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Regional Stable Election Protocol (RSEP) for WSNs

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Abstract: *Wireless Sensor Networks (WSNs) consists of millions of sensor nodes, with limited energy, that accomplish a sensing task. Variety of routing protocols are developed for transmission of data in WSNs. In this paper a hybrid routing protocol RSEP is proposed for heterogeneous WSNs. In proposed protocol some nodes transmit data directly to Base Station (BS)and the rest of the nodes use clustering technique to transmit data in to BS as in Stable Election Protocol (SEP) .RSEP is implemented and simulation results are compared with Low Energy Adaptive Clustering Hierarchy (LEACH) and SEP. Simulation results prove that RSEP has improved stability period and throughput than LEACH and SEP*

Keywords: *Regional,Stable,Election,Protocol,Wireless,Sensor,Network.*

I. Introduction

WSNs consists of millions of sensor nodes that are deployed haphazardly to detect physical or environmental conditions. Sensor nodes in WSNs consist of components which are capable to sense data, to process data and communication components for further transmission and reception of data. The protocols and algorithms of suck networks must possess self organizing capabilities to ensure accurate and efficient functioning of the network. Communication in WSNs is possible in different ways based on the application. Usually there three main types of communication

1.Clock driven : Sensors detect and collect data at constantly and periodically communicate
2. Event driven : Communication is triggered by a specific event
3. Query driven : Communication occurs in response to a query

In all three types of communication , efficient use of energy is of concern while studying, designing or deploying such networks to prolong the sensing time and overall lifetime of the network .Hierarchical routing protocols have been proved more energy efficient routing protocols. Many protocols are developed for homogeneous networks. LEACH [1] os one of the first clustered based routing protocol for homogeneous network. LEACH assigns same probability for all nodes to become Cluster Head (CH).But LEACH does not perform well in heterogeneous environment. Heterogeneity of nodes with respect to their energy level has also proved extra lifespan for WSNs. To improve the efficiency of WSNs SEP[2] was designed. SEP is a two level heterogeneous protocol. SEP allocates different probability (to become CH) for nodes depends on their energy level. But , SEP does not use extra energy of higher level nodes efficiently .

To transfer data from nodes to Base Station (BS) we need minimum dissipation of energy. Hence a better routing protocol is essential for efficient usage of energy. Traditional protocols were inefficient to fulfill this demand. In this paper, a hybrid approach is proposed for transmission of data to BS. In this approach some nodes send their data directly to BS and the rest of the nodes use clustering algorithm for sending data to BS. The proposed protocol improves the stability period, network lifetime and throughput of the network.

II. related work

LEACH [1] is a hierarchical clustering algorithm for accurate usage of energy in the network. LEACH uses randomized rotation of the local CH. LEACH performs well in homogeneous environment. In LEACH every node has same probability to become a cluster head. However, LEACH is not well suited for heterogeneous environment. SEP is a two level heterogeneous protocol introducing two types of nodes, normal nodes and advance nodes. Advance nodes have more energy than normal nodes. In SEP both nodes (normal and advance nodes) have weighted probability to become cluster head. Advance nodes have more chances to become cluster head than normal nodes. SEP does not guarantee efficient deployment of nodes. Enhanced Stable Election Protocol (E-SEP) [3] was proposed for three level hierarchies. ESEP introduced an intermediate node whose energy lies between normal node and advance node. Nodes elect themselves as cluster head on the basis of their energy level. The drawback of ESEP is same as in SEP. Distributed Energy-Efficient Clustering Protocol (DEEC) [4] shows multilevel heterogeneity. In DEEC the cluster head formation is based on residual energy of node and average energy of the network. In DEEC the high energy node has more chance to become cluster head than low energy node. TEEN [5] is reactive protocol for time critical applications. TEEN was proposed for homogeneous network. In TEEN the criteria for selection of cluster head is same as in LEACH, TEEN introduces hard and soft threshold to minimize the number of transmissions thus saving the energy of nodes. In this way the life span and stability period of the network increases.

In SEP normal nodes and advance nodes are deployed randomly. If majority of normal nodes are deployed far away from base station it consumes more energy while transmitting data which results in the shortening of stability period and decrease in throughput. Hence efficiency of SEP decreases. To remove these flaws we divide network field in regions. As corners are most distant areas in the field, where nodes need more energy to transmit data to base station. So normal nodes are placed near the base station and they transmit their data directly to base station. However advance nodes are deplore far away from base station as they hay more energy. If advance nodes transmit data directly to base station more energy consumes, so to save energy of advance nodes clustering technique is used for advance nodes only.

Proposed RSEP :

In many routing protocols, nodes are deployed haphazardly in the network field and energy of nodes in network is not efficiently used. In the proposed work this concept is modified, that is, the network field is divided into three regions: Region 0 , Head Region 1(HR1), Head Region 2 (HR2) based on energy levels and Y coordinate of the network field. We consider that a fraction of the total nodes are equipped with more energy. Let m be the fraction of the total nodes n, which have α time more energy than rest of the nodes. . These nodes are referred to as advance or high energy nodes, $(1-m)\times n$ are normal nodes.

Region 0 (R0): Normal nodes are deployed haphazardly in R0, lies between $20 < Y \leq 80$

Head Region 1(HR1) : Half of high energy nodes are deployed haphazardly in HR1,lies between $0 < Y \leq 20$

Head Region 2(HR2) : Half of high energy nodes are deployed haphazardly in HR2,lies between $80 < Y \leq 100$

The reason for this kind of deployment is that advance nodes have high energy than normal nodes .Corners are most distant places in the network field. so a node at corner requires more energy to communicate with BS. Then High energy nodes are deployed in HR1 and HR2.

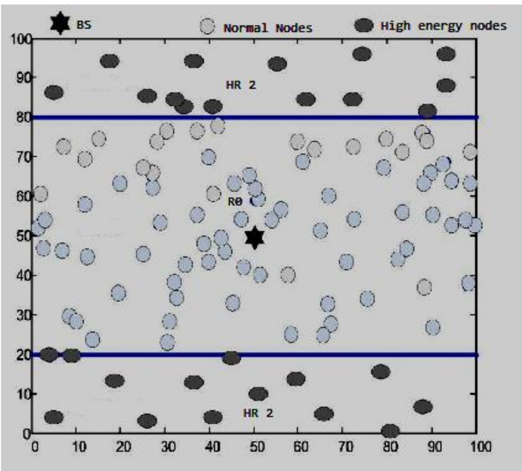

Figure1: Network field

RSEP operation :

RSEP transmit data to BS in two modes

- Direct communication
- Transmission through CH

Direct Communication :

Nodes in R0 send data directly to BS. Normal nodes detect environment, collect data of interest and send it directly to BS.

Transmission through CH:

Nodes in HR1 and HR2 transfer data to BS through clustering algorithm. CH is selected among nodes in HR1 and HR2. CHJ gathers data from member nodes, aggregate it and transfer it to BS. CH selection is very important. As shown in figure 1 high energy nodes are deployed haphazardly in HR1 and HR2.Cluster is formed only in high energy nodes. Let an optimal number of clusters k_{opt} and n is the number of high energy nodes. According to SEP optimal probability of CH is

$$p_{opt} = \frac{k_{opt}}{n} \dots\dots\dots\dots\dots..(1)$$

every node decides whether to become CH in current round or not. A random number between 0 and 1 is generated for each node. If this random number is less than or equal to threshold value $T(n)$ for a node then it is selected as CH. $T(n)$ is expressed as

$$T(n) = \begin{cases} \frac{P_{opt}}{1-P_{opt}\left(r \times mod \frac{1}{p_{opt}}\right)} & if\ n \in G \\ 0, & \text{otherwise} \end{cases} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

where

$G =$ Set of nodes which have not been cluster heads in the last $\frac{1}{P_{opt}}$ rounds

Probability for high energy nodes to become CH is given by

$$p_{adv} = \frac{P_{opt}}{1+(\alpha.m)} \times (1+\alpha) \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

accordingly the threshold value for advance node is given by

$$T_{adv} = \begin{cases} \frac{P_{adv}}{1-p_{adv}\left(r \times mod \frac{1}{p_{adv}}\right)} & if\ \text{adv} \in \text{G}' \\ 0,\ otherwise & \end{cases} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

where G' = set of advance nodes that have not been CH in last $\frac{1}{p_{adv}}$ rounds

Once CH is chosen then the CH broadcasts an advertisement message to the nodes . The nodes receive the message and decide to which CH it will belong for the current round. This phase is known as cluster formation phase .Based on received signal strength nodes respond to CH and become member of CH.CH then allocates a TDMA schedule for the nodes during which nodes can send data to CH. After the formation of cloisters each node sends data to CH in allotted time slot to that node. This is shown in figure2 .

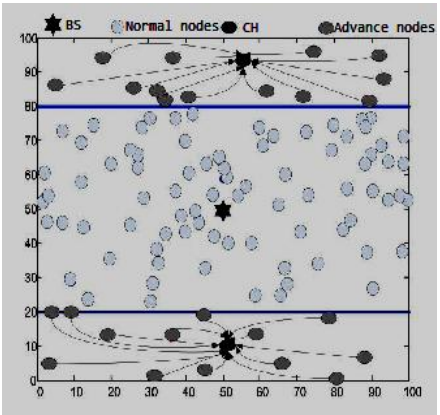

Figure 2: Nodes sending data to CH

After receiving data from nodes CH then aggregates this data and transmit it to the BS. This phase is referred to as transmission phase , shown in the figure 3 .Normal nodes(nodes in R0) are not able to form cluster as energy of normal node is less than high energy node(advance node) and CH consumes more energy than cluster members in receiving data from cluster members. If normal nodes are allowed to become CH they die soon that results in shortening of stability period. Figure 4 shows the operation of RSEP

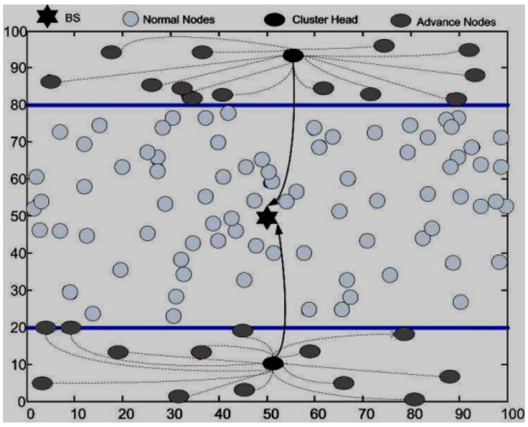

Figure 3 : CH transmitting data to BS

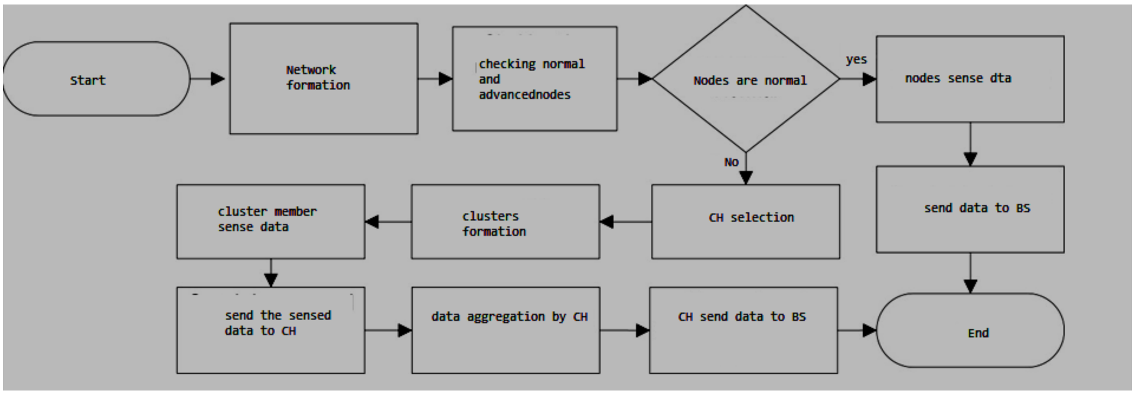

Figure 4: Flow chart of RSEP

Simulations

The proposed protocol is simulated in a field of dimensions $100m \times 100m$.100 nodes are deployed in particular regions based on their energy. BS is deployed at the center of the network field. assume 20% of nodes are high energy nodes and half of them are deployed on HR1 and the rest of the half is deployed in HR2.Since p_{opt} is 0.1, then we have two CHs per round. One CH in HR1 and the other in HR2 per round. MATLAB is used to implement simulations .Simulation parameters are given in table1.

Table 1: Simulation parameters

Parameter	**Value**
Initial energy E_0	$0.5\ j$
Initial energy of advanced nodes	$E_0(1+\alpha)$
Energy for data aggregation E_{DA}	$5nj/bit/$signal
Transmitting and receiving energy E_{elec}	$5nj/bit$
Amplification energy for short distance E_{fs}	$10pj/bit/m^2$
Amplification energy for long distance E_{amp}	$0.013pj/bit/m^4$
Probability P_{opt}	0.1

III. Result analysis

The simulation results of proposed protocol is compared with SEP and LEACH. We have introduced heterogeneity in LEACH with the same parameters as in proposed protocol, so as to assess the performance of all protocols in presence of heterogeneity. The main objective of conducting simulations are to examine the stability period and throughput of LEACH, SEP and RSEP. Figure 5 and figure 6 shows simulation results for the case when $m = 0.2\ and\ \alpha = 1$.that is , there are 20 high energy nodes out of 100 nodes. In proposed protocol 10 high energy nodes are deployed haphazardly in HR1and 10 high energy nodes are deployed in HR2.Figure 5shows that the number of active nodes versus rounds .Figure 5 shows that the proposed protocol has better stability than SEP and LEACH.As LEACH is highly sensitive to heterogeneity so nodes die at a fasterrate.SEP perform better than LEACH in two level heterogeneity, because SEP has weighted probability for selection of CH for both normal nodes and high energy nodes

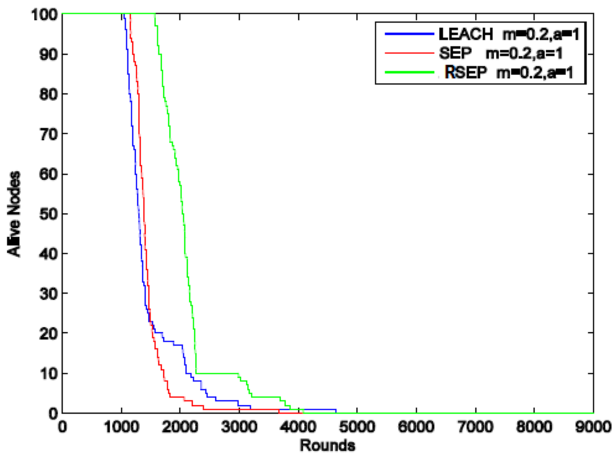

Figure 5: Alive nodes in LEACH,SEP and RSEP

RSEP performs better than LEACH and SEP because normal nodes in R0 communicates directly to BS while nodes in HR1 and HR2 communicates through CH to BS.As in clustering technique , CH consumes energy in the form of data aggregation and also by receiving data from nodes in the cluster. This energy is conserved in normal nodes because, no need to aggregate data and receive data from other nodes. So energy is not dissipated as that of CH, which results the increase of stability period. From figure it is obvious that the network lifetime is also increased because of high energy nodes. High energy nodes have α time more energy than normal nodes. So high energy nodes die later than normal nodes .so this increases the instability period.Figure 6 shows that the throughput of RSEP is much better than SEP and LEACH as every normal node send data directly to BS. Throughput of SEP and LEACH is less than RSEP because only CH send data to BS .

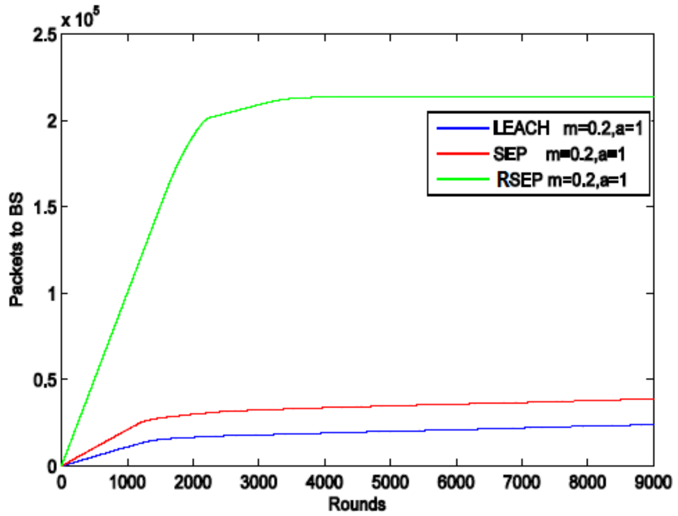

Figure 6: Throughput of LEACH, SEP and RSEP

Figure 7 and figure 8 shows simulation results when $m = 0.1$ *and* $\alpha = 2$, that is, there 10 high energy nodes in the field , 5 nodes in HR1 and 5 nodes in HR2.However there energy is increased, that is, $\alpha = 2$. Figure 7 shows that the stability period of RSEP is same for both when $m = 0.1$ *and* $\alpha = 1$ *and* $m = 0.1$ *and* $\alpha = 2$. This is because normal nodes have same amount of energy, they consume same amount of energy and die at the same time as before, but network lifetime is increased because of extra energy of high energy nodes. As LEACH is very sensitive to heterogeneity its stability period is decreased .LEACH does not have weighted probability as in SEP for even distribution of extra energy .In LEACH each node has equal opportunity to become CH. So normal nodes die at faster rate than high energy nodes. Figure 8 shows throughput of LEACH,SEP and RSEP .Throughput of RSEP is better than LEACH and SEP though energy of high energy nodes has been increased.

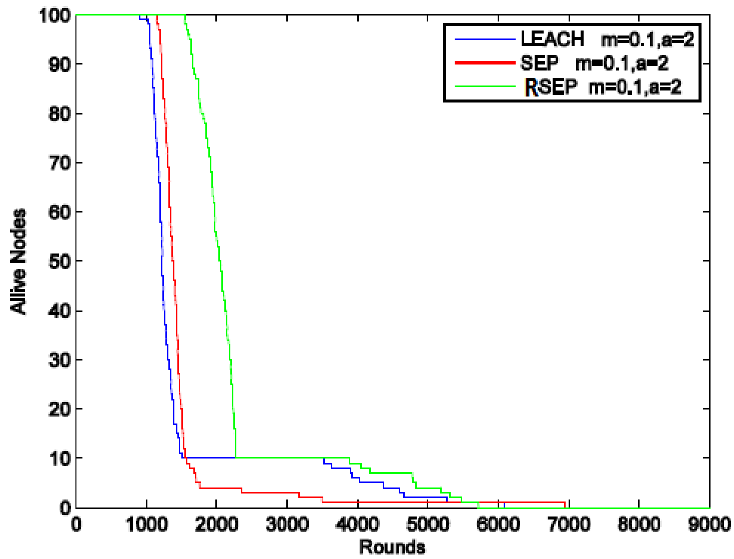

Figure 7: Alive nodes in LEACH,SEP and RSEP

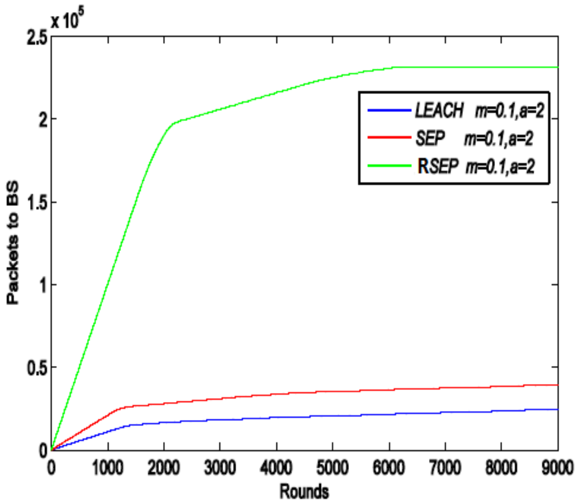

Figure 8: Throughput of LEACH,SEP and RSEP

Table 2 and table 3 shows the comparison results for LEACH,SEP and RSEP. Table 3 shows that the stability period of proposed protocol is far better than SEP and almost double to LEACH. But network life time is decreased when compared to LEACH. When compared with SEP,RSEP network lifetime is increased as high energy nodes die at slower rate than normal nodes

Table2: Comparison table when $m = 0.2\ and\ \alpha = 1$

Protocol	Stability period(rounds)	Network lifetime (rounds)	Throughput(packets)
LEACH	1018	4685	1.99×10^4
SEP	1089	3005	3.43×10^4
RSEP	1531	4119	2.21×10^4

Table3: Comparison table when $m = 0.2\ and\ \alpha = 2$

Protocol	Stability period(rounds)	Network lifetime (rounds)	Throughput(packets)
LEACH	899	5583	2.44×10^4
SEP	1150	5078	4.02×10^4
RSEP	1584	5966	2.26×10^5

IV. Conclusion

In this paper a new protocol RSEP is proposed for heterogeneous network. Two level heterogeneity. Network fields is divided into three regions as R0,HR1 and HR2.Normal nodes are deployed in Ro ro minimize the energy consumption and they directly transfer data to BS. Half of high energy nodes are deployed in HR1 and rest of the high energy nodes are placed in HR2and they utilize clustering technique to transfer data to BS. Simulation results proved that the stability period is increased by approximately 50%.Throughput of RSEP is also improved in comparison to LEACH and SEP .

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