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Improved Rendezvous Nodes Based LEACH Using Hybrid PSO/GA

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Abstract*-- Wireless sensor networks consists of many spatially distributed small sensor nodes that are used to monitor various environmental conditions. The sensor nodes are equipped with limited power supply, so utilization of the energy efficiently and increasing their lifetime becomes a primary design objective for wireless sensor networks. Number of methods has been proposed to increase the lifetime of these sensor nodes in a network. The present research proposes a new rendezvous nodes LEACH protocol with the hybrid PSO/GA based routing. The PSO/GA based technique has improved the path selection of rendezvous nodes LEACH .The proposed technique is designed and implemented in MATLAB 2013.The results has shown significant improvement of the proposed technique.

***Index Terms*-- Clustering, Cluster Head., Mobility, Rendezvous node (RN), Wireless sensor network (WSN).**

I. INTRODUCTION

A rapid development in Micro-Electro-Mechanical System (MEMS) technology and wireless communication technology, wireless sensor networks are used in many applications. Most known applications are military reconnaissance, disaster management, security surveillance, habitat monitoring, medical and health, industrial automation [1].Wireless sensor networks (WSNs) composed of large number of tiny sensor nodes that are battery powered, low cost and energy constrained. These nodes are small in size with sensing, computation and data processing capabilities [2,4].Sensor nodes collect all the data and send it to the sink node that is known as base station(BS).Base station send the data to the end user for further processing through the internet facility[3].Data generated by each node has been sent to the base station using number of hops. Transmission of data consumes most of the limited energy of nodes. So for the long term use of nodes increasing their lifetime is very important. Various data aggregation techniques that are based on routing and clustering are proposed to increase the lifetime of the sensor network. The main goal of these techniques is to decrease the transmission distance of data or to save the energy of the nodes within a network. Since transmissions that are required to send the data consumes most of the energy of nodes so by reducing the size of data number of transmissions can be reduced for sending the data [5,6,7].There are number of clustering protocols like LEACH,PEGASIS,TEEN,HEED etc. that are energy preserving and are active area of research. LEACH is simplest among all these protocols based on clustering that distributes the energy load among all the nodes in a network to increase the lifetime of the network [8,11].

Various limitations of LEACH protocol are :

1. In LEACH distribution of nodes is not uniform [6].
2. To send the data to the cluster heads time slot is provided to each node but in some cases nodes have no data to transmit [11].
3. LEACH does not consider mobile sink.

Recent studies considered mobility of the sink node as another approach to increase the lifetime of nodes in wireless sensor network. Mobile sink moves inside or around the environment to collect the data from all the nodes [9].All the nodes in a cluster send their data to the cluster head. Cluster head performs the aggregation of data and send the filtered data to the mobile sink. Mobile sink reduces the long hop relaying and the dissipation of energy of sensor nodes that are placed near the base station. The major performance bottleneck of WSNs with a mobile BS is the increased latency in data collection. A new technique named as rendezvous-based data collection approach explores the controlled mobility of BS and the capability of in-network data caching [9, 21]. In this approach, a few nodes in a large sensing field serve as rendezvous points (RPs) that buffer data sent (possibly through multiple hops) from source nodes. Cluster heads send the collected data to the nearby rendezvous node. The use of rendezvous points helps the cluster heads to collect a large volume of data at a time without traveling a long distance which achieves high data bandwidth and low communication delay at the same time [22] and increases the lifetime of the network. The remainder of the paper is organized as follows: Section II presents the related work. Section III presents the proposed algorithm and section IV describes the experimental results. Finally, section V concludes the paper.

II. RELATED WORK

LEACH (Low Energy Adaptive Clustering Hierarchy) [12] is a self organized communication protocol that uses the randomized rotation of cluster heads to distribute the load among all the nodes in a network. Nodes form a cluster and among all nodes one node performs as cluster head. The main goal of cluster head is to collect data from

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all member nodes and send it to the base station. All the nodes perform the aggregation of data that is received from all the member nodes. To increase the lifetime [20] compares LEACH and various modified versions of it. In [18] self organized property of sensor nodes is described and nodes are deployed in a network according to the characteristics of specific applications. Various applications of wireless sensor networks are focused [17] and comparison is done depends on convergence rate, cluster stability, cluster overlapping, location awareness and mobility of the node. In [13] [14] mobility of base station is taken to check the improvement in network lifetime of wireless sensor network. Position of mobile base station is taken as main consideration. Optimal solution is obtained when the position of the base station is constrained on pre determined points. Different trajectories of mobile sink and effects of it on the real world mobile wireless sensor network is also discussed. Due to low movement speed of mobile base stations [15] proposed a rendezvous-based approach in which rendezvous nodes(points) that are from the subset of nodes are responsible to forwarded the data to mobile elements when they arrive. Mobile elements without travelling long distances can collect the large amount of data from sources with the use of rendezvous points. In[19]a new routing protocol GROPUP(Genetic algorithm inspired ROUTING PROTOCOL) overcomes the limitations of LEACH and PEGASIS schemes. Genetic algorithm [16] is used to arrange the nodes in a network. This algorithm decreases the communication energy by taking clustering nodes and arranging them in nearby distance in every cluster and increase the network lifetime for different network positioning method. For creating the energy aware clusters and for optimal selection of cluster head [8] particle swarm optimization is used. The selection procedure of objective function is based on various parameters like residual energy, minimum distance of member nodes and count of the cluster head nodes. This technique provides more effective lifetime than other alternative methods. [23] Examines two clustering protocols, LEACH and LAECH-C with the help of NS-2 tool. These protocols are simulated and analyzed using various parameters. Experimental results show that LEACH is adopted if the coordination between the nodes is local in clustering and involvement of base station is less than other factors like over desired number of clusters etc. whereas LEACH-C is chosen when desired number of clusters and more network lifetime is expected. [24] deals with the network lifetime improvement of wireless sensor network. Different approaches are used to select the cluster head. Selection of the cluster head depends on the maximum residual energy, minimum distance and finding the optimal path to transmit the data between the cluster heads to the base station. [25] Introduced an improvement over LEACH protocol named as BN-LEACH. In BN – LEACH selection of cluster heads is done on the basis of Bayesian Network. This method takes into consideration the factors like distance to the Base Station (BS), remaining energy and density to improve the lifetime of the network. Results show that the proposed method extends the node death time than the LEACH protocol. [26] Provides an improvement over LEACH protocol. Authors proposed an improved V-LEACH protocol in which vice cluster head works when cluster head will die. Simulation results show that V-LEACH provides better network lifetime than the LEACH protocol. [27] Proposed a protocol named as OP-LEACH that outperforms over the LEACH protocol. Proposed method reduces the energy consumption among all nodes of the wireless sensor network.[28] provides a efficient protocol than the LEACH protocol .Proposed method named as MOD LEACH decreases the energy dissipation of nodes by using the replacement of cluster head and also use a dual transmission power levels.[29] improves the LEACH protocol by taking the residual energy of sensor nodes. Proposed method PR-LEACH improves the cluster head selection of LEACH protocol by considering the residual energy of sensor nodes .Proposed algorithm balances the energy dissipation between all sensor nodes and provides better performance than the LEACH protocol.

III. PROPOSED ALGORITHM

This section provides the various steps required to successfully accomplish the objectives of the paper.

1. **Deployment of sensor nodes:** Sensor nodes are deployed randomly in a wireless sensor network and distribution of these nodes is done in a square region.
2. **Apply threshold function to get cluster heads**: Like the LEACH protocol, cluster heads are chosen based on the percentage of existing cluster heads (CHs) that is usually between 5% and 10%, number of times a node becomes the cluster head and its level of energy. To become a cluster head nodes generate a random number between 0 and 1 . If the number is less than the present threshold $T(n)$, then the node becomes cluster head for the current round and the label of cluster head will attach to it.The threshold is defined as :

$$T(n) = \begin{cases} \dfrac{p}{1 - p\left(t \bmod \frac{1}{p}\right)} & if\ n \in G \\ 0 & otherwise \end{cases} \quad (1)$$

Where p is desired CHs number, t represents the current round, G represents the number of nodes that have not become cluster heads in the last $\frac{1}{p}$ rounds. At this threshold each node gets a chance to become a cluster head within $\frac{1}{p}$ rounds. Nodes that are not elected as cluster heads are still act as normal nodes (NN).

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3. Associate member nodes with Cluster Heads: When the cluster heads (CHs) are chosen, each CH broadcasts the advertisement message to the normal nodes. Cluster heads use the CSMA protocol to send the advertisement message. All the nodes depending upon the distance to the cluster head decides to which cluster it belongs.

4. Evaluate position of Rendezvous nodes: Rendezvous nodes(RN) are chosen from the normal nodes(NN).The important condition to become a rendezvous node is the distance from the mobile sink trajectory that is given as:

$$if\ \frac{y_m}{2}(1-R_X) \le y_i \le \frac{y_m}{2}(1+R_X) => Type = RN \quad (2)$$

where $\frac{y_m}{2}$ is the width of the sampling region, y_i is the location of the node in the y-dimension and R_X is a constant with a value of <1.

5. Apply PSO/GA based routing: PSO (Particle Swarm Optimization) and GA (Genetic Algorithm) are used to find the shortest path between the cluster heads to the base station. The PSO algorithm provides the idea of particle's best solution and the best global solution. After this it is combined with the crossover and mutation of genetic algorithm.

6. Evaluate and Update Energy Consumption: In this step energy that is consumed to send or receive a data is calculated. Consumption of energy is calculated according to the basic energy formula:

$$E_{TX} = \begin{cases} l * E_{TX} + l * d^2, & d < d_0 \\ l * E_{TX} + l * d^4, & d \ge d_0 \end{cases} \quad (3)$$

$$\text{Where } d_0 = \sqrt{\frac{E_{fs}}{E_{amp}}}$$

E_{TX} is the energy consumed by the radio elcectronic circuit, E_{fs} is the energy consumed by the power amplifier on the free space model, E_{amp} is the energy consumed by the power amplifier in the multipath model.

7. **Count dead nodes**-In the next step count the number of nodes that are dead. These nodes now do not have energy to send the data.

8. **Network lifetime**-In the last step evaluate the lifetime of the network when all the nodes becomes dead.

IV. EXPERIMENTAL RESULTS

A MATLAB simulation of PSO/GA algorithm is done to evaluate the performance. In this section we have evaluated the performance of the proposed PSO/GA scheme and compare it with the Rendezvous nodes LEACH on the basis of first node dead time, network lifetime at different energy levels.

A. When first node dies: Table 1 shows the comparison between Rendezvous nodes based LEACH and PSO/GA based routing technique when the first node dies at different energy levels. Figure.1 shows the comparison graph where x-axis represents the energy level and y-axis represents the number of rounds. Red color in the graph represents the PSO/GA technique and blue color represents the Rendezvous nodes LEACH (RN-LEACH).

Table .1 First Node Dead Time Analysis

Energy Level	RN-LEACH	PSO/GA routing
0.02	61	69
0.04	120	129
0.06	181	210
0.08	261	269
0.10	327	334
0.12	354	421
0.14	430	541
0.16	485	568
0.18	570	617
0.20	641	715

The graph obtained when first node dies in RN-LEACH and PSO/GA routing technique is shown in figure .1

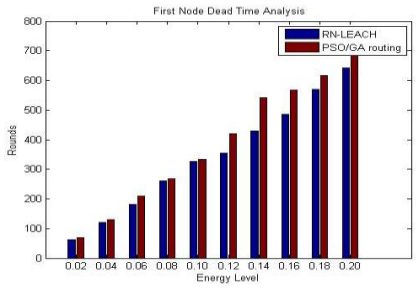

Fig .1 Graph when first node dies in RN- LEACH and PSO/GA routing.

B. Network Lifetime: Table 2 shows the difference in network lifetime between RN- LEACH and PSO/GA routing. In the table we can see that PSO/GA routing technique gives longer lifetime values than the RN-LEACH.

Table .2 Network Lifetime Analysis

Energy Level	RN-LEACH	PSO/GA routing
0.02	97	108
0.04	194	212
0.06	292	318
0.08	389	414
0.10	482	521
0.12	583	631
0.14	676	731
0.16	765	825
0.18	868	942

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0.20	961	1056

The graph obtained for network lifetime in RN-LEACH and PSO/GA routing technique is shown in figure 2.

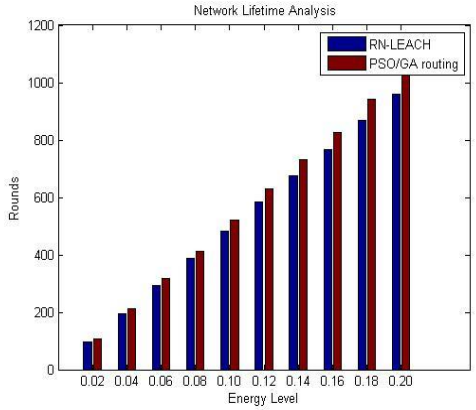

Fig 2 Graph for Network Lifetime in RN-LEACH and PSO/GA routing

V. CONCLUSION

A wireless sensor network plays a vital role in various applications. The nodes in a sensor network have limited power supply, so improving their lifetime is very important. In this paper we have proposed a rendezvous nodes based LEACH protocol with the hybrid PSO/GA based routing. The path selection in Rendezvous nodes LEACH has been improved by PSO/GA based technique. Experimental results have shown that the proposed technique provides the better results on the basis of various parameters.

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