=\left\{\frac{Eo-p}{6*(Eo-p*\mathrm{mod}(r,round(1+a/Eo-p)*(\frac{n}{Eo-p\text{^}2}))))}\right\}$$

if $S\in G$ (10)

where P is the weighted election probability of nodes to become a CH(cluster Head). T(s) is threshold value, Eo is initial value of energy, the new sep algorithm decreasing the value of Election of cluster head by using initial energy Eo. The threshold formula contain probability of nodes per epoch but the new sep algorithm Threshold formula is initial energy minus weighted election probability of nodes per six times of, (Eo-p) initial energy Eo is subtracted by the weighted election probability of nodes p, modulus of current round and round of (1+ a).(1+a) is an supplementary energy factor between the nodes divided by (Eo-p).and multiplies with number of nodes divided by (Eo-p^2). Finally decreasing the threshold value so decreasing the amount of cluster head selection . At the same time increasing amount of alive nodes , alive nodes are using their own energy for data aggregation and data transmission .In this process take the minimizing level of energy consumption and it provide more energy efficiency, and prolongs the stability period and network life time. Using the parameters described in Table 1.

Parameter	Value
n	300
r	10000
E0	0.5J
The Length of Packets	4000
Ctr Packet Length	100
ETX	5×10^{-8} pJ/bit/m^4
ERX	5×10^{-8} pJ/bit/m^4
Efs	10 pJ/ bit/m^2
Emp	0.0013pJ/bit/m^4
EDA	5 nJ/bit/message
P	0.05

Table 1:Parameters used in simulations

V. Simulation Result

The proposed EE-sep protocol goal is to increase the stability and lifetime of the network, energy efficiency and as a result increase the alive node than previous sep algorithm. That improve the energy efficiency, stability period and network life time, in the presence of heterogeneous nodes. It Compare total amount of alive nodes and proposed EE-SEP algorithm. The simulation results shows the EE-SEP protocol can get large amount of alive nodes and reduced the amount energy consumption , and energy efficiency, network stability period and life time also better than sep protocol.

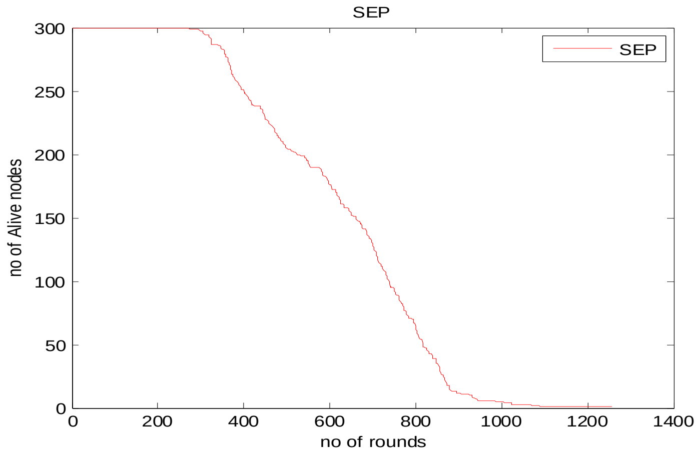

Fig 1: Alive nodes presents the sep in heterogeneous networks.

Figure [1] shows the amount of alive nodes present in SEP algorithm. Rounds increases from 0 to 10,000. The number of alive nodes was calculated for each round in order to find the energy efficiency of the network. The existing algorithm increasing the number of alive nodes is 12% percentages. When the number of rounds is 500,250 nodes are alive and 1000, 10 nodes were alive and when the number of rounds 2000, there has no alive nodes in SEP protocol.

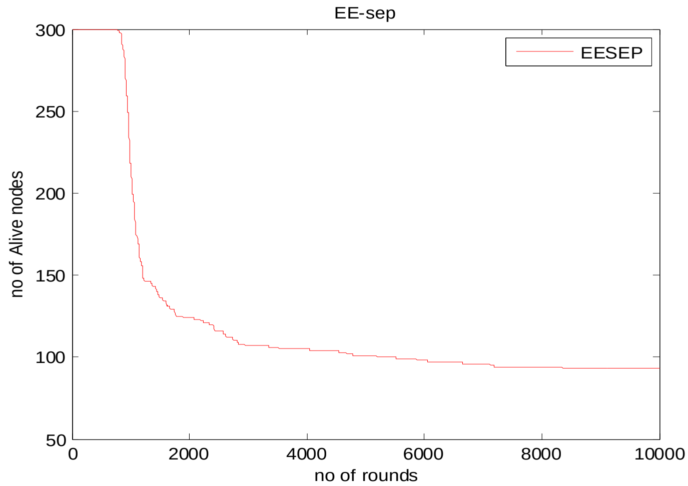

Fig 2: Amount of alive nodes presents the EE-SEP in heterogeneous networks.

Figure[2] shows the amount of alive nodes present in the EESEP algorithm. Rounds increases from 0 to 10,000. The number of alive nodes was calculated for each round in order to find the energy efficiency of the network. The proposed Energy Efficient SEP algorithm increasing the number of alive is 54% percentages. When the number of rounds is 1000, 300 nodes were alive and when round=2000, 120 nodes are alive and when round=4000, 110 nodes are alive and round=6000, 100 nodes are alive and round= 8000,10000,below 80 nodes are alive in EESEP protocol.

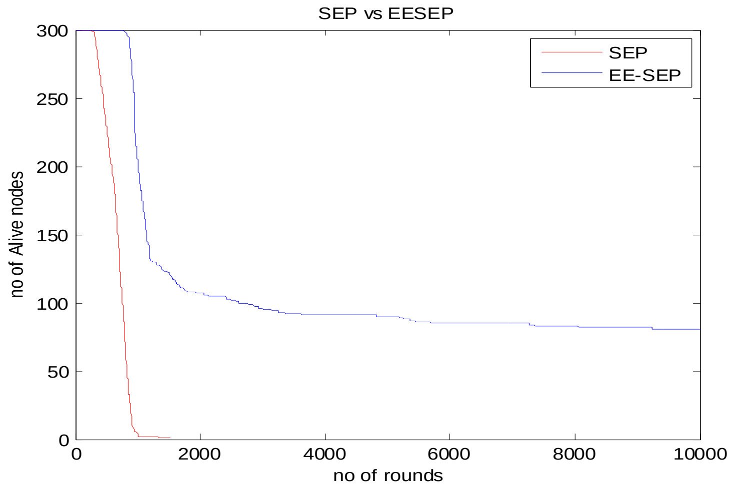

Fig 3: Comparison of SEP and EE-SEP protocols

Number of rounds	Number of Alive nodes	
	SEP protocol	EE-SEP protocol
500	250	300
1000	10	300
1500	0	130
2000	0	120
4000	0	110
6000	0	100
8000	0	80
10000	0	80

Table-2:The alive nodes of SEP and EE-SEP protocol

fig.3 shows that the EE-SEP and SEP protocol comparisons ,table.2 is the Observation of figure.3. SEP protocol has above 250 alive nodes in 500 rounds, it contain only 10 alive nodes in 1000 rounds and1500,2000rounds has there is no alive nodes. The SEP algorithm increasing the number of alive nodes is12% percentages.

But EE-SEP protocol has above 300 alive nodes in 500 rounds, above 300 alive nodes in 1000 rounds, above 70 alive nodes in 1500 round,125 alive nodes in 2000 rounds, above 110 alive nodes in 4000 rounds and 100 nodes in 6000 rounds. Below 100 alive nodes present in 8000 and 10000rounds. The proposed Energy Efficient SEP algorithm increasing the number of alive nodes is 54% percentages.

finally the simulation results shows more than 42% of alive nodes present in EESEP protocol, alive nodes are using their own energy at that time of data aggregation or data transmission. so alive nodes are minimizing the amount of energy consumption. alive nodes are the basic factor of network lifetime, EESEP algorithm contain more amount of alive node as a result it has the more network lifetime and stability . so EESEP protocol is better than comparative with SEP protocol.

VI. Conclusion

The EE-SEP protocol for the heterogeneous wireless sensor network , discussed the two types of sensor nodes (normal and advanced) possible for the wireless sensor networks. It evaluates the performance of SEP and EE-SEP protocol under these energy models using MATLAB. EE-SEP is energy efficient than SEP. It is observed that there is minimizing level of energy consumption, energy efficient, more stability, and network life time ,only required in case of EE-SEP protocol in comparison with SEP protocol.

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