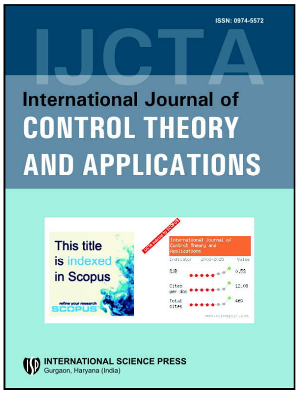

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Low Energy Stable Election Content Matching Routing Protocol for Wireless Sensor Network

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Abstract: Content filtering is one of the major challenging area in wireless sensor networks (WSNs). Generally WSN incorporates a set of sensor devices and a sink node (SN). Every sensor device has constraints with respect to their sensing ranges and transmission ranges. The life span of network depends on the sensor devices because of the limited battery power associated with the sensors. Several proposals and models are already been designed for efficient communication among the sensor devices and sink node with reduced battery consumption and with increased overall throughput of the network. In our model we have designed a Low Energy Stable Election Content Aware Energy Efficiency Routing Protocol (R-SEP) for wireless sensor network which is content oriented routing protocol to provide the desired content to the specific node. Our protocols perform better in terms of throughput, network life and the period of stability of the whole network.

Keywords: Wireless Sensor Network; Energy Efficient; SNR; R-SEP

1. INTRODUCTION

A sensor network contains a set of independent wireless nodes and having a sink node. Each sensor node monitors the environment for natural phenomena like temperature, humidity, pressure or any change in environment. After monitoring data are transmitted to the neighboring nodes or directly to the base station. Every sensor node has a sensing unit, processing unit and transceiver unit which are described in Fig.1. One of the important functions of sensor network is to minimize the battery usage whenever the data are transmitted to base station or neighboring nodes. Keeping these constraints many routing protocol are designed for wireless sensor networks. The routing protocols are classified in three categories like hierarchical, flat and location based routing. In our paper we focus on hierarchical routing which uses the clustering technique and direct routing method to increase the stability period, time span and throughput of the network as compare other network model. In this paper mainly focus on how the filtering contents can be transmitted to the base station or neighboring nodes with minimum energy consumption (MEC) [1].

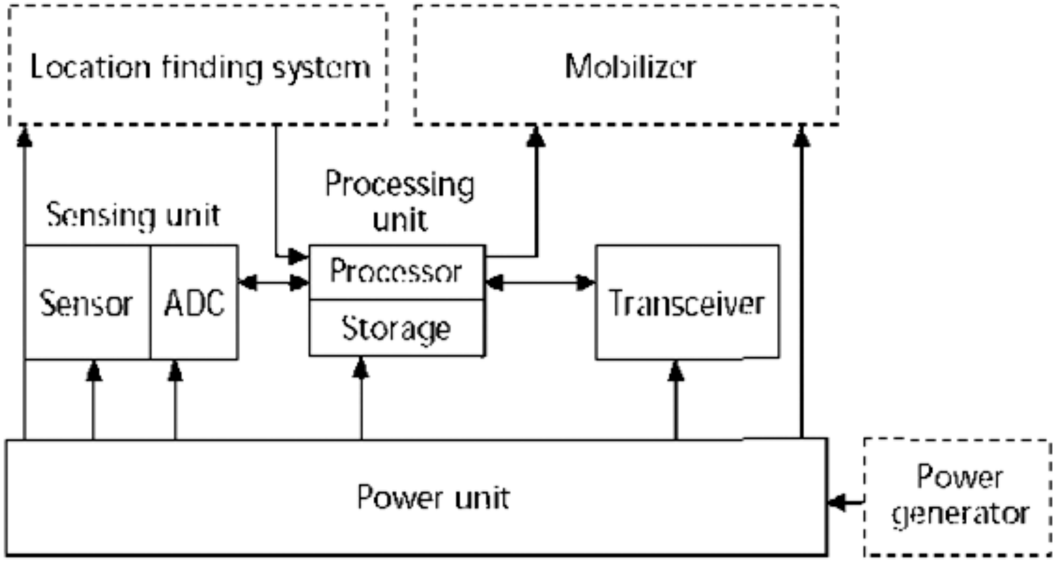

Figure 1: Sensor node architecture

2. HETEROGENEOUS WSN MODEL

We assume that the sensors deployed in the field are of different types with respect to battery power, processing power and transmission power in same network—this is referred as heterogeneous sensor network [4] in Fig.2. Some sensor nodes having more battery power i.e. more energy as compared to the others nodes in network, which provide heterogeneous in network in form of energy consumption and battery usages. At the outset the architecture of wireless sensor network with different types of nodes having different energy level are set for their operation purpose [3]. Let us assume that some nodes having more energy resources as compare to the other nodes. Assume that n portion of the total number sensor m, having more energy that is α times more battery power than the other nodes in the network. Sensors having more power are known advanced sensor nodes or relay sensors and other remaining $(1 - n) \times m$ as the normal sensors in the operation area. In our model it has been assumed that all sensors are deployed uniformly within the region irrespective of their sensed values or usages of data in application.

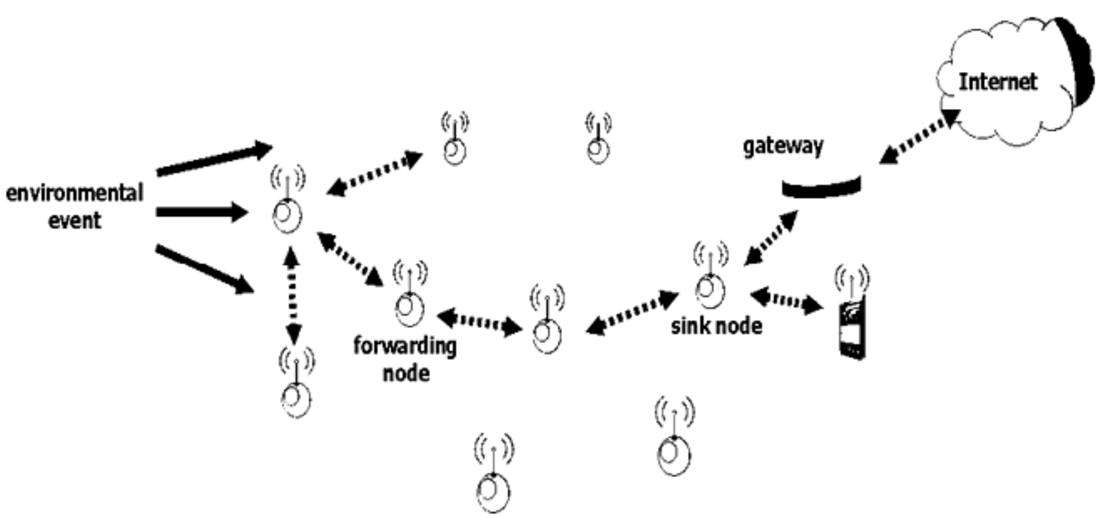

Figure 2: WSN Communication Architecture

3. THE LEACH (LOW ENERGY ADAPTIVE CLUSTERING HIERACHY PROTOCOL)

In this protocol, the re-formation of different clusters can be carried out in each iteration. The cluster head (CH) is chosen according to their residual battery power. Therefore, network traffic is well managed and congestion in the network can be reduced [3]. In LEACH protocol each node has to transmit sensed data to nearest neighbors or cluster head so as to decrease the transmission power cost to the base station. Every cluster head transmits the sumerised data to the BS which may require a huge battery power, however in LEACH every sensor has chance to become CH node in every equal interval. Besides that each node has the optimal probability (p_{opt}) to become a CH in every round, keeping in mind that sensors are equally deployed in the network. In case of LEACH sensors are homogeneous in nature that is all the nodes in the operational area have the same battery power. In LEACH protocol it is guaranteed that each and every sensor in the network has the privilege to become a CH sensor exactly once in each iteration. In LEACH the number of round is defined the epoch of the sensor network.

3.1. Clustering Hierarchy Approach

At the beginning of the network operation each node has an option to become cluster head having probability (p_{opt}). In average, $p \times p_{opt}$ numbers of nodes become the cluster heads in every iteration. Sensor node which is chosen to be cluster head in the recent iteration, it can't be available again to be a cluster head in the next round.

The nodes which are not selected as CH belong to the set G and have to keep track record of different cluster heads in every round. The probability of a node belong to set *G* has a chance to be a cluster head has been increased after each iteration in the same round. The decision of making cluster head is constructed at the initial stage of each iteration. A random number is selected by every sensor node in [0,1]. If the selected random number is less than a predefined threshold value T(s), then the sensor a head cluster in the present iteration [5].

The predefined threshold value is calculated as:

$$T(s) = \begin{cases} \dfrac{P_{opt}}{1 - P_{opt} \cdot \left(r \bmod \dfrac{1}{P_{opt}} \right)} & if\ s \in G \\ 0 & \text{otherwise} \end{cases}$$

r, represents is the current iteration number.

Round(r) is defining as a time interval where all sensors have to transmit their data to the corresponding cluster head.

The probability of choosing a node belongs to G to be a cluster head has been increased in every step in the equal epoch and equals one in the last round of the that iteration.

In this model we observe that selection process of CH is suitably adapted to handle the heterogeneous nodes. So, the initial battery powers of all the nodes present in the network are different, which establishes the heterogeneity status of the network at the beginning.

3.2. Optimal way of Clustering

In this framework the energy radio transmission model as given in fig-3.In this model to get an acceptance level of signal to noise ratio (SNR) for transmitting L–bits data on a distance d, the power is consumed by this model is given by:

$$E_{Tx}(L,d) = \begin{cases} L.\ E_{elec} + L.\ \in_{fs.}\ d^2 \ \ if\ d < d0 \\ L.\ E_{elec} + L.\ \in_{mp.}\ d^4 \ \ if\ d \geq d0 \end{cases}$$

- E_{elec} is the power consumption in every bit to run the transmission or receiving antenna in given radio model,
- The value of $\in_{fs}$ *and* $\in_{mp}$ depend on the transmitter amplifier used in this radio model.
- d is the distance between source and the receiver.
- F: Filteringe Contents

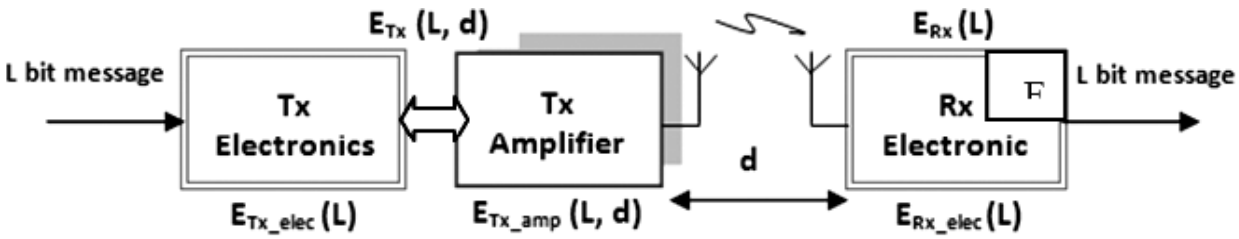

Figure 3: Radio Energy Model

3.3. Energy Calulation for Cluster Head and Non Cluster Node

For calculation of energy for cluster and non cluster head, let us consider a operational area having size N × N square meters and m is the sensors which are equally distributed over that area [2]. For application convenient the base station is deployed at middle of the operational area. The power consumption for the sensor head node at the time of operation for each iteration is computed by the given equation:

$$E_{CH=L.}E_{elec}\left(\frac{n}{k}-1\right)+L.EDA\frac{n}{k}+L.Eelec+L.d\ to\ BS$$

k is the number of clusters

E_{DA} is the data aggregation cost .

d_{toBS} is the distance between cluster head and the sink.

The energy consumed in a non cluster head node is equal to:

$$E_{CH(non)}=L.\ E_{elec}+L.\ \in_{fs}\ D\ to\ CH$$

D to CH is the distance between sensor to its cluster head.

The power consumption in a cluster for every round is computed as in given equation:

$$E_{Cluster}\approx E_{CH}+\frac{n}{k}E_{nonCH}$$

The aggregated power consumption in whole network is computed as in given equation:

$$E_{tioal}=L.\left(2nE_{elec}+nE_{DA}+\in_{fs}\left(k.d^{2}{}_{toBS}+n\frac{M^{2}}{2.\pi.k}\right)\right)$$

4. THE SEP(STABLE ELECTION PROTOCOL)

It is a heterogeneous-routing protocol which aims at improving the time interval before the death of the first node to end of the first round [6]. The selection process of CH is based on the principle of weighted election probabilities of nodes to become a CH inconsideration to their remaining battery power [4]. In SEP routing protocol the stability of the region can be improved by the process of clustering hierarchy. The different parameters of heterogeneity are the ratio of the advance and normal nodes (m) and the other additional battery level in both the category. To make the improvement in stability on operational region, SEP balance the constraint of power consumption. In SEP, advanced nodes have more chance to be a cluster head as compare to the normal nodes, which is provided the fairness in terms of power consumption in transmission.

In the newly formed heterogeneous network the updated values in settings (with advanced and normal nodes) has no impact to the number of nodes present in the network with any prior knowledge of setting of probability (P_{opt}). Which indicate the total power consumption of the network may change. Let E_o is the starting power of every sensor in the network.

The energy of advanced node can be computed as $E_o \cdot (1 + \alpha)$. The total energy of the newly formed heterogeneous network can be computed as:

$$n * (1 - m) * E_0 + n * m * E_0 * (1 + \alpha) = n * E_0 * (1 + \alpha * m)$$

Therefore the total power consumption network is enhanced by $1+ \alpha \cdot m$ times. In order to optimize the stability of the system, the number of round equal to $\frac{1}{P_{opt}} * (1 + \alpha * m)$. Because the model has $\alpha * m$ times more energy and with assumption that $\alpha * m$ more nodes have the same power as compared to the normal nodes.

5. THE R-SEP (LOW ENERGY STABLE ELECTION CONTENT MATCHING ROUTING PROTOCOL)

In framework, a Low Energy stable election content aware energy efficiency routing protocol (R-SEP) [4] which place a sink node, with random distribution of nodes in the WSNs, having heterogeneous characters in nature. The procedure of selecting cluster heads in this model is based on the minimum consumption of the extra associated power and residual power for every sensor [7]. The selection process of CH is based on the principle of shortest path to the BS by choosing between the direct way and indirect way in consideration with the closest CH.

The cluster head selection in R-SEP is defined as follows:

$$T(s) = \begin{cases} \dfrac{P_{opt}}{1 - P_{opt} \cdot \left(r \bmod \dfrac{1}{P_{opt}} \right)} & if \ s \in G \\ 0 & otherwise \end{cases}$$

where, P_{opt} is the probability of nodes to become cluster heads among all sensor nodes, $\frac{1}{P_{opt}}$ is the expected number of nodes in a cluster, r represents the current round and G represents the set of nodes which have not been CHs in the last $\frac{1}{P_{opt}}$ rounds. In R-SEP protocol, we have considered the network type as heterogeneous. In our network, the number of advanced nodes is m, having the additional energy factor (α) within it, as compared to the normal nodes. With the presence of advanced as well as normal nodes the heterogeneity layout has no effect onto the density of the network. Hence, there no need to change the previous set of P_{opt} in consideration with the CH. We have considered the initial energy as E_0. The energy of advanced node in our R-SEP is $E_0 \cdot (1+ \alpha)$. Now the total energy level of the newly formed heterogeneous network can be computed as:

$$N * (1 - m)\, E_0 + N * m * E_0\, (1 + \propto) = N * E_0 * (1 + \propto\ m)$$

where N is the total numbers of nodes in network.

E_0 is the initial energy of each node.

α is the additional energy of the advance nodes.

5.1. Content Based Matching Algorithm

1. Begin
2. Let A be an interest.
3. Let $a_1, a_2, a_3, a_4, a_5, \ldots \ldots, a_n \in A$ be the set up attributes.
4. Let $n_1, n_2, n_3, \ldots\ldots\ldots, n_m$ be the set up sensor nodes.
5. for each attributes $a_i \in$ A $\forall$ $i = 1, 2, 3, 4, \ldots\ldots\ldots\ldots, n$.
6. *if* $a_i\,.\,A == Key_k\,.n_j$ is actual value &&
7. $key_k\,.n_j$ is satisfies the subscription then
8. Acceptance = true
9. Publish (Content)
10. Else
11. Acceptance = false
12. Ignore (Content)
13. End

5.2. R-sep Flow Chart

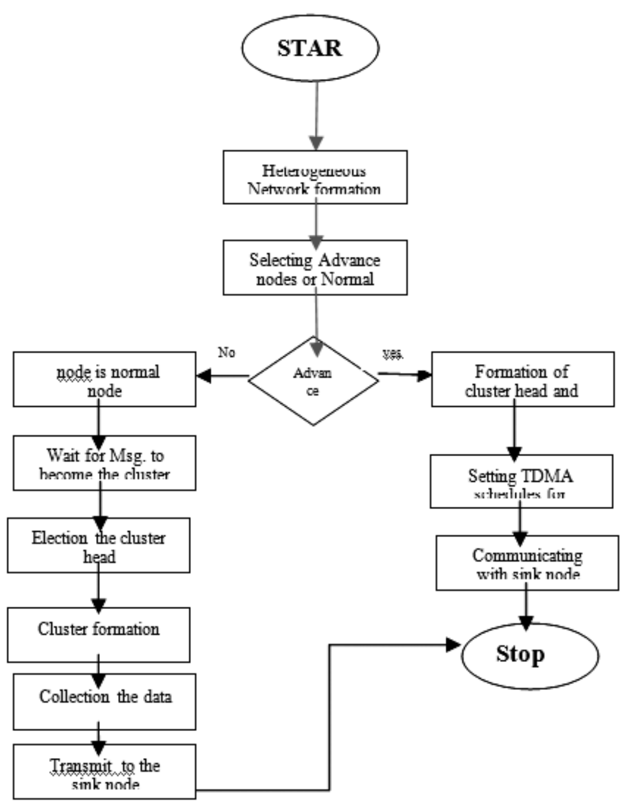

Figure 4: Flow-Chart for R-SEP

6. ALGORITHM FOR R-SEP

1. Start
2. if node_i Cluster head then check is it a advance node_i or not
3. if yes then it broadcasts ADV_Msg to all other nodes depending on distance mesurment
4. Wait for J_Msg for cluster formation
5. Communicate with TDMA schedule for members to transmit data
6. Communicate with the sink node.
7. if node_i is not advance node , it finds a advance node for forwarding data which is CH
8. cluster formation is done
9. The data transmission to the selected advance cluster head node
10. is node_i is a normal node wait for cluster head ADV_Msg
11. send J-Msg for chossen cluster head
12. wait for TDMA schedule
13. transmit the data to chossen CH
14. the process is continuted until all advance nodes become the CH
15. stop

7. SIMULATION AND RESULT ANALYSIS

For the simulation and performance analysis of the three protocols LEACH, SEP, and R-SEP we have used MATLAB. The network parameters and their values are represented in in Table 1. We have considered 100 sensor nodes within the deployed square shaped region of size 100 × 100 m^2. The sensors are randomly distributed within this region. Among the total nodes 20% are advanced nodes. These advanced nodes have more battery power in comparison to the normal nodes (i.e. m is 0.2 and a is 2). In the network scenario, the density of the advanced nodes is fair enough to provide support for extension of the network lifetime.

Table 1
Analysis variables

Variables name	*Parameter value*
Number of sensor nodes (N)	100
Initial power (E_0)	0.5J
Initial energy of advance nodes	$E_0(1+ \alpha)$
Data aggregation	5 nJ/bit/signal
transmitter amplifier between CH and cluster member	0.003 pJ/bit/m^2
transmitter amplifier between CH and sink node	10 pJ/bit/m^2
Probability P_{opt}	0.1

Our protocol has been compared with the two protocols SEP and LEACH. With the same setup, as mentioned in our proposed model all the protocols are being tested considering heterogeneity- the major criteria for evaluation. One such parameter is to investigate the stability period of LEACH, SEP and R-SEP. The simulation results

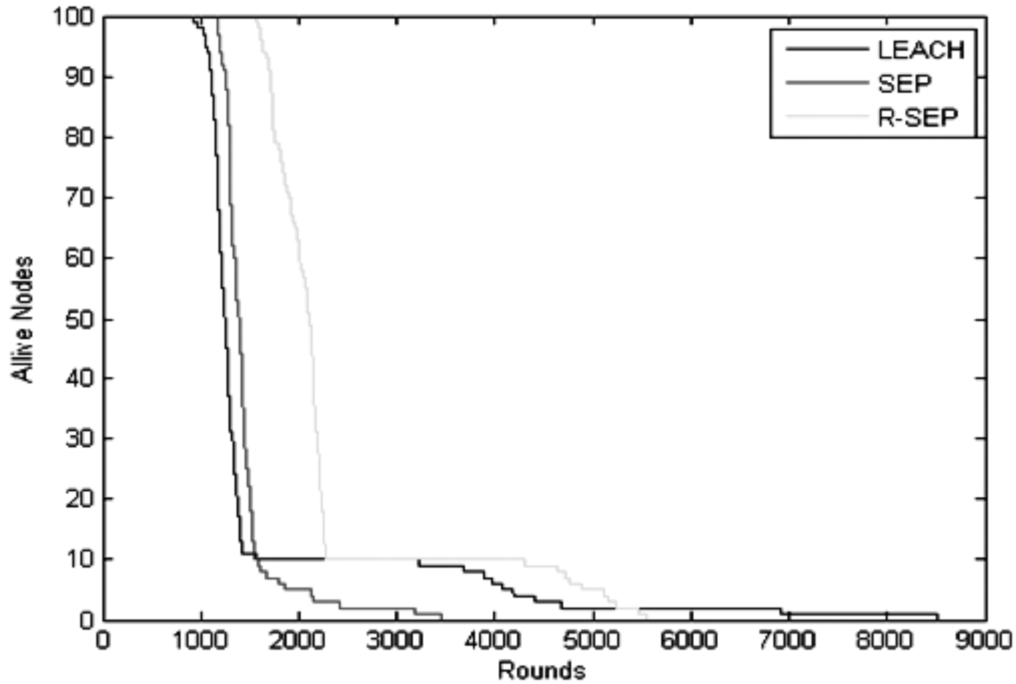

Figure 5: No. of alive nodes in each round

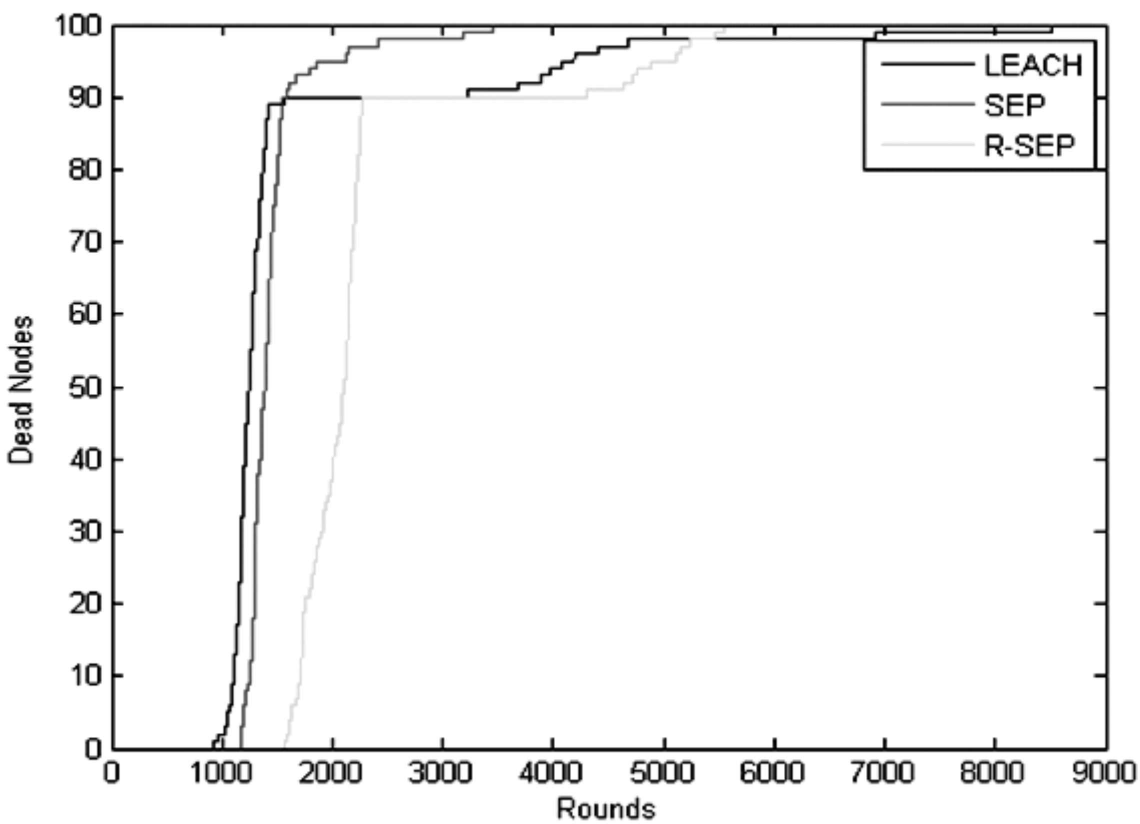

Figure 6: No. of dead nodes in each round

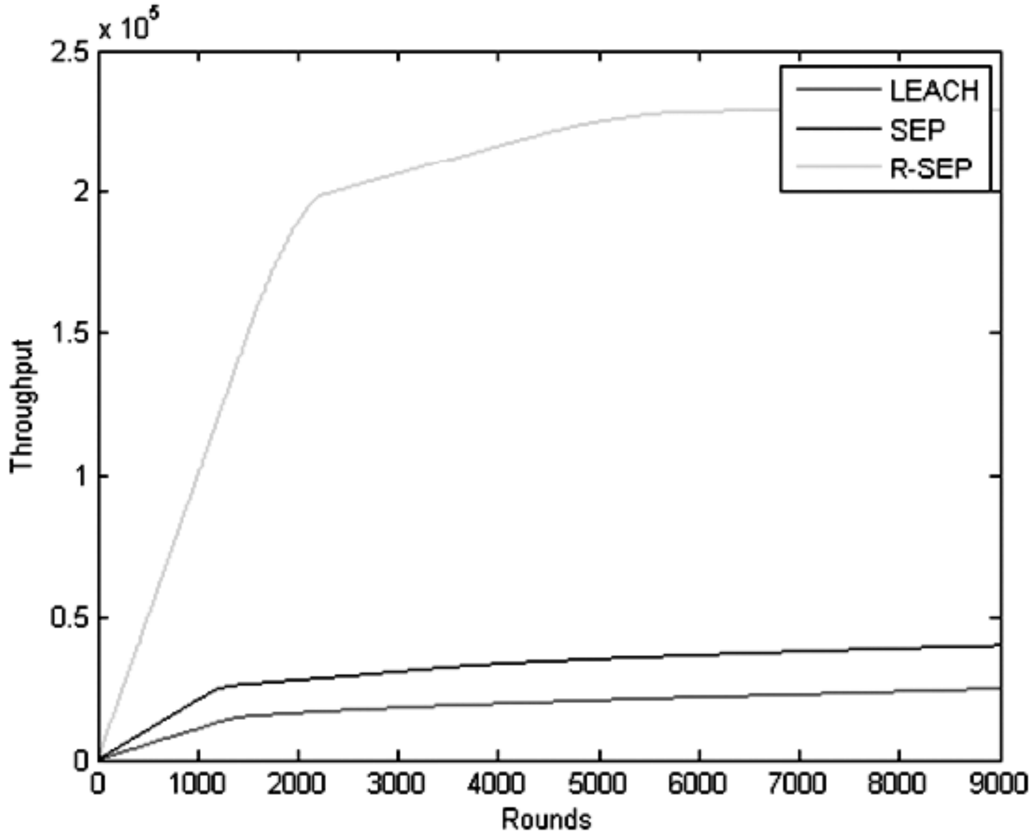

Figure 7: Throughput in each round

about the number of live nodes, dead nodes and throughput of LEACH, SEP and R-SEP are reflected in Fig.4, Fig.5 and Fig.6 respectively, where our proposed model R-SEP outperforms over other two protocols. In addition to that the process of selection of CH for both ordinary and powerful nodes in R-SEP is performed better as compare to LEACH and SEP. Unlike clustered network, the CH requires more energy for collection as well as aggregation in a cluster, the same has been avoided in our case for the ordinary nodes as they do not have to aggregate data and receive data from other nodes. So the CHs are not affected by the normal nodes and perform equivocally, results in increasing the stability period of the whole network. From Fig.5, it can be observed that the lifetime of the whole network is increased due to the contribution of the advance nodes. The available energy in advance nodes are α time more than the normal nodes due to which the life time of advance nodes are extended after the inactiveness of the normal nodes. So this increases both stability and network life time of the whole network.

8. CONCLUSION

In this paper we introduced the heterogeneity in LEACH, SEP and R-SEP. In this network we have taken some nodes are advance nodes and some nodes are normal nodes. Since the advance nodes have more energy as compare to normal nodes, so the normal nodes can't send data directly to base station. The advance node forms the cluster by using some normal nodes and transmits the data to sink node. This will improve the stability in network as well as the network life span. In our simulation results it shows that the R-SEP improve the network life as compare to LEACH and SEP. The throughput is higher as compare to LEACH and SEP. The performance of R-SEP is encouraging in comparison to LEACH and SEP with respect to the network parameters such as cluster stability, easing the CH selection process, network life time and throughput.

Table 2
Comparasion for LEACH,SEP and R-SEP

Performance criteria	*LEACH*	*SEP*	*R-SEP*
Heterogeneity level	No	Yes	Yes
Cluster Stability	Lower	Two	Multi level
Energy Efficient	Lower as compare to SEP and R-SEP	good	high
Cluster Head Select-ion condition	Based on initial energy and resi-dual energy	Based on initial energy and resi-dual energy	Based on initial energy, residual energy and the energy of the advance node
Network life time	Lower as compare to SEP and R-SEP	good	Maximize the network life as compare to LEACH and SEP
Throughput	good on homogenous scenario	good on heterogeneous scenario	Good on both heterogeneous and homogenous scenario

REFERENCES

[1] W. R. Heinzelman, A. P. Chandrakasan, and H. Balakrishnan, "Energy efficientcommunication protocol for wireless microsensor networks," in Proceedings of the 33rd Hawaii International Conference on SystemSciences (HICSS-33), January 2000.Computer communications, 30(14), 2826-2841.

[2] A. Manjeshwar and D. P. Agarwal. 2001. TEEN: a routing protocol for enhanced efficiency in wireless sensor networks. In 1st International Workshop on Parallel and Distributed .Computing Issues in Wireless Networks and Mobile

[3] Li Qing, Qingxin Zhu, Mingwen Wang, Design of a distributed energy-efficient clustering algorithm for heterogeneous wireless sensor networks, Computer Communications, Volume 29, Issue 12, 4 August 2006, Pages 2230-2237.

[4] G. Smaragdakis, I. Matta, A. Bestavros, SEP: A Stable Election Protocol for clustered heterogeneous wireless sensor networks, in: Second International Workshop on Sensor and Actor Network Protocols and Applications (SANPA 2004), 2004.

[5] Ming Yu, Leung, K.K. and Malvankar, A. "A dynamic clustering and energy efficient routing technique for sensor networks". IEEE on Wireless Communications, Vol: 6(8): pp3069-3079, August 2007

[6] V. Mhatre and C. Rosenberg. Homogeneous vs. heterogeneous clustered sensor networks: A comparative study. In Proceedings of 2004 IEEE International Conference on Communications (ICC 2004), June 2004.

[7] S. Bandyopadhyay and E. J. Coyle. Minimizing communication costs

[8] In hierarchically-clustered networks of wireless sensors. Comput. Networks, 44(1):1–16, January 2004.