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Comparison of Routing Algorithm of Optimized and Non-Optimized PSO in Wireless Sensor Networks

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Abstract:
Wireless sensor networks (WSN's) are comprised of various devices such as sensors and actuators that examine various physical phenomenon. Localization of nodes is one of the important components of the WSN function. Various algorithms are used to locate nodes and reduce the physical interruptions in the WSN network. Various constraints related to the wireless sensor networks are energy consumption by the node, node allocation and the lifetime of the network. The nodes perform various tasks that includes sensing, communication and data transferring. The efficiency of data transfer is increased by using optimization algorithm as compared to the non-optimized networks. The versatility of the network can be improved by using the optimization techniques that help in increasing the lifetime of the network. An efficient PSO (Particle Swarm Optimization) algorithm is used for fast convergence and energy efficient results. The algorithm provides an efficient scheme for fitness function. LEACH (Low Energy Adaptive Clustering Hierarchy) algorithm is used with PSO that helps in saving energy and improving the lifetime of the network. PSO is deployed with LEACH as to solve the routing problem and also it doubles the lifespan of the network.PSO optimized LEACH algorithm is used to obtain various favourable results.

Keyword: Energy consumption, LEACH algorithm, PSO, Routing, Wireless Sensor Networks.

1. INTRODUCTION

The implementation of a proficient design into a wireless network has become an interesting issue in the present scenario.

Wireless networks have vast applications in the present world therefore various researches have been carried out to improve the efficiency. There are nodes in the wireless networks which help in efficient data transfer as compared to the non-optimized data transfer.

There are various applications of wireless sensor networks that is in the field of medical sciences, in Transportation and logistics domain, Healthcare domain, Smart environment (home, office, plant) domain, Personal and social domain. With the help of WSN we can help in monitoring the patient heath, it can help in detecting the environmental parameters etc. WSN uses the sensors and actuators to determine the physical conditions and can lead towards a result.

There are different kind of sensors that are much reliable and flexible. The physical data can be obtained with the help of these sensors and can be stored in the database, so that it can be transferred from one point to another with the help of wireless networks [1].

Therefore, the networking protocols that are used for transmission should be reliable, efficient and secure. However, one of the main concern of WSN is the limited power sources of the sensor nodes. Due to the unattended hostile environment, the replacement of the battery is almost impossible which leads to the energy constraint for the sensor node. Therefore, energy conservation is one of the main challenge for the development of the wireless sensor networks in large scale.

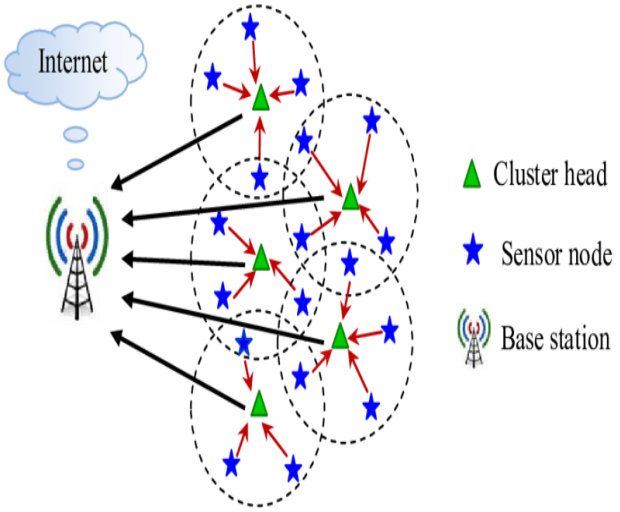

Figure.1. A Cluster based WSN model

However, the major constraint of WSNs is the limited power sources of the sensor nodes. The battery operated sensors are often deployed in an unattended hostile environment, so replacement of their battery is almost impossible which make the sensor node energy constraint. Therefore, energy conservation of the sensor nodes is the main challenging issue in Clustering sensor nodes is one of the most effective techniques which is employed to conserve the energy of the sensor nodes [6]. In the process of clustering, the network is divided into several groups, called clusters. Each cluster has a leader referred as cluster head (CH). CHs are responsible to collect the local data from their member sensor nodes within the clusters, aggregate them and send it to a remote base station (BS) directly or through other CHs. The BS is connected to a public network such as Internet for public notification of the event. As an example, the functionality of cluster based WSN is shown in Fig. 1. Clustering has the

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The simulation results are explained in The rest of the paper is organized as follows. Section 2 presents the related works. The preliminaries of PSO, network and energy models are provided in Sect. 3. The proposed approach, terminologies, LP formulation for CH selection, PSO based algorithm and Cluster formation are provided in Sect. 4. The simulation results are explained in The rest of the paper is organized as follows. Section 2 presents the related works. The preliminaries of PSO, network and energy models are provided in Sect. 3. The proposed approach, terminologies, LP formulation for CH selection, PSO based algorithm and Cluster formation are provided in Sect. 4. The simulation results are explained in The rest of the paper is organized as follows. Section 2 presents the related literature. The preliminaries of PSO, network and energy models are provided in Sect. 3. Also, the proposed approach, terminologies, PSO based algorithm are provided in section. The results and conclusion is provided in section 4 followed by the references.

2. REVIEW OF RELATED LITERATURE

There are a large number of algorithms that have been developed for WSN's[3]. There is optimized and non-optimized approach but we mainly concentrate on the optimized approach. A large number of algorithms have been developed for WSN's. LEACH (Low energy adaptive clustering hierarchy)[4]-[5] algorithm is one of the main clustering algorithm. In it clustering head is one of the sensor node with some probability. With the help of this LEACH algorithm significant energy saving is done and it help in prolonging the lifetime of the network compared to the non-optimized approach. . However, the main disadvantage of this algorithm is that there is a possibility to select a CH with very low energy, which may die quickly and thus degrades the performance of the network. The algorithms have been developed to improve LEACH protocol. algorithms have been developed to improve LEACH pro- tocol, PEGASIS [11] and HEED [12] are popular among them. PEGASIS organizes the nodes into the chain so that each node transmits and receives the data only from its neighbour nodes. In each round, a randomly selected node from the chain is selected as a CH. PEGASIS is more energy efficient over LEACH but it is unstable for large size networks. Moreover the delay is significantly high. Recently, many algorithms [13–17] have been developed for data gathering schemes for extending the lifetime of WSNs. Loscri et al. [18], have proposed TL-LEACH protocol introducing a new level of hierarchy. It improves the network lifetime over LEACH, however, with an extra over head for electing secondary CHs and also non-CH nodes assign to the CHs based on distance only, which may cause severe energy imbalance to the network. Xiaoyan et al. [19], have proposed M-LEACH algorithm, it is similar to LEACH, the only difference is instead of sending the data directly to the BS, it forward to the next hop CH node, in this way it saves energy compared to LEACH and TL-LEACH. However, it doesn't take care of cluster formation phase. Also, in multi-hop data transfer between CHs, it does not consider the important metrics like energy, node degree etc. Yassein et al. [20], have proposed V-LEACH protocol for improving the LEACH protocol in which some CHs referred as vice CHs are selected along with the main CHs, when the main CHs die, the vice CHs act as a CHs. It is shown to perform better than original LEACH. However, sensor nodes need extra processing energy for selecting vice CHs. Also, it doesn't take care of formation of clusters, which may cause severe energy inefficiency of the WSN. In [21], the authors have proposed E-LEACH protocol, which is similar to LEACH protocol, but in the selection of CHs residual energy of the CHs was taken into account, which can extend the life of the network by saving the low energy of CHs. Means, it may not selects the CH with low energy. According to [22], M-LEACH is better than the TL-LEACH, E-LEACH [21] is better than M-LEACH. Bari et al. [23], have proposed least distance clustering (LDC) for improving the lifetime of WSNs. The merit of LDC is that it executes faster, because of assigning of non- CH nodes to the nearest CH. The main disadvantage of LDC is the improper formation of clusters. However, it is difficult to find the optimal clusters for large scale networks because the computational complexity varies exponentially. In [24–27], the authors have proposed energy efficient cluster based routing schemes for reliable networks and in [28] a framework for energy evaluation in WSNs has proposed. For topology control and delay Earlier PEGASIS [6] and HEED [7] were common protocols. PEGASIS helps in receiving the data only from its neighbor nodes. In every round a node is selected randomly as

the clustering head. PEGASIS is not suitable for large sized networks but it is more efficient as compared to LEACH. But delay in high in this which results in the overhead. Xiaoyan et al. [8][12], have proposed M-LEACH algorithm, it is similar to LEACH, the only difference is instead of sending the data directly to the base station, it forward to the next hop clustering head node, in this way it saves energy compared to LEACH and TL-LEACH. But in this care of cluster formation is not taken. Also, it is not efficient in multi-hop data transfer[9]. A different algorithm called V-LEACH has also been proposed by Yassein et al. [10], which improves the LEACH protocol. In this particular algorithm some of the clustering heads are referred as vice clustering heads which are selected among the main clustering heads. When main clustering heads die the vice clustering heads act as the clustering heads. This algorithm proves better than the original LEACH, but it require extra energy to select the vice clustering heads. Also, it doesn't take care of formation of clusters, which may cause severe energy inefficiency of the WSN. These are all the heuristic approaches for the LEACH algorithm. In particle swarm optimization, the first Molecule Swarm Enhancement (Sharma and Sharma, 2012) is an assumptive inquiry handle, framed after the conduct of a winged animal run. The calculation keeps up a populace of agents, where every agent has a potential answer for an enhancement problem. With PSO, a swarm alludes to various potential answers for the advancement issue, where every potential arrangement is alluded to as a particle.

The PSO algorithm proceeds via discovering the agent position that outcomes in maximal assessment of a given wellness function. Although, naive K-means gets stuck at local optima points, it takes less number of iterations to reach a result than PSO. This segment manifests that the execution of the PSO bunching calculation can be additionally upgraded by embedding the underlying swarm with the yield of naive K-Means algorithm on the data. One of the agents in the swarm is initialized according to the outcome of K-means (Mechta et al., 2014), while remaining agents are assigned haphazard values. Therefore as a consequence, after initialization, PSO clustering (Parwekar et al., 2018) is incorporated in the proposed work and a new algorithm namely ESO-LEACH is proposed as a part of this research work in order to get a LEACH version which is best of all the worlds in a sense.

Our proposed algorithms have the following advantages over the non-optimized one:

- It is an efficient scheme which considers distance parameters and energy consumption as an important function which is important for lager WSN networks.

- In many existing algorithms [11]-[13], the nodes are assumed to be equipped with a location finding system such as GPS which is not at all weight effective in deploying a large scale WSN. The proposed algorithm does not require any GPS.

3. PSO ALGORITHM

3.1 Overview of PSO

Particle swarm optimization (PSO) [50] is a nature inspired swarm intelligence based algorithm, modelled after observing the choreography of a flock of birds, i.e., how they can explore and exploit the multi-dimensional search space for food and shelter. PSO consists of a predefined number of particles say NP, called a swarm. Each particle provides a potential solution. A particle Pi, 1BiBNP has position Xi, d and velocity Vi, d, 1BdBDin the dth dimension of the search space. The dimensionDis same for all particles. A fitness function is used to evaluate each particle for verifying the quality of the solution. The objective of PSO is to find the particle's positions that result best evaluation of the given fitness function. In the initialization process of PSO, each particle is assigned with a random position and velocity to move in the search space. During each iteration (generation), each particle finds its own best, i.e., personal best called P best i and also the Particle swarm optimization (PSO) [12]-[15] is a nature inspired swarm intelligence based algorithm, modelled after observing the choreography of a flock of birds, i.e., how they can explore and exploit the multi-dimensional search space for food and shelter. PSO consists of a predefined number of particles say N_P, called a swarm. Each particle provides a potential solution. A particle P_i, $1 \leq i \leq N_p$, has position $X_{i,d}$and velocity $V_{i,d}$, $1 \leq d \leq D$ in the dth dimension of the search space. The dimension Dis same for all particles. A fitness function is used to evaluate each particle for verifying the quality of the solution. The objective of PSO is to find the particle's positions that result best evaluation of the given fitness function[8].In the initialization process of PSO, each particle is assigned with a random position and velocity to move in the search space. During each iteration (generation), each particle findits own best, i.e., personal best called P best and also the global best called Gbest. To reach the global best solution, it uses its personal and global best to update the velocity Vi,d and position Xi,d using the following equations global best called Gbest. To reach the global best solution, it uses its personal and global best to update the velocity Vi,d and position Xi,d using the following equations

$$v_{i,d} = \omega \times v_{i,d}(t) + c_1 \times x_1 \times \left(X_{Pbest\ i,d} - X_{i,d}\right) + c_2 \times x_2 \times \left(X_{Gbest} - X_{i,d}\right) \quad (3.1)$$

$$X_{i,d}(t+1) = X_{i,d}(t) + V_{i,d}(t+1) \quad (3.2)$$

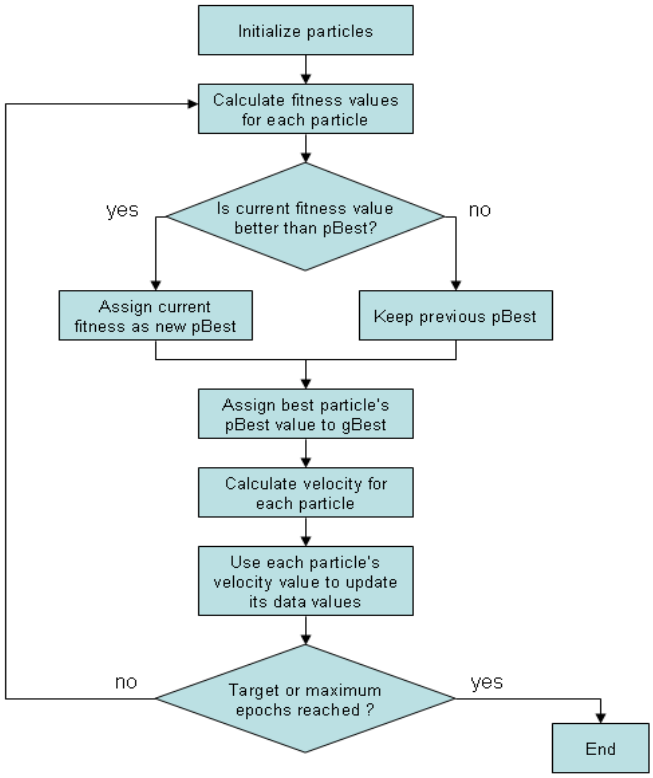
whereω, $0 < \omega < 1$, is the inertia weight, C_1, C_2 where $0 \leq C_1, C_2 \leq 2$ are the acceleration coefficients and x_1, x_2 where $0 \leq x_1, x_2 \leq 1$ are the randomly generated values. The updating process is repeated until it is reached to an acceptable value of Gbest. After getting new updated position, the particle evaluates the fitness function and updates Pbests well asGbest for the minimization problem as follow

$$\text{Pbesti} = \begin{cases} Pi & if\ (fitness(Pi) < fitness\ (Pbesti) \\ Pbest & otherwise \end{cases} \quad \ldots.(3.3)$$

$$\text{Gbesti} = \begin{cases} Pi & if\ \ (fitness\ (Pi) < fitness\ (Gbest)\ ) \\ Gbest & otherwise \end{cases} \quad \ldots..(3.4)$$

The particle explores in the multi-dimensional search space to achieve a global best solution. It is clear that initially a particle Pi, occupies the position $X_{i,\ d}$ with velocity Vi, d at a point of time and it is moving in some direction.

Later the particle changes the direction and moves to another position using its memory. It then again changes its direction by the influence of the swarm and occupies a new position $X_{i,d}(t+k)$ with velocity $V_{i,\ d}$ (t+k) and finally reaches the global best position $X_{i,\ d}$ (s), where $t+k < s$ and the variables s, t and kare defined on a particular period of time.The following algorithm is used for the research.



3.2 Steps to Initialize

Step 1.Initialize the particle swarm.
Step 2. While (number of iterations, or stepping criterion is not met)
Step 3: Evaluating the fitness particle swarm.
Step 4: For N = 1 to the number of particles
Step 5: Finding the gbest and pbest location.
Step 6: For X = 1 to the number of dimension of particle
Step 7: Updating the position of particles
Step 8: Next X
Step 9: Next N
Step 10: Update the value by equation
Step 11: Next generation.

4. RESULTS

The graphical representation presents the results obtained from the process during the simulation environment.

Table.1. Values of simulation

Parameter	Value
Area	2000*2000 m^2
Sensor nodes	100-700
Initial energy of node	0.5 J
Number of rounds	5000
Communication range	100 m
EFS (energy for data receiving)	1PJ/m^3(pico joule)
Packet size	2000 bit
Message size	200 bit
E_{DA}	5nj/bit
D_0	87m

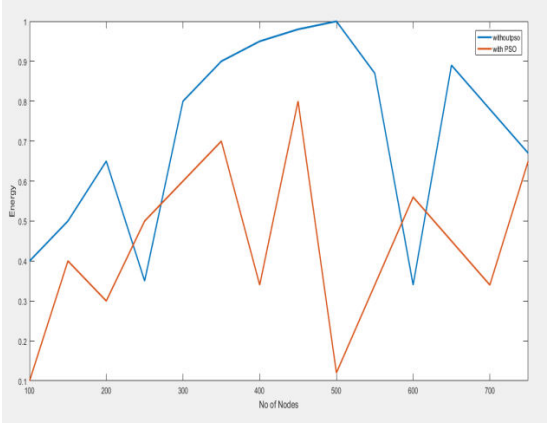


Figure.3.Energy vs.No. of Nodes

This graph (figure 3) shows the relation between energy and no.of nodes. Without PSO energy used is maximum and with PSO it reduces.
WITHOUT PSO : x-axis (no. of nodes) = 500 (max value); y-axis (energy) = 1 (max value)
WITH PSO : x-axis (no. of nodes) = 450 (max value); y-axis (energy) = 0.1 (max value)

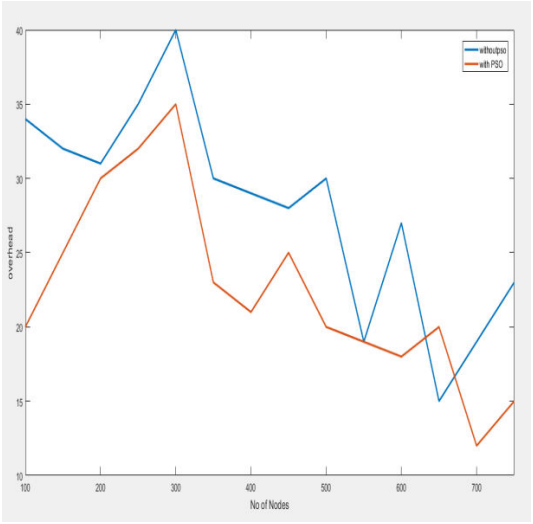


Figure.4. Overhead vs. No. of nodes

This graph (figure 4) depicts the relation between overhead and no.of nodes. The maximum value is without PSO and with PSO it reduces. Further with gwo it reduces even more. The values are shown below:
WITHOUT PSO : x-axis (no. of nodes) = 260 (max value); y-axis (overhead) = 34 (max value)
WITH PSO : x-axis (no. of nodes) = 260 (max value); y-axis (overhead) = 20 (max value)

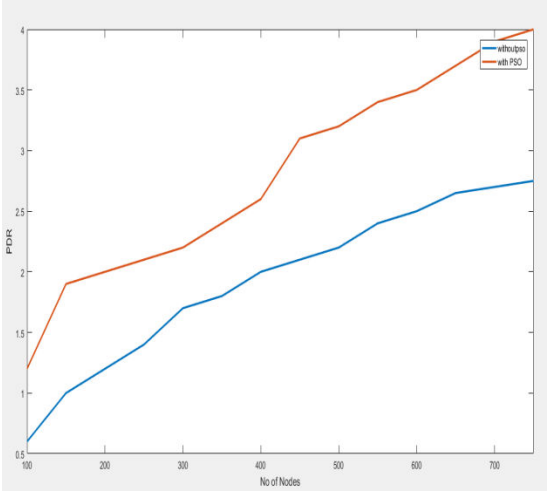


Figure.5. PDR vs. No of nodes

This graph (figure 5) depicts the relation between PDR and no.of nodes.The Preliminary Design Review (PDR) forms the Allocated Baseline of a system and ensures that the system is operationally effective. The graph shows the system is more stable with PSO.

5. CONCLUSION

The network performance of the WSNs is enhanced by various PSO-based clustering and cluster head selection scheme algorithms in terms of increasing the throughput, packet delivery ratio, energy, and overhead. The PSO algorithm constructs clusters in a centralized manner within a base station and the cluster heads are selected by using PSO in distributed manner. The sensed data from the sensor nodes are aggregated by the head and transmit to the BT directly or using relay node based on the threshold value for which the multihop routing protocol is used. The performance metrics such as throughput, packet delivery ratio, network lifetime, normalized overhead, delay, residual energy, and total energy consumption are evaluated and compared with non-optimized methodology. The simulation outcome shows that the projected (PSO) scheme gives improved performance in order to minimize the total consumed energy and increase the lifetime and packet delivery ratio of WSN. In future, this work can be extending to improve the network lifetime and data transmission using multiple sink or mobile sink [15] and efficient data collection using data aggregation [6] owing to reduction of the delay in a certain level in the proposed system.

6. ACKNOWLEDGEMENT

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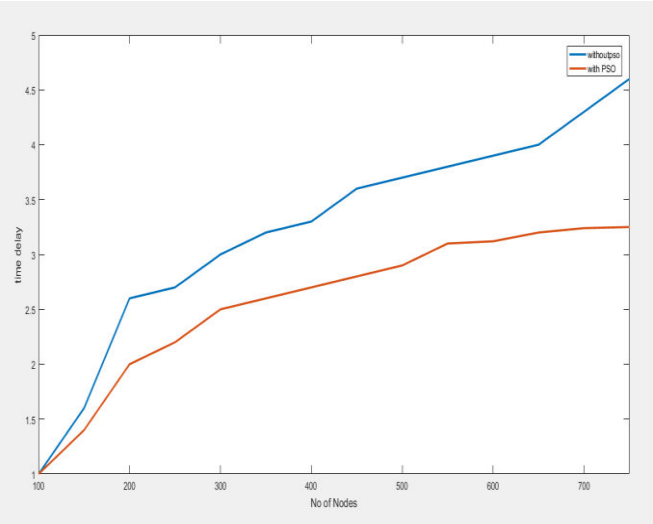

Figure.2.Time Delay vs. No. of Nodes

Figure 2 is plotted between time delay and no.of nodes. Without PSO time delay is maximum and with PSO it reduces.

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