INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X

Impact factor: 4.295

(Volume3, Issue2)

Available online at www.ijariit.com

Hybrid Multi-Hop Routing Approach for Heterogeneous Wireless Sensor Networks using Fuzzy Logic Technique

Anju Verma
CSE Jhansi
anju.verma11@gmail.com

C. P. Singh
CSE Jhansi
cp.singh1984@gmail.com

Abstract— **in recent years, Wireless Sensor Network (WSN) has led to many new protocols designed for such networks have to be energy aware in order to improve the lifetime of the network. To find an effective and an efficient routing protocol, across whole network topology, is a major issue in networking. So Multi-hop and clustering communication are most efficient routing methods in WSN. Though, cluster heads have to heavy traffic around the Base Station (BS). In this paper, we have implemented a Region Based hybrid multi-hop routing method for heterogeneous WSN in which to use multi-hop communication method for transmission and use fuzzy logic technique for clustering. Simulation results show that our method reduces consumption of energy and enhance the lifetime of network in comparison to other clustering and multi-hop communication methods.**

Keywords- ***Multi-hop; Heterogeneous; Hybrid Routing; Fuzzy Logic; Region-based Clustering.***

I. INTRODUCTION

Wireless Sensor Networks (WSN) is networks composed of tiny, battery powered sensor nodes with limited on-board processing, storage and radio capabilities [1], [2]. In recent year our main goal to reduce energy consumption in wireless communication devices.

Therefore, Energy minimization is one of the most important factors in the field of WSN research in order to prolong the network's life time. To send messages from nodes to base station we require minimum dissipation of energy. For such purpose a need of better routing protocol arises which should efficiently utilize the energy.

Multi-hop and clustering communication are most efficient routing methods in WSN. Multi-hop routing methods are effectively overcome shadowing and path loss effects, if the node density is high enough [3]. Multi-hop routing using a large amount of nodes enables to balance the relay traffic all over the WSN.

Clustering [4] is one of the best technique which have good scalability and support data aggregation for Sensor Network. The data aggregation collects data from multiple sensors to eliminate redundant information and transmit to base station. It also guarantees that the energy load is well balance. Clustering can be use in one-to-many, many-to-one, or one-to-all (broadcast) communications. On the other hand, all data directed to sink and CH around the sink comes to have high relay traffic. As a result, CH around sink uses much energy in a short time, and this is one of the main problems that shorten the network life time [5] in clustered WSN.

In this paper, we propose hybrid Multi-hop approach for heterogeneous WSN which combines clustering and multi-hop communication methods. Hybrid routing approach used to enhance lifetime of network. In hybrid sensor nodes sense and send their data to base station. Multi-hop communication methods reduce long distance transmission into short distance transmission in the WSN so for battery life to be extend**.** In heterogeneous WSN some nodes have high energy and some low energy nodes .In this paper we used a region based clustering in which total area is divided into fixed number of regions .In which a region near to base station has low energy node that is normal node and high energy node is assume advance node in outer region. In Clustering fuzzy logic approach is used for cluster head selection among advance nodes on the behalf of residual energy and transmission distance. After the selection of CHs, cluster members nodes communicate with their respective CHs. The CHs collect the data from the member nodes in their respective clusters, aggregate the received data, and send it to the BS using multi-hop communication.

II. RELATED WORK

Energy conservation of sensor nodes for increasing the network life is the most crucial design goal while developing efficient routing protocol for wireless sensor networks.

Multi-hop-LEACH [6] uses both inter cluster as well as intra cluster communication. The power usage, latency and success rate in Multi-hop-LEACH can further improved by increasing probability of clustering. We can still minimize the energy consumption and extend the network life time by improving the clustering technique. The drawback of M-LEACH is that only powerful nodes can become cluster heads (even though not all powerful nodes are used in each round).

In SEP [7] normal nodes and super 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 this drawback one solution is to divide the network field into fixed no. of regions and use hybrid Multi-hop routing technique to improve lifetime of the network.

The energy model for the wireless sensor network with heterogeneous nodes and his setting is described [8] as follows: Consider the case in which a percentage of the sensor nodes which have more energy is equipped than the rest of the nodes. Consider m as the fraction of the total number of nodes n, which are equipped with α times more energy than the other nodes. These powerful nodes are named as super nodes and the rest (1-m) x n node is named as normal nodes. All the nodes are distributed uniformly over the sensor field and consider that architecture of a sensor network is hierarchically clustered. In each round cluster heads are elected and result as load will well distributed and balanced among the nodes of the network. The cluster head has to report to the base station and may expend a large quantity of energy, but this happens periodically for each node. The energy model is illustrated in Figure1:,

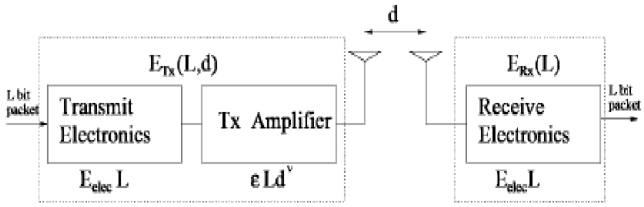


Figure 1 Radio energy dissipation model

In order to achieve an acceptable Signal-to-Noise Ratio (SNR) in transmitting *L* bits messages over a distance *d*, the energy expended by the radio is given by equation:

$$E_{Tx}(L, d) = \begin{cases} L \,.\, E_{elec} + L.E_{fx.}\ \varepsilon_{fs}.d^2 & if d \leq d_0 \\ L\,.E_{elce} + L\,.\varepsilon_{mp.}d^2 & if\ d \geq d_0 \end{cases}$$

Where, E_{elec} is the energy dissipated per bit to run the transmitter or the receiver circuit [7]. The optimal construction of clusters is very important because it is equivalent to the setting of the optimal probability for a node to become a cluster head. The energy dissipated in the cluster head node during a round is given by the following formula:

$$E_{ch} = \left(\frac{n}{k} - 1\right) L.E_{elec} + \frac{n}{k} L.E_{DA} + L.E_{elec} + L.\varepsilon_{fx}\ d_{BS}^2 \qquad (1)$$

Where, k is the number of clusters, E_{DA} is the processing cost of a bit report to the BS, and d_{BS} is the average distance between a cluster head and the sink. The energy used in a non-cluster head node is equal to

$$E_{non\ ch} = L.E_{elec} + \mathrm{L}.\ \epsilon_{fx}\ d_{CH}^2 \qquad (2)$$

Where, d_{CH} is the average distance between a cluster member and its cluster head. Assuming that the nodes are uniformly distributed, it can be shown that:

$$d_{CH}^2 = \int_0^{x_{max}} \int_0^{y_{max}} (x^2 + y^2)\,\rho(x,y)dxdy = \frac{M}{2\pi k} \qquad (3)$$

Where, *ρ(x,y)* is the node distribution. The total energy dissipated in the network is equal to:

$$E_t = L(2n.E_{elec} + n.E_{DA}(k\,.d_{BS}^2 + n.d_{CH}^2)) \qquad (4)$$

By differentiating, E_t with respect to k and equating to zero the optimal number of constructed clusters head to the sink is given by:

$$K_{opt} = \sqrt{\frac{n}{2\pi}} \sqrt{\frac{\epsilon fs}{\epsilon mp}} \frac{M}{d^2_{Bs}}$$

If the distance of a significant percentage of nodes to the sink is greater than d_0 then, the average distance between a cluster head and base station [8] is given by:

$$d^2_{BS} = \int_A (x^2 + y^2) \frac{1}{A} = 0.765 \frac{M}{2} \quad (5)$$

The optimal probability of a node to become a cluster head, p_{opt} can be computed as follows:

$$p_{opt} = \frac{k_{opt}}{n}$$

To evaluate the performance of clustering protocols, following metrics are used:

(i) Stability Period: is the time interval between the start of network operation until the death of the first sensor node. It is also called "stable region".

(ii) Instability Period: is the time interval between the deaths of the first node until the death of the last sensor node. It is also called "unstable region".

(iii) Network lifetime: is the time interval between the start of operation (of the sensor network) until the death of the last alive node

(iv) Throughput: is the rate of data sent from cluster heads to the sink as well as the rate of data sent from the nodes to their cluster heads**.**

In SEP protocol there are two types of heterogeneous nodes uses dynamic clustering. In which n is the total no. of nodes in the network, m is the fraction of n having α time more energy than the normal node called super nodes. To increase the stable region, SEP try to maintain balanced energy consumption. Super nodes have to become cluster heads. Because normal nodes. Have not enough energy for clustering. The new heterogeneous setting (with super and normal nodes) has no effect on the spatial density of the network [7].

Suppose, Initial energy of each normal node = E_0

And the initial energy of each super node = $E_0 (1+ \alpha)$.

Total initial energy of super nodes = $n.m.E_0. (1+ \alpha)$

The total (initial) energy of the new heterogeneous network $n. (1- m). E_0 + n.m.E_0.(1+ \alpha) = n.E_0 .(1+ \alpha.m)$ (6)

Total energy of the system is increased by a factor =
$(1 + \alpha.m)$.

In RBHR [9] total area is divided into fixed regions. The two types of sensor nodes (normal node and super node) are considered for data collection and transmission. Normal nodes are placed near the base station region and Super nodes having energy more than the Normal nodes are placed far away from the base station. The sensor nodes are uniformly distributed within the fixed regions. All sensors nodes and BS are stationary after deployment.

But in RBHR there is no equal distribution of nodes in each region. Direct transmission from CH to Base station to be assumed. If distance between CH to Base station more than transmission range then CH consume more energy to send data to base station.

III. PROPOSED WORK

Network field is considered as concentric circle form whose diameter is 100 meter and radius of circle 55 m. we consider that inner circle radius is 30 m and outer circle radius is 55 m**.** Base station is located nearly at the center of inner circle. Outer area is divided into fixed regions that are region1, region2, region3, region4, region5. The two types of sensor nodes normal and advance are considered for data collection and transmission. Normal nodes are placed near the base station region and advance nodes have more energy than the normal nodes. Advance nodes are placed far away from the base station. We consider that region 1, region2, region3, region4 have equal no. of nodes that is 10. All sensors nodes and BS are stationary after deployment. The total energy of the heterogeneous network is calculated by equation (6). The distance and the energy dissipation are calculated by equation (1) to (5). The proposed protocol has following sections:
]

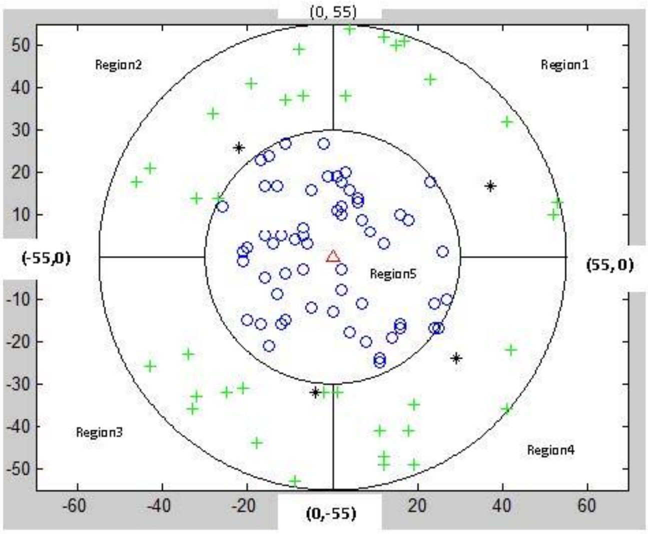


Figure2: Network Architecture

○ Normal Node * Cluster Head

+ Advance Node △ Base Station

A: Region-based clustering:

In Region based clustering technique network area is divided into no. of regions. Nodes have been distributed uniformly each region. In Clustering, cluster Head (CH) is elected by using the highest residual energy and the node degree. Cluster communication is at the most two-hop which results in less number of messages from member nodes to BS. Within a cluster, data is sent to CH by member nodes. After some time CH's energy level goes below threshold value, then new CH is elected and clusters are reformed within each region.

B: Hybrid Multi-hop Routing in Heterogeneous Sensor Network:

In Hybrid Multi-hop routing (HMR), the two multi-hops routing that is flat multi-hop routing that utilizes efficient transmission distances, and hierarchical multi-hop routing that used for data aggregation.
There are two types of nodes in heterogeneous network. A node that has higher energy to be considering advance node and that has low energy normal node. In Hybrid Multi-hop routing (HMR) normal nodes transmit data direct to base station and advances nodes by using cluster head transmission. CHs and member nodes communicate with their respective CHs. CH communicate to normal node by using multi-hop communication. This leads efficient utilization of energy and improving lifetime of the network.

Multi-hops between Cluster Heads When communication threshold exceed between CHs to BS then multi-hop strategy is used . Multi-hop does not always apply, since, depending on the layout of the nodes, the clusters may be formed too far. The multi-hop strategy is implemented to reduce energy dissipation during the communication. In this proposal, first we determining which leaders will pass through the data propagation process of the farthest CHs, the fuzzy system adopts distance and energy level criteria. First is used the calculation (7) to determine the communication distances between the farthest CHs and the rest of the elected leaders.
We consider d that the BS knows the energy level and placement of each sensor the nodes, information that is sent at the beginning of the network formation and the nodes dissipate energy in this process. The BS selects each node and calculates the Euclidean Distance of the nodes to the center of their respective clusters defined by fuzzy technique The node with higher centrality (CH), will allow more smoothly power dissipation during communication comparing to other associated nodes.

$$Dis(\ d_{i,}\ d_j\ ) = \sqrt{(x_i\ - x_j\ )^2 - (\ y_i\ \ -\ \ y_j\ \ )^2} \quad (7)$$

C. Cluster-Head Selection using Fuzzy Logic:

We can improve the balance of energy in the network using the Fuzzy logic technique.

The proposed protocol is based on fuzzy logic technique that is used for cluster head selection. In cluster head selection process, two input functions distance and residual energy of sensor node are converted into fuzzy sets. X and Y fuzzy set consists of degree of membership. The distance and residual energy Fuzzy sets are defined as,

$X = \{(d, \mu_x (d))\}, d \in D$

$Y = \{(e, \mu_y (e))\}, e \in E$

Where, D is a universe of discourse for Distance and E is a universe of discourse for residual Energy, d and e are particular element of D and E respectively. μ_x (d), μ_y (e) are membership functions, the degree of membership of the element in a given set.

$$\mu_X (d) = \begin{cases} 1, & \text{if } d \le th_1 \\ (d - th_2) / th_1 - th_2, & \text{if } th_1 < d < th_2 \\ 0, & \text{if } d \ge th_2 \end{cases}$$

$$\mu_y (e) = \begin{cases} 0, & \text{if } e \le th_1 \\ (e - th_1) / th_2 - th_1, & \text{if } th_1 < e < th_2 \\ 1, & \text{if } e \ge th_2 \end{cases}$$

Where,
th_1= Threshold to activate system
th_2 = Threshold which identifies the level of activeness

A fuzzy relation is a relationship between elements of D and elements of E, described by a membership function,

$\mu_{D \times E}$ (d, e), $d \in D$ and $e \in E$

The fuzzy operator AND (∧) is used to find the fuzzy relation,

$$\mu_X (d) \wedge \mu_Y (e) = \min (\mu_X (d), \mu_Y (e))$$

$$= \begin{cases} \mu_X (d), \text{ if and only if } \mu_X (d) \le \mu_Y (e) \end{cases}$$

The process of Cluster Head selection consists of distance and residual energy of a advance node. The Table 1 uses three membership functions to show the various degrees of input variables. The various probable output functions are shown in Table 2.

TABLE 1: INPUT FUNCTION

Input	Membership		
Distance to the BS	Near	Considerable	Far
Residual Energy	Low	Medium	High

TABLE 2: OUTPUT FUNCTION

Output	Membership
Cluster Head Formation Probability	Lowest, Very Low, Low, Medium Low, Medium, Medium High, High, Very High, Highest

Triangle and Trapezoidal membership functions are used because their degree is more easily determined [10].
The fuzzy relationships are defined in Table 3. For selecting an optimal cluster head following rule sets are considered.

TABLE 3: LOGICAL RULE SETS

Distance to Base Station	Residual Energy	Cluster Head Formation Probability
Near	Low	Low
Near	Adequate	Very high
Near	High	Highest
Considerable	Low	Medium
Considerable	Adequate	High
Considerable	High	Medium high
Far	Low	Lowest
Far	Adequate	Very low
Far	High	Medium low

The rule sets are defined and aggregations of these fuzzy rules to generate a fuzzy output shown in Table 4. The rules are designed as follows

TABLE 4: RULE SETS

Rule 1:
IF Distance is Near AND Residual Energy is Low THEN Probability is Low
Rule 2:
IF Distance is Near AND Residual Energy is Adequate THEN Probability is Very High
Rule 3:
IF Distance is Near AND Residual Energy is High THEN Probability is Highest
Rule 4:
IF Distance is Considerable AND Residual Energy is Low THEN Probability is Medium
Rule 5:
IF Distance is Considerable AND Residual Energy is Adequate THEN Probability is High
Rule 6:
IF Distance is Considerable AND Residual Energy is High THEN Probability is Medium High
Rule 7:
IF Distance is Far AND Residual Energy is Low THEN Probability is Lowest
Rule 8:
IF Distance is Far AND Residual Energy is Adequate THEN Probability is Very Low
Rule 9:
IF Distance is Far AND Residual Energy is High THEN Probability is Medium Low

Proposed Algorithm for Hybrid Multi-hop Routing :

The proposed hybrid Multi-hop routing protocol for data transmission is described as follows:

CH= Cluster Head; CM= Cluster Member; BS= Base Station; R= Circle radius

Start
 Total Area = π x R x R meter
 Total No. of Nodes = n
 m = fraction of total no. of nodes (no. of Advance Node
  having α time more energy and 1 < α < 5)
 n x (1-m) = no. of Normal Node

 If node = normal
  node sense data

  data → BS
 end if

 else node = Advance
  Cluster formation
  CH selection using Fuzzy logic rule
  CM sense data
  data → CH
  data aggregation by CH

 If CH distance < Transmission range
  CH → BS
 End else
 CH using Multi-hop
 To choose Normal Node
 CH → Normal Node
 Normal Node → Base Station
 End

The heterogeneous nodes are deployed within fixed region to provide efficient utilization of total area. The cluster head among advance nodes have been selected by the Fuzzy rule set. The validations of the algorithm improve the stability and lifetime of the network.

VALIDATION AND ANALYSIS

Let us consider a network of 5 advance nodes.

Now suppose the set of node Distance (in meters) from base station as: D = {34, 37, 40, 46, 55 }

And the Residual Energy at each node as:

E = {0.7, 0.9, 1.0, 1,2, 1.3}

A membership function based on the node distance from base station

$$\mu_x(d) = \begin{cases} 1, & \text{if }_{distance}(d) \leq 37 \\ ((37 - _{distance}(d)) / 11, & \text{if } 37 < _{distance}(d) < 48 \\ 0 & \text{if }_{distance}(d) \geq 48 \end{cases}$$

A membership function based on the residual energy of each node .

$$\mu_y(e) = \begin{cases} 0, & \text{if }_{re}(e) \leq 0.7 \\ ((re\,(e) - 0.7) / 0.6 & \text{if } 0.7 < _{re}(e) < 1.3 \\ 1, & \text{if }_{re}(e) \geq 1.3 \end{cases}$$

Now calculate the degree of membership of Distance and Residual Energy using the above defined membership functions for these input variables shown in Table 5 and 6.

TABLE 5: DEGREE OF MEMBERSHIP OF DISTANCE

Distance (D)	**Degree of Membership**
34	1
37	1
40	0.3
46	0.8
55	0

In Table 5 for the Distance {34, 37 ,40 ,46, 55**}** the degree of memberships are {1, 1, 0.3, 0.8 ,0} respectively. According to fuzzy decision rule the membership of the above distances are,

{34|reachable, 37|reachable, 40|considerable, 46|considerable, 55| far}

TABLE 6: DEGREE OF MEMBERSHIP OF RESIDUAL ENERGY

Residual Energy (RE)	**Degree of Membership**
0.7	0
0.9	0.3
1.0	0.5
1.2	0.8
1.3	1

In Table 6 for the Residual Energy {0.7, 0.9, 1.0, 1.2, 1.3} the degree of memberships are {0, 0.3, 0.5, 0.8, 1} respectively. According to fuzzy decision rule the memberships of the above Residual Energy are,

{0.7| low, 0.9| medium 1.0| medium, 1.2| high, 1.3| high}

Now create Table 7 that shows the fuzzy relation between membership functions of Distance and Residual Energy.

TABLE 7: FUZZY RELATION ON MEMBERSHIP VALUE OF DISTANCE AND RE

E \ D	**34**	**37**	**40**	**46**	**55**
0.7	0 ^ 1	0 ^ 1	0 ^ 0.3	0 ^ 0.8	0 ^ 0
0.9	0.3 ^ 1	0.3 ^ 1	0.3 ^ 0.3	0.3 ^ 0.8	0.3 ^ 0
1.0	0.5 ^ 1	0.5 ^ 1	0.5 ^ 0.3	0.5 ^ 0.8	0.5 ^ 0
1.2	0.8 ^ 1	0.8 ^ 1	0.8 ^ 0.3	0.8 ^ 0.8	0.8^ 0
1.3	1 ^ 1	1 ^ 1	1 ^ 0.3	1 ^ 0.8	1 ^ 0

The result of the AND (**Λ**) process on membership values of Distance and Residual Energy is shown in Table 8.

TABLE 8: RESULT AFTER AND (**Λ**) FUZZY OPERATION

E \ D	34	37	40	46	55
0.7	0	0	0	0	0
0.9	0.3	0.3	0.3	0.3	0
1.0	0.5	0.5	0.3	0.5	0
1.2	0.8	0.8	0.3	0.8	0
1.3	1	1	0.3	0.8	0

The possible combinations of distance and residual energy with higher membership values are shown in Table 9.

TABLE 9: OUTPUT TABLE

E \ D	34	37
1	1	1

The degree of membership of distance and residual energy is shown in Table 10.

TABLE 10: OUTPUT TABLE WITH THE DEGREE OF MEMBERSHIP

S. No	Distance to BS	Degree of Membership	Residual Energy	Degree
1	34	Near	1.3	High
2	37	Near		

The possible resultant combinations of Distance and Residual Energy of node which are reachable are as follows.

- $Distance_1$ = 34 and Residual $Energy_1$ = 1.3
- $Distance_2$ = 37 and Residual $Energy_1$ = 1.3

The node to be selected can have any of the above combinations. But according to the rule 3 from the rule set, the best combination is when the distance factor is 34, and Residual Energy = 1.3 i.e. the output Membership for these values is “Highest” as “Distance is near, and Residual Energy is high”. This will be best among all advance nodes for the selection of cluster head.

V. SIMULATION RESULTS

Proposed work is implemented on MATLAB. To the performance of HMRA are simulate a heterogeneous clustered wireless sensor network in a field with 100 m diameter. The total number of sensors (n) = 100. The nodes, both normal and advance, are randomly distributed over the field. For simulation we have following node settings:

Let 40% (m) of nodes are advance nodes and 60% are the normal node. Nodes are deploy in different regions according to their energy level are defined in Table-11. And other simulation parameters are shown in Table-12.

TABLE-11

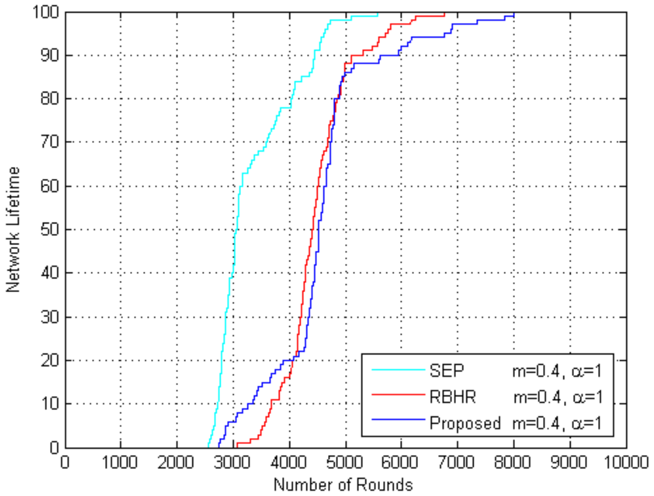
Total no. of normal node	60
Total no. of advance node	40
Total no. of advance node in Region 1	10
Total no. of advance node in Region 2	10
Total no. of advance node in Region 3	10
Total no. of advance node in Region 4	10
Total no. of normal node in Region 5	60

TABLE 12: SIMULATION PARAMETERS

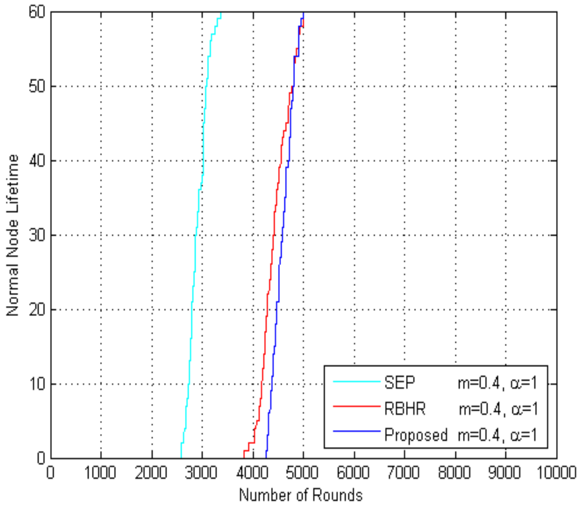
Parameters	**Value**
Initial Energy **E_0**	0.5 J
Initial Energy of advance node	$E_0.(1+\alpha)$
Energy factor **α**	1
Energy consumed in the electronics circuit to transmit or receive the signal **E_{elec}**	50 nJ/bit
Energy consumed by the amplifier to transmit at a short distance **E_{fs}**	10 pJ/bit/m^2

Energy consumed by the amplifier to transmit at a longer Distance **E_{amp}**	0.0013 pJ/bit/m^4
Data aggregation energy **E_{DA}**	5 nJ/bit/report

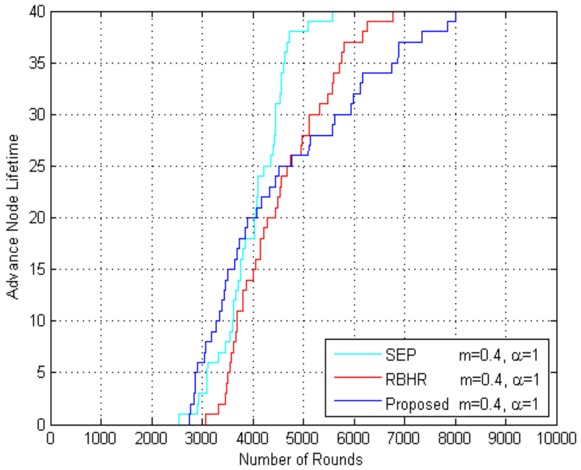
In this section, for 10000 rounds we compare the performance of our RBHMR and RBHR protocol, SEP protocol in the same heterogeneous setting.



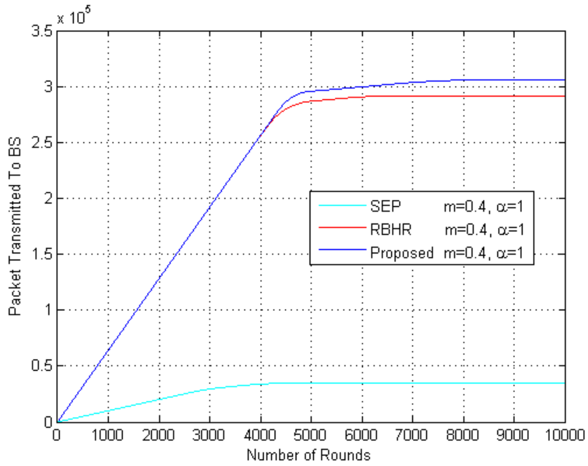
(a) Network life nodes in SEP, RBHR and HMRA



(b) Normal nodes Lifetime in SEP, RBHR and HMRA



(c) Advance node lifetime in SEP, RBHR and HMRA



(d) Packet Transmission to BS in SEP.RBHR and HMRA

In Figure-6 comparative view of the behavior of SEP protocol and RBHR protocol is illustrated, for different heterogeneity parameters. Figure-3 (a) shows network lifetime for different no. of rounds and Figure-3 (b) shows the no. of data packets received at the base station during lifetime of network.

Figure-3 (c) shows the no. of dead super nodes per round and Figure-3 (d) shows the no. of dead normal nodes per round.

TABLE 12: PROTOCOL COMPARISON TABLE

Performance Metrics	SEP	RBHR	HMRA
Network Lifetime (No. of rounds after all node dead)	5567	6763	8003
advance node Lifetime (No. of rounds after all advance node dead)	5567	6763	8003
Normal node Lifetime (No. of rounds after all normal node dead)	3369	4997	4997
Throughput (Total no. of packets transmitted to BS)	35294	289077	297853

We have compared the average results for SEP, RBHR and HMRA that are given in Table-12. From the Table-12 we conclude that the network lifetime , advance node lifetime and throughput of HMRA protocol is increased by 15.49 %, 15.49 % and 3% respectively as compare to SEP and RBHR protocol. Therefore lifetime and throughput of the sensor network is improved as compare to SEP and RBHR.

CONCLUSION

In this paper, in order to increase the network lifetime in the heterogeneous sensor network, we proposed Region based hybrid multi-hop routing method which is combines clustering and multi-hop communication methods.

Fuzzy information is used to minimize cluster head selection process time and re-election process time. The Region based clustering and deployment of the different type of nodes in different regions according to their energy increases the stability of the network throughput.

Hybrid Multi-hop Routing for long range transmission in wireless sensor network is proposed.

References

1. E. H. Miller, "A note on reflector arrays (Periodical style—Accepted for publication)," *IEEE Trans. Antennas Propagat.*, to be published.

2. B. Smith, "An approach to graphs of linear forms (Unpublished work style)," unpublished.

3. Sampath Priyankara, Kazuhiko Kinoshita, Hideki Tode† and Koso Murakami," A Clustering/Multi-hop Hybrid Routing Method for Wireless Sensor Networks with Heterogeneous Node Types " 978-1-4244-8865-0/10 ©2010 IEEE.

4. A.A. Abbasi and M. Younis, "A survey on clustering algorithms for wireless sensor networks," Computer Communications, vol. 30, no.14–15, pp. 2826–2841, 2007.

5. X. Du, Y. Xiao, and F. Dai, "Increasing network lifetime by balancing node energy consumption in heterogeneous sensor networks," Wireless Communications and Mobile Computing, vol. 8, pp. 125–136, Sept.2006.

6. Rajashree.V.Biradar [1] , Dr. S. R. Sawant [2] , Dr. R. R. Mudholkar [3] Dr. V.C .Patil [4]" Multihop Routing In Self-Organizing Wireless Sensor Networks" IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 1, January 2011 155 ISSN (Online): 1694-0814

7. Aderohunmu, F. A., & Deng, J. D. (2009). An Enhanced Stable Election Protocol (SEP) for Clustered Heterogeneous WSN (No. 2009/07) Discussion Paper Series.

8. Smaragdakis G., Matta I., and Bestavros A., "SEP: A Stable Election Protocol for Clustered Heterogeneous Wireless Sensor Networks," in Proceedings of 2nd International Workshop on Sensor and Actor Network Protocols and Applications (SANPA' 2004), 2004.

9. Sonam Maurya, A.K. Daniel "RBHR: Region-Based Hybrid Routing Protocol for Wireless Sensor Networks Using AI Technique" is under review in the ***4th International Conference on Soft Computing For Problem Solving (SocProS-14)***

10. N. A. Torghabeh and al., "Cluster Head Selection using a Two-Level Fuzzy Logic in Wireless Sensor Networks", 2nd International Conference on Computer Engineering and Technology IEEE Vol. 2 August 07 (2010)