Energy Efficient Inter And Intra Cluster Movement of Mobile Sink In Wireless Sensor Network

Nisha Sharma, Kanika Sharma

Abstract: WSN has brought revolution in monitoring or examining the particular area of the network. It has acquired many sectors like agricultural sectors, smart cities (Smart grids, Sewage treatment plants) and automation industries etc. the most prominent concern of battery of the sensor nodes are reported to deal with the energy efficient solution but still there is a lot of scope in enhancing the network performance of the WSN. The sink mobility in a controlled scenario with optimized Cluster head selection after every round using PSO has improved the network performance. The proposed scheme beats the ICM in terms of stability period, lifetime and half node dead. Stability Period, Half Node Dead and Network lifetime has increased by 19.8%, 42.1% and 37% respectively. Standard average coverage time decreases with increase in network area size.

I. INTRODUCTION

The sensor senses different attributes depending upon the application for which the sensor network is deployed. It may range from temperature, pressure, moisture, vibration, etc. [1]. Deployment of sensor nodes is random but uniform. The data is sensed and the processed data is forwarded to the base station. The information regarding any monitoring attribute is forwarded to the user via internet. The sensor technology is inspired from the military applications for which the sensor network used to be deployed in the battlefield. Apart from the military applications, there are various other applications in which the WSN plays a significant role that ranges from environmental monitoring, health care management, agricultural operations, landslide detection, etc. [2]. Clustering is one of the techniques to improve the energy efficiency and large scale Monitoring. It also adds the feature of scalability into the network. Proper cluster-head selection with unequal clustering increases the throughput. Different Approaches used for cluster head selection can be either centralized or distributed. In centralized approach sink elects the cluster head by inspecting various attributes. Cluster head is static. In distributed approach cluster head selection depends on cluster only. Cluster head is dynamic, which changes after every round (depends on residual energy).

* Correspondence Author

Nisha Sharma ME scholar, Electronics and Communication Department, NITTTR, sector 26, Chandigarh, B.Tech (ECE) from Punjab Technical University, Jalandhar.

Dr. Kanika Sharma Assistant Professor, Electronics and Communication Department, NITTTR, sector 26, Chandigarh, PHD, ME and BE (ECE)

The Cluster Heads that are located around the sink consume more energy since their energy is utilized for collecting and transmitting the data packets from its member nodes, and relay the sensuous data from outer area Cluster heads to inner area Cluster head which is called Multi-hopping technique[3].

As the distance between Sensor Nodes and Cluster Head is increased, the energy exhaustion of participating nodes in order to transfer data to cluster head also increases and the nodes located at the far distant points from cluster head depletes its residual energy much earlier[4][5]. Afterwards, the environment of the drained participating nodes cannot be watched, which brings about degradation of the performance of the network like appearance of coverage holes and degradation in the quality of information received and specially coverage time of the network.Normally, WSNs are not concentrated one as it involves site-to-site communication in-between the nodes. Therefore, the prior established infrastructure is not required for deployment of the network [6]. WSN provides pliability of increasing the count of nodes, expanding the network and removal of the nodes as required. But this leads to many significant changes in the network topology such as changing the path, or modernizing the network. In a WSN the node that collects the information from the deployed sensor node refers to as sink or Base Station. The connection of sink might be to the outside world through internet, so as to utilize the information within time bound.Sink is used as a doorway between the sensor network and the destination. Employing dynamic sink is nowadays is very common and known way to enhance duration of the network and energy efficiency of the network. Mobile sink follows different mobility patterns, sojourns at many locations while traversing through the monitoring region and collects the precise data from nodes. Movement patterns of mobile sink can be random, predefined or optimized [7]. In Random mobility, Movement of sink is independent of network parameters. In case of dedicated path, A Strategic plan is implemented for the movement of sink. Optimization of the sink movement may be depending on Residual energy of nodes, inter-node distance, node density etc. Optimization of sojourn time, sojourn position, movement path of sink and velocity is done for better energy efficiency of the network. Data collection can be done through two strategies i.e. push and pull. In push strategy Nodes forwards the data when sink initiates the request but in pull strategy nodes proactively sends its data to the sink [8].

II. PARTICLE SWARM OPTIMIZATION

Particle Swarm Optimization is a technique that mimics swarm intelligence.

It is population based stochastic optimization technique that copies the navigation system followed by birds flocking and fish schooling. The basic concept of PSO algorithm is that each bird is considered as a particle, and the fitness value of each particle is optimized, result corresponds to the position of the particles in the search space [9]. In each step of iteration, all the particles information is upgraded by following two best values: one is the particles best solution achieved until now(personal best) and another one is the population best solution obtained by any of the particle in the population by this time(global best).

Particles learning with each step and transparency of information among each particle determine the next personal best solution and global best solution. This degree of intelligence is absolutely unattainable for any member of the swarm. With cooperation among the members of swarm this level of intelligence is reached. Exploring space is denoted by X and is a collection of all feasible solutions to the optimization problem and finds the best solution amongst all viable solutions in exploring space. x_a is a vector that denotes the position of particle 'a'.

$x_a \in X$

To discriminate between time steps, a time measure is added to the position and is denoted by 'T'. It is a discrete time step and it tells the number of iterations in the algorithm. The position of particle 'a' in the time space 't' is symbolized as x_a(t). This is the vector denoting to the position in time space. Incorporation with position, velocity associated with each particle is represented by v_a(t). This is a vector in same space as position. Velocity explains the movement of particle 'a' in terms of direction and step size. So, the position of a particle in time space T is located at x_a(t) is a member of swarm and it moves on the way to a vector v_a(t). Particles of swarm are interacting with and learning from one another and also, following some basic rules to find the best solution for optimization problem by describing the mathematical model of movement of particles in the PSO. Every particle has some memory to store best experience denoted by P_a(t). In addition there is a common best experience amongst swarm members is denoted by G_a(t), which is a global best (Gbest) experience. Therefore, optimized network has personal best (Pbest) of every particle and a global best (Gbest)[10]. Thus, the introduction of PSO algorithm can improve the WSNs performance to a great degree in terms of load balancing, energy consumption etc.

x_a(t+1) = x_a(t) + v_a(t+1)

v_a(t+1) = W.v_a(t) + R$_1$ .C$_1$. (P_a(t) - x_a(t)) + R$_2$ .C$_2$.(G_a(t) - x_a(t))

W= Inertia Coefficient and w.v_a(t) is called inertia term

C$_1$=Personal Acceleration Coefficient and r$_1$ .C$_1$. (P_a(t)-x_a(t)) is intellectual component

C$_2$= Social Acceleration Coefficient and r$_2$ .C$_2$. G_a(t) -x_a(t)) is social component

R$_1$ and R$_2$ are uniformly distributed random range 0 to 1.

The value of W ranges from 0.8≤W≤1.4.

When C1=C2=0 then v_a(t+1)= v_a(t).

When C1>0 and C2=0 then all the particles become individualistic and velocity be

v_a(t+1) = W.v_a(t) + R$_1$ .C$_1$. (P_a(t) - x_a(t)).

When C2>0 and C1=0 then all the particle moves towards Gbest v_a(t+1) = W.v_a(t) + R$_2$ .C$_2$.(G_a(t) - x_a(t))

When C1 = C2 ≠ 0, then all particles move in the direction of the average of individual best position and global best

position. If C1>>C2, then individual best position has great impact on the resulting solution which in-turn results in excessive travelling. When C1<<C2, then global best position effects the results, which causes all particles to move early to the optimal solution. The optimized values of C1 and C2 are found empirically. Therefore, it has been proposed that the two acceleration constants if stationary should be set to the value C1 = C2 = 2.

Thus, the introduction of PSO algorithm can improve the WSNs performance to a great degree in terms of load balancing, energy consumption etc [11].
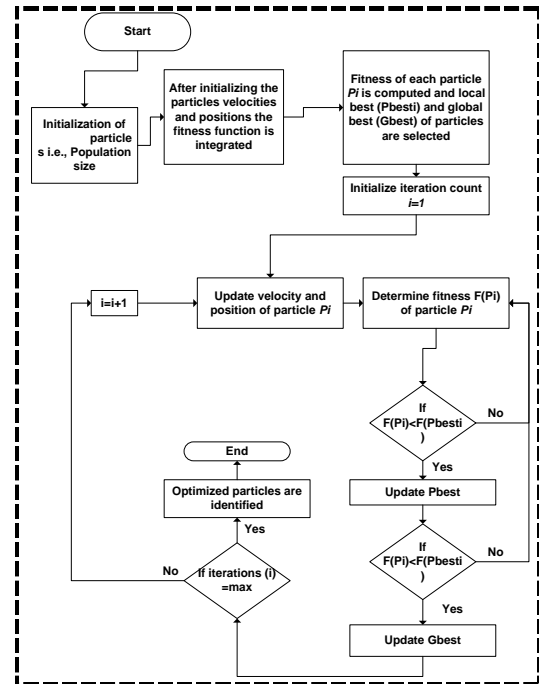

Fig1. Shows Flowchart of PSO Algorithm

In this Paper we proposed Energy efficient Inter and intra cluster movement of mobile sink by using PSO algorithm. Homogeneous nodes are deployed for monitoring of the area. Virtual clustering is used, which divides the network into several smaller sectors. Each cluster uses same clustering algorithm for the selection of cluster head in the cluster. Clustering will be done on the basis of PSO technique considering energy, average inter-cluster distance and node density as key parameters. Initially mobile sink is situated at the centre of the network area. Sojourn time and sojourn locations of the mobile sink are optimized. In addition to that leftover energy of nodes and distance determine the movement of sink (which cluster sink visits first). The proposed algorithm improves the network performance by enhancing the network lifetime and stability period. It also avoids the coverage holes and hotspot problems

III. RELATED WORK

Saranya et al. in [12] presented an algorithm named as EECS (Energy Efficient Clustering Scheme) that inflate the network lifetime and throughput in the network. Cluster head selection depends on a) leftover energy of the nodes; b) interspace and c) the amount of data a particular node have, to transfer to the sink.

Unequal clustering is employed to evade hotspot problem and energy holes. Markov model is used to estimate the transition within the inter-state. The performance of EECS outshines when compared with MOD-LEACH (Modified-low energy adaptive-clustering hierarchy) and MOD-GEAR (Gateway-based energy-aware multi hop routing-protocol algorithm).Kumar et al. in [13] presented that Nodes closer to sink depletes its energy rapidly as compared to other nodes that are at a distance from the sink, due to heavy traffic and that part of the network become dead. Employing mobile sink in the network provides uniform energy consumption, network lifetime enhancement, minimizing the delay and many others. Location Aware Routing for Controlled Mobile Sinks (LARCMS) algorithm is used to minimize the delays, to provide uniform energy consumption, to update the sink position eventually and to enhance the lifetime. Two mobile sinks are coordinated in this way that meanwhile one sink arrives at the outer edge of the network, another one transverses to the centre. The pre-determined track for data gathering provides full coverage and performs more desirable than the other algorithms. However, network cost is enhanced due to the employment of two sinks.Kaswan et al. [14] presented an algorithm that considered rendezvous points (RPs) to define the trajectory for moving sink in the most efficient manner. In the other algorithm, the delay bound path formation of moving sink is taken into consideration. K-means clustering and weight functions are employed for selection of different parameters to cover the entire area. The scheduling technique is applied to perform effective data gathering. Comparison is done with several other algorithms. It has a limitation of having negligible time for sojourn time for MS and the sensor node has equal load for the data generation.Wang et al. in [9] presented a clustering algorithm based on particle swarm optimization with mobile sink in the network. Virtual clustering technique is done on the basis of particle swarm optimization algorithm. The leftover energy and node position are the ruling parameters in cluster head selection. The trajectory of mobile sink is well designed. Simulation shows that the energy utilization is balanced, the network lifetime is comparatively larger, and the transmission becomes faster in EPMS.Gharaei et al. in [15] proposed two algorithms to enhanced network lifetime. The first algorithm determines the sojourn time for the mobile sink. In the second algorithm, the sojourn position of mobile sink is computed through the optimization so that the energy utilization of the Cluster heads could be equitable. It focuses on the sojourn time along with the sojourn position altogether to make the energy efficient data collection in WSN. It also targets those nodes in a cluster which are located far to the cluster heads and therefore, they are moved to the different sojourn positions in the cluster. Mobile sinks have Fermat Spiral motion in the corona topology. Two-stage Genetic Algorithm is employed for intra-cluster communication. In the first step, the optimal sojourn locations within the cluster are determined for moving sink and in the second step, the optimized global position is computed. However, the selection of cluster head is not established firmly. The hot-spot problem still exists and the time taken for the proposed scheme is too high.

IV.   SYSTEM MODELS

A. Network Model

The Network has n number of homogeneous sensor nodes that are arbitrary but uniformly dispersed in the area of Radius R. Clustering is used to divide the network area into smaller sections. It supports in easier management of the network. Particle Swarm Optimization technique guides nodes in cluster formation by using Residual or unused energy of the nodes, avg. inter-cluster distance and node density. Cluster head collects data from Cluster member nodes. It computes the data and then sends the data to the mobile sink. The Mobile sink is initially places in the center of the area network. Network area could be any shape square, circle, rectangle or any polygon. Network stability and lifetime is the main concern of the implementation.In order to have deep insight into the methodology for the proposed work, the flow chart for the methodology is shown in Fig.The network start functioning with the number of nodes deployed in the network and sink is placed at the center of the network. The clustering is done with the help of CH selection which is basically done with the residual energy, inter-cluster distance and node proximity. These factors help in the energy efficient CH selection.Then the sink mobility is introduced with the PSO optimization technique as the lowest energy CH regions are targeted first to save the energy of those CHs which are about to die and is computed through the fitness function.Sink moves to the selected CH and the sojourn time for the sink is computed based on the number of nodes that belongs to cluster from which it has to collect data.Then subsequently, CH moves to the next higher energy CH region. This process is repeated till the energy of the nodes is sustained.After that the residual energy of each node is calculated, if it is sufficient enough for the data transmission and the number to the dead nodes is checked in parallel if it exceeds the total number of nodes. Once it occurs, the network stops functioning. Otherwise, the node again participates in the next round of CH selection.
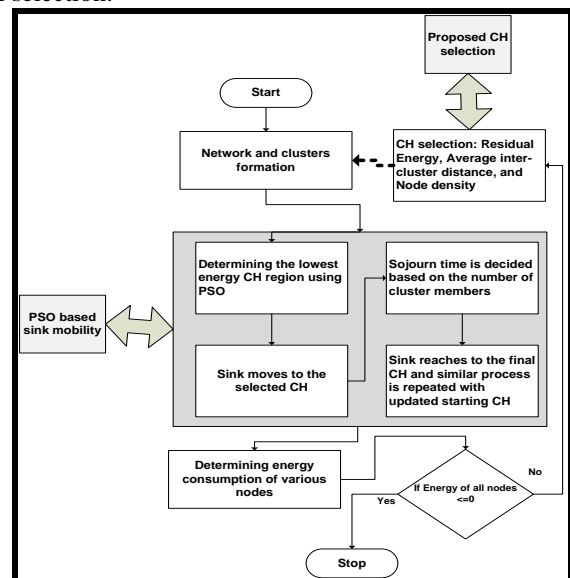

Fig. 2 The design methodology for the proposed work

Parameter	Value
Network coverage	(100, 100) m
BS location	(0,0) m
Node Number	400
Initial energy (Quantity)	In Joules 0.5
E_{elc}	50nJ/bit
E_{efs}	10pJ/bit/m^2
E_{mp}	0.0013pJ/bit/m^4
d_0	87m
E_{da}	5nJ/bit/signal
Data packet size	4000bits

B. Radio Energy Model

Energy consumed by transmitter to run the process is the sum of energy consumed by radio electronics components $E_{elect}(n)$ and power amplifier $E_{amp}(n,d)$ to transfer n no. of bits over distance d. Energy consumed by receiver is the only the radio electronic components $E_{elect}(n)$ [9].

$E_{trans}(n, d) = E_{elect}(n) + E_{amp}(n,d)$.

$$E_{tans}(n,d) = \begin{cases} n \times Eelect + n \times \varepsilon \times d^2 & d < d_o \\ n \times Eelect + n \times \varepsilon \times d^4 & d > d_o \end{cases}$$

$E_{rec} = E_{elect}(n)$

$E_{rec}(n) = n \times Eelect$

Distance between source and destination is d_o. Free space power loss depends on d^2. Multipath loss depends on d^4.

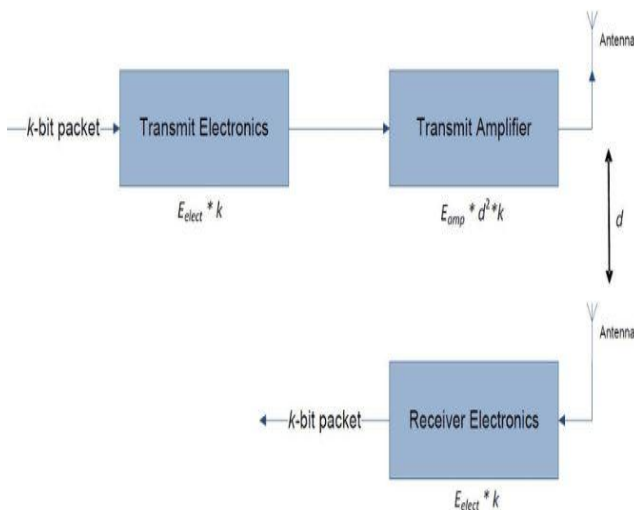$$d_o = \sqrt[2]{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}}$$

Fig. 3 Shows Energy Model

C. Performance Metrics

There are some performance metrics which are utilized to evaluate the performance of proposed protocol. The performance of proposed technique is compared on the basis of following parameters.

a) **Stability Period:** It is described as number of rounds covered until the first node is dead. Optimized clustering and optimized mobile sink movement has bought tremendous increase in the stability period of the network by balancing the energy consumption. Number of rounds completed by the sink with no dead node also explains about the network stability.

b) **Network Lifetime:** It is determined as the number of rounds covered until last node of the network is dead. It depends on the area of the network. As area of the same network increases, lifespan of the network decreases because

movement path of mobile increases, transition time increases and sojourn time is affected [16].

Network's remaining energy: It is the parameter that tells the status of network energy with the passage of rounds. After every round residual energy is calculated, as residual energy plays a crucial role in choosing the cluster head for next round [17].

In addition, it has enormous improvement in the energy hole problem and hotspot problem.

The simulation parameters taken for the simulation analysis of proposed protocol is given as following. It is to be noted that sink is moving in nature, rest all nodes are stationary

V. SIMULATION ANALYSIS

The simulation parameters used in the proposed protocol are given in Table 4.1 [18]. The initial energy of normal nodes is 0.5 J. The proposed technique is simulated in MATLAB version 2013. Here is the following performance matric being used to evaluate proposed protocol.

A. Stability Period

The number of rounds covered till the first node dies, is termed as stability period. It can be seen in the Fig. 4.1 that the proposed technique is enhanced by 19.8% as compared to ICM protocol in terms of stability period. Whereas, the proposed protocol shows the tremendous improvement over the EPMS and TTDD protocols who manages to cover only 74 and 25 rounds, respectively until the first node dead. The reason behind such enlargement in the stability period of the proposed protocol is the PSO that considers various parameters for the CH selection and also optimized sink mobility. The survival of the nodes is elongated by the energy efficient approach that considers the important parameters like residual energy, distance and node density for cluster member and cluster head selection that makes it even consumption of the energy from all the nodes. By using optimized mobile sink, energy utilization of the cluster head decreases considerably which helps in saving the huge amount of energy.
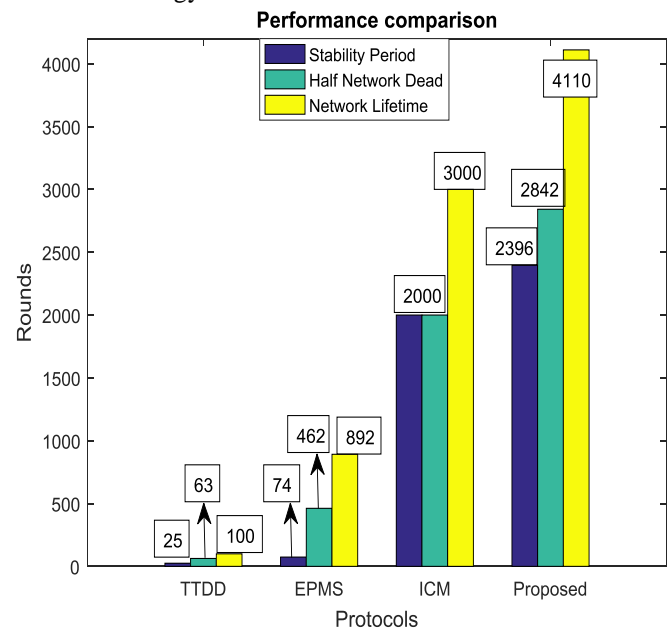

Fig 4 Performance comparison of protocols

B. Half Network Dead

It is determined as the number of rounds, until 50% nodes are dead in the network. In the Fig. 4, the proposed protocol has 2842 rounds covered till the half network is dead while TTDD, EPMS, and ICM protocols has covered only 63, 462, 2000 respectively. It is evident that the percentage improvement of the proposed protocol over ICM protocol is 42.1% which is very significant. The proposed protocol covers 2380 rounds more as compared to the EPMS protocol which is a huge improvement in the given network scenario. This improvement shows the load balancing in the network and further the whole network is made energy efficient. It is due to the fact that the as the network's energy is saved initially by the proposed CH selection, the later energy saving is done by the data collection approach. Sink is made to move to the CH which was consuming its energy at the fastest due to transmission and receiving of the data. Therefore, the data transmission energy is saved tremendously and the nodes are made to operate for the longer duration.

C. Network Lifetime

It is one of the most significant parameter for the evaluation of performance of proposed protocol. It defines the upper possible limit for the number of rounds that can be covered until the whole nodes die. The total number of rounds covered by proposed protocols is 4110, while ICM has covered 3000.rounds. Therefore, proposed protocol is enhanced by 37 % as compared to ICM protocol as shown in Fig. 4.2. However, as seen from the Fig. 4.2, the numbers of rounds covered by the TTDD and EPMS protocols are only 100 and 892, respectively which are very less as compared to the suggested protocol.
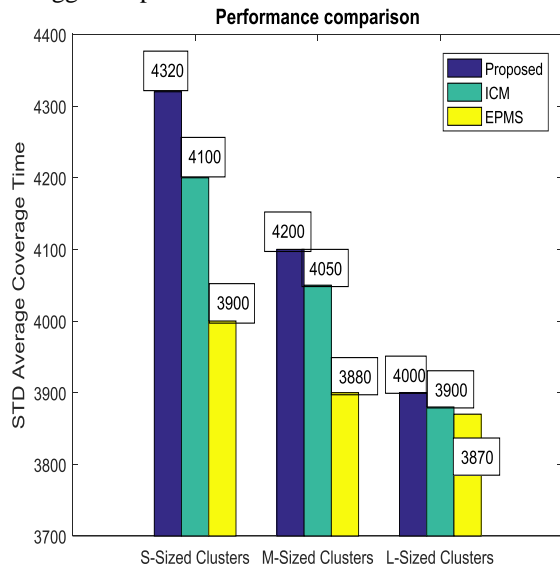

Fig 5 Performance comparison of protocols with increase in area

In Fig. 5, the simulation analysis of the proposed protocol is observed against the ICM and EPMS protocols under different sized clusters. It is noted that the small sized clusters are of 50m, medium sized to be 250m and large area to be 500m respectively. It is evident that, the proposed protocol has overpass the other two comparing protocols as it has very high coverage time in different dimensions of area. It is due to the optimized sink mobility in network. However, coverage time decreases as the magnitude of the network area increases. It is due to the fact that with the

increase in the network size, the distance between the Cluster head and the other nodes increases and hence energy consumption is increases in collecting data from other nodes that ultimately reduces the coverage time.
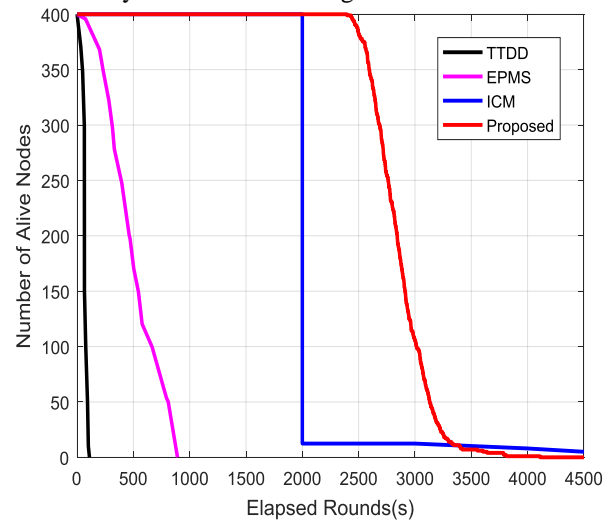

Fig 6 Alive Nodes Vs Rounds

D. Number of Alive nodes vs rounds

The Fig. 6 gives the clear demonstration how the network lifetime is improved to a great level as compared to TTDD, EPMS and ICM protocols. The LND (Last Node Dead) is obtained at 4110 rounds which are much higher than the ICM protocol. Due to change in cluster head after every round (higher residual energy node chosen as Cluster head) and movement of mobile sink towards lowest energy cluster head, energy utilization of all the nodes becomes uniform and that makes network highly stable and ensures no node dead early. The steeper graph of the proposed protocol shows the uniform energy consumption in the network which is always an add-on to the performance of the network.
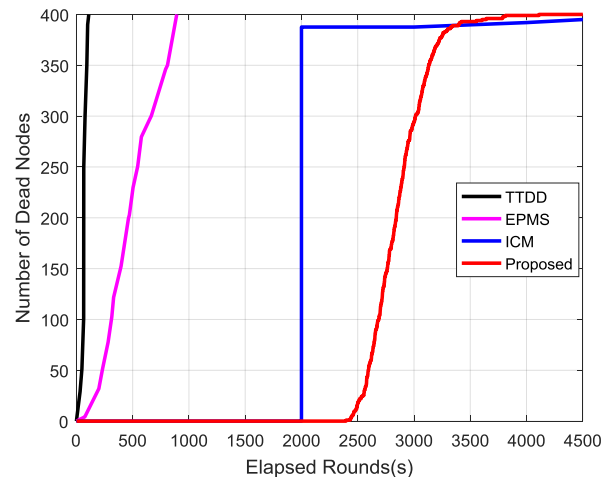

Fig. 7 Dead Nodes Comparison

It is observed that the protocol ICM shows a steep curve in the graph; however the regular behaviour is seen in the graph of proposed protocol. It is due to the fact that due to the optimized mobility; the number of cluster nodes is made to survive for longer duration; therefore, such result is obtained for the proposed protocol.

E. Number of dead Nodes

It is shown in the figure 7 that graph of number of dead nodes vs rounds of proposed protocol as compared to TTDD, EPMS and ICM is much better. First node dead is obtained at 2396 rounds where it was just 25, 74 and 2000 rounds in case of TTDD, EPMS and ICM, respectively. Last node dead is achieved at 4110 rounds where it was just 100, 892, 3000 rounds in case of TTDD, EPMS and ICM, respectively. The reason for such improvement in the plot of dead nodes vs rounds, is due to proposed approach that reduces the energy consumption of the nodes making them live for longer duration.
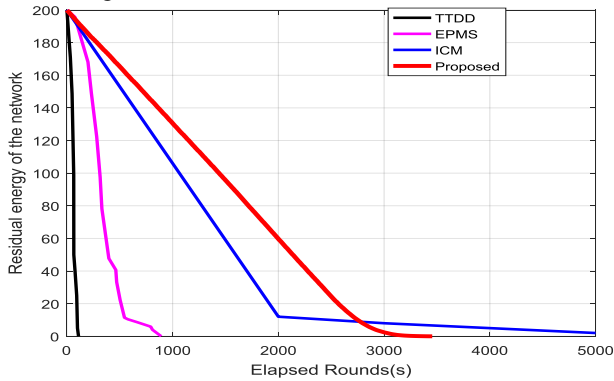

Fig 8 Remaining Energy Comparison

F. Remaining Energy of Network

G. It is another essential performance matric which gives the status of energy depletion i.e. how the energy is consumed while data transmission is going on. It can be seen the energy depletion of proposed protocol is very less than TTDD, EPMS and ICM. Total energy of network is 200J as 400 nodes are involved in the network, which is reducing at much slower rate in case of Proposed Protocol as compared to TTDD, EPMS and ICM protocol as shown in Fig.8.The reason behind improvement in the residual energy graph is the reduction in the intra-cluster distance between the CH node and the nodes of cluster. In addition, the energy distribution is done uniformly when the process is initiated.
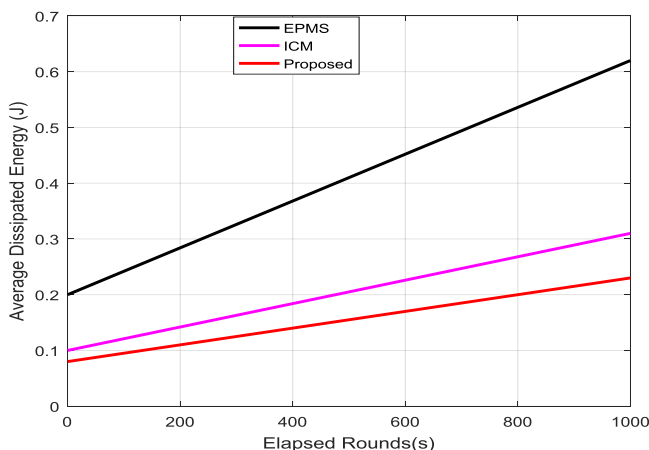

Fig. 9 Average dissipated energy vs time

As shown in Fig. 9 average dissipated energy of the proposed protocol is reduced to the great margin as compared to the other protocols. The reason behind such performance is the optimized movement of the sink in the inter-cluster region that helps in the data collection from the various CHs of different clusters.
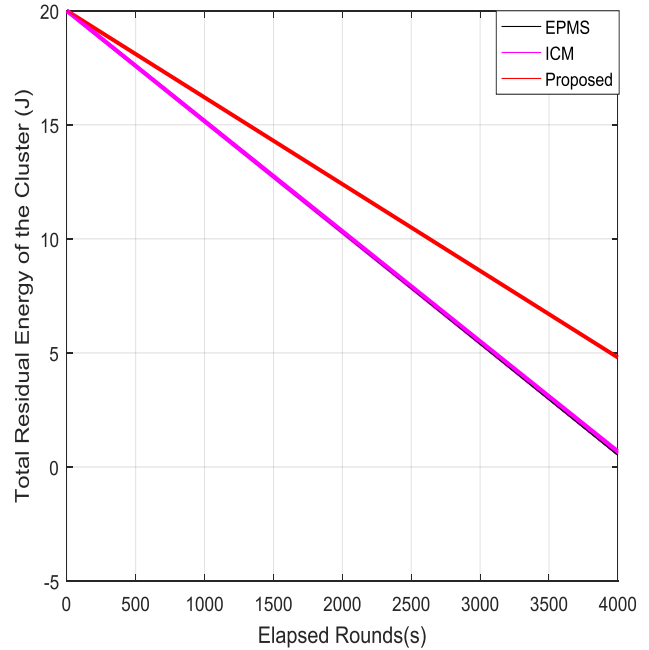

Fig. 10 Total residual energy of the cluster vs time

Furthermore, Fig. 10 shows the total residual energy of the cluster with respect to the number of rounds. It is due to the fact that, the CH is made to move to the clusters of low energy CHs so that the data could be saved before they are completely exhausted of their energies.

Table 2 Summarized analysis of Proposed, EPMS and ICM protocols

Protocols	TTDD (Rounds)	EPMS (Rounds)	ICM (Rounds)	Proposed (Rounds)
Stability Period	25	74	2000	2396
Half Node Dead	63	462	2000	2842
Network Lifetime	100	892	3000	4110

Table 3 Percentage improvement by Proposed as compared to other protocols

Protocols	ICM (%)
Stability Period	19.8
Half Node Dead	42.1
Network Lifetime	37

In Table 4.2 and Table 4.3, the summarized analysis is given about the number of rounds and percentage improvement covered by the Proposed as compared to TTDD, EPMS and ICM protocols.

VI. CONCLUSION

The proposed protocol is an improvement over the TTDD, EPMS and ICM protocols. When the protocol is simulated in MATLAB, the proposed protocol improves stability period by 19.8% as compared to ICM protocol.

Furthermore, the network lifetime is enhanced comprehensively i.e., by 37% as compared to ICM protocol. This enhancement is due to the energy efficient cluster head selection by the use of PSO based optimization technique. The survival of the nodes is elongated by the energy efficient approach that considers the important parameters like residual energy, distance and node density of the node that makes it saving the huge amount of energy.

Future Scope

In future, QoS (Quality of Service) parameters can be taken into investigation. The enhanced QoS parameters make it easy to implement proposed scenarios. Furthermore, the base station can be made to move to collect data to improve throughput by significant amount. The mobility not only reduces the delay in data collection but also improves the data delivery. The sensor networks have requirement to be placed at continuous monitoring areas. Internet of things (IoT) used with WSN can be a biggest achievement if used in smart cities or smart project for monitoring purpose and evolution.

REFERENCES

1. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "Wireless sensor networks: a survey," Computer Network, Vol. 38, No. 4, pp. 393–422, 2002.
2. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A survey on sensor networks," IEEE Communication Magazine. Vol. 40, No. 8, pp. 102–114, 2002.
3. Van der Merwe, D. W., and Andries Petrus Engelbrecht. "Data clustering using particle swarm optimization." In The 2003 Congress on Evolutionary Computation, 2003. CEC'03., Vol. 1, pp. 215-220. IEEE, 2003.
4. Y. Yang, C. Lai, and L. Wang, "An energy-efficient clustering algorithm for wireless sensor networks," in 2013 10th IEEE International Conference on Control and Automation (ICCA), pp. 1382–1386, 2013.
5. N. Mittal, U. Singh, and B. S. Sohi, "A Stable Energy Efficient Clustering Protocol for Wireless Sensor Networks," Springer, Wireless Networks, Vol. 23, No. 6, pp. 1809–1821, 2017.
6. Y. Wang, "Topology control for wireless sensor networks," in Wireless sensor networks and applications, Springer, pp. 113–147, 2008.
7. Khan, Majid I., Wilfried N. Gansterer, and Guenter Haring. "Static vs. mobile sink: The influence of basic parameters on energy efficiency in wireless sensor networks." Computer communications Vol. 36, No. 9, pp. 965-978, 2013.
8. Liu, Wang, Kejie Lu, Jianping Wang, Guoliang Xing, and Liusheng Huang. "Performance analysis of wireless sensor networks with mobile sinks." IEEE Transactions on Vehicular Technology Vol. 61, No. 6, pp.2777-2788, 2012.
9. J. Wang, Y. Cao, B. Li, H.J. Kim, and S. Lee, Particle swarm optimization based clustering algorithm with mobile sink for WSNs. Future Generation Computer Systems, Vol. 76, pp.452-457, 2017.
10. S. Alam, G. Dobbie, Y.S. Koh, P. Riddle, and S. U. Rehman, Research on particle swarm optimization based clustering: a systematic review of literature and techniques. Swarm and Evolutionary Computation,Vol. 17, pp.1-13, 2014.
11. S. Mohaghegi, Y. del Valle, G.K.Venayagamoorthy, R.G. Harley. "A comparison of PSO and backpropagation for training RBF neural networks for identification of a power system with STATCOM", Proceedings 2005 IEEE Swarm Intelligence Symposium, 2005.
12. V. Saranya, S. Shankar, and G. R. Kanagachidambaresan, "Energy efficient clustering scheme (EECS) for wireless sensor network with mobile sink," Wirel. Pers. Commun., Vol. 100, No. 4, pp. 1553–1567, 2018.
13. V. Kumar, and A. Kumar, "Improving reporting delay and lifetime of a WSN using controlled mobile sinks" Journal of Ambient Intelligence and Humanized Computing, Vol.10, No.4, pp.1433-1441, 2019.
14. Kaswan, K. Nitesh, and P. K. Jana, "Energy efficient path selection for mobile sink and data gathering in wireless sensor networks," AEU-Int. J. Electron. Commun., Vol. 73, pp. 110–118, 2017.
15. N. Gharaei, K. A. Bakar, S. Z. M. Hashim, and A. H. Pourasl, "Inter- and intra-cluster movement of mobile sink algorithms for cluster-based networks to enhance the network lifetime," Ad Hoc Network, Vol. 85, pp. 60–70, 2019.
16. A. Salim, W. Osamy, and A. M. Khedr, "IBLEACH: intra-balanced LEACH protocol for wireless sensor networks," Wirel. Netw., Vol. 20, No. 6, pp. 1515–1525, 2014.
17. M. Akbar, N. Javaid, M. Imran, N. Amjad, M.I. Khan and M. Guizani, Sink mobility aware energy-efficient network integrated super heterogeneous protocol for WSNs. EURASIP Journal on Wireless Communications and Networking, No.1, pp. 66, 2016.
18. Lecture Notes in Computer Science, 2007.

AUTHORS PROFILE

Nisha Sharma ME scholar, Electronics and Communication Department, NITTTR, sector 26, Chandigarh, B.Tech (ECE) from Punjab Technical University, Jalandhar.

Dr. Kanika Sharma Assistant Professor, Electronics and Communication Department, NITTTR, sector 26, Chandigarh, PHD, ME and BE (ECE)