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Cluster Head Selection Optimization Prolong Lifetime of Wireless Sensor Networks

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Abstract: This work mainly focus on the network based algorithm development that can support for enhancing the entire network lifetime. The work truly follows the objective that can balance the energy consumption among all sensor nodes to enhance the lifetime of the network so that there would be no overflow sensor nodes used to run out of energy before the others. Generally, the energy consumption by a sensor node integrated sensing, communication and data processing. Among the three operations, a sensor node expends the maximum energy in the data communication. A major concern is the design and development of energy management algorithm that wishes to recover energy in order to extended network lifetime. We developed our proposed strategy named as LEACH GA. We discuss network characteristics and working principle of proposed scheme for efficient performance.

Keyword: Energy Consumption, Leach, GA, and WSN.

1. Introduction:

Wireless Sensor Networks (WSNs) represent a new paradigm in wireless technology drawing significant research attention from diverse fields of engineering. WSN technology is listed in “Top 10 Emerging Technologies” that will change the world. WSNs consist of many sensor nodes. These nodes sense the changes in the physical parameters similar to – pressure, temperature, etc. The data sensed by these nodes are then transmitted to the Base Station (BS) for estimation. WSNs are used for the variety of purposes like military surveillances, habitat monitoring, forest fire detections, and landslide detections (Figure 1).

The main task of many researchers in this field is to develop smart surroundings with the help of WSNs containing thousands of planned or ad-hoc deployed sensors, each capable of detecting ambient conditions like temperature, sound, movements, light, or the presence of particular objects. It is very important to make these sensing nodes as cheap and energy efficient as possible and trust them to obtain high quality results. Hence, to have battery operated sensor nodes is a good option. But despite of their small sizes, these batteries must be capable of giving a longer life to these sensing nodes. The network protocol used must be very efficient to optimize the lifetime of the nodes.

We also need to focus on algorithms and physical circuitries that can make maximum out of limited power source. Some of the promising routing algorithms can be categorized into three types as direct transmission algorithms, hop to hop transmission algorithms and cluster based algorithms. In cluster based protocols, most of the energy consumption depends on cluster head selection, cluster formation and the algorithm developed for routing the information.

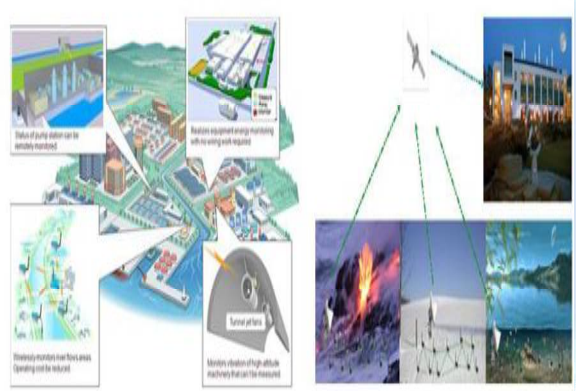

Fig 1. Application of Wireless Sensor Network

For the proposed protocol following network assumptions are considered:

• All sensor nodes are homogenous.

• All nodes are stationary once deployed in the field and have location information.

• There is single base station located outside the field.

• The nodes are considered to die only when their energy is exhausted.

Genetic Algorithms (GA) are direct, parallel, stochastic technique for global seek and optimization, which imitates the evolution of the residing beings, described with the aid of Charles Darwin. GA are part of the institution of Evolutionary Algorithms (EA). The evolutionary algorithms use the three important principles of the herbal evolution: duplicate, herbal selection and diversity of the species, maintained by the differences of each era with the preceding. Genetic Algorithms works with a fixed of people, representing possible answers of the task. The

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choice precept is applied by using using a criterion, giving an assessment for the character with respect to the preferred solution. The great-acceptable individuals create the following era. The big kind of troubles within the engineering sphere, in addition to in other fields, calls for the use of algorithms from exclusive kind, with unique characteristics and settings.

Genetic algorithms are a type of optimization algorithm, meaning they are used to find the optimal solution to a given computational problem that maximizes or minimizes a particular function. Genetic algorithms represent one branch of the field of study called evolutionary computation, in that they imitate the biological processes of reproduction and natural selection to solve for the `fittest' solutions [1]. Like in evolution, many of a genetic algorithm's processes are random, however this optimization technique allows one to set the level of randomization and the level of control [1]. These algorithms are far more powerful and effcient than random search and exhaustive search algorithms, yet require no extra information about the given problem. This feature allows them to find solutions to problems that other optimization methods cannot handle due to a lack of continuity, derivatives, linearity, or other features.

2. Related Work:

The dynamic nature of wireless sensor networks (WSNs) and numerous possible cluster configurations make searching for an optimal network structure on the- fly an open challenge. To address this problem, **Xiaohui Yuan, (2017) [1]** proposed a genetic algorithmbased, self-organizing network clustering (GASONeC) method that provides a framework to dynamically optimize wireless sensor node clusters. In GASONeC, the residual energy, the expected energy expenditure, the distance to the base station, and the number of nodes in the vicinity are employed in search for an optimal, dynamic network structure. Balancing these factors is the key of organizing nodes into appropriate clusters and designating a surrogate node as cluster head. Compared to the state-of-the-art methods, GASONeC greatly extends the network life and the improvement up to 43.44 %. The node density greatly affects the network longevity. Due to the increased distance between nodes, the network life is usually shortened. In addition, when the base station is placed far from the sensor field, it is preferred that more clusters are formed to conserve energy. The overall average time of GASONeC is 0.58 s with a standard deviation of 0.05. Forming network clusters is an effective way of improving the scalability and longevity of WSNs. A pre-determined communication structure or a randomized clustering scheme is far from fulfilling the critical need of maximizing the network life. Despite the great efforts in automatic organizing nodes, the dynamic nature of sensor network and numerous possible cluster configurations make searching for an optimal network structure on-the-fly an open challenge. To address this problem, we propose a GA-based, self-organizing network clustering method that provides a framework to integrate multiple factors and optimize dynamic node clustering.

A cluster-based model is preferable in wireless sensor network due to its ability to reduce energy consumption. However, managing the nodes inside the cluster in a dynamic environment is an open challenge. Selecting the cluster heads (CHs) is a cumbersome process that greatly affects the network performance. Although there are several studies that propose CH selection methods, most of them are not appropriate for a dynamic clustering environment. To avoid this problem, several methods were proposed by **Mohamed Elhoseny, (2017), [2]** based on intelligent algorithms such as fuzzy logic, genetic algorithm (GA), and neural networks. However, these algorithms work better within a single-hop clustering model framework, and the network lifetime constitutes a big issue in case of multi-hop clustering environments. This work introduces a new CH selection method based on GA for both single-hop and the multi-hop cluster models. The proposed method is designed to meet the requirements of dynamic environments by electing the CH based on six main features, namely, (1) the remaining energy, (2) the consumed energy, (3) the number of nearby neighbors, (4) the energy aware distance, (5) the node vulnerability, and (6) the degree of mobility. We shall see how the corresponding results show that the proposed algorithm greatly extends the network lifetime.

NitinMittal (2016), [3] worked on nature-inspired algorithms are becoming popular among researchers due to their simplicity and flexibility. The nature-inspired metaheuristic algorithms are analysed in terms of their key features like their diversity and adaptation, exploration and exploitation, and attractions and diffusion mechanisms. The success and challenges concerning these algorithms are based on their parameter tuning and parameter control. A comparatively new algorithm motivated by the social hierarchy and hunting behavior of grey wolves is Grey Wolf Optimizer (GWO), which is a very successful algorithm for solving real mechanical and optical engineering problems. In the original GWO, half of the iterations are devoted to exploration and the other half are dedicated to exploitation, overlooking the impact of right balance between these two to guarantee an accurate approximation of global optimum. To overcome this shortcoming, a modified GWO (mGWO) is proposed, which focuses on proper balance between exploration and exploitation that leads to an optimal performance of the algorithm.

Vehicular Ad hoc NETworks (VANETs) are a major component recently used in the development of Intelligent Transportation Systems (ITSs). VANETs have a highly dynamic and portioned network topology due to the constant and rapid movement of vehicles. Currently, clustering algorithms are widely used as the control schemes to make VANET topology less dynamic for Medium Access Control (MAC), routing and security protocols. An efficient clustering algorithm must take into account all the necessary information related to node mobility. In this work, **Mohamed Hadded,(2015) [4]** proposed an Adaptive Weighted Clustering Protocol (AWCP), specially designed for vehicular networks, which takes the highway ID, direction of vehicles, position, speed and the number of neighboring vehicles into account in order to enhance the stability of the network topology. However, the multiple control parameters of our AWCP, make parameter tuning a nontrivial problem. In order to optimize the protocol, we define a multi-objective problem whose inputs are the AWCP's parameters and whose objectives are: providing stable cluster structures, maximizing data delivery rate, and reducing the clustering overhead. We address this multi-objective problem with the Nondominated Sorted Genetic Algorithm version 2 (NSGA-II). We evaluate and compare its performance with other multi-objective optimization techniques: Multi-objective Particle Swarm Optimization (MOPSO) and Multi-objective Differential Evolution (MODE).

Every type of network, be it wired or wireless, will be influenced by several key factors for its efficient functioning. Routing issue, applicable to all types of networks, is one among the several such key factors. Wireless Sensor Networks (WSN) has not been exception to this. Moreover, such issues are very critical due to severe resource constraints like efficient energy utilization, lifetime of network, and drastic environmental conditions in WSNs. Neither hop-by-hop or neither direct reach ability is possible in case of WSNs. In this regard, many routing protocols have been proposed **by Geetha. V.(2012) [5]** to optimize the efficiency of WSNs amidst of above mentioned severe resource constraints. Out of these, clustering algorithms have gained more importance, in increasing the life time of the WSN, because of their approach in cluster head selection and data aggregation. LEACH (distributed) is the first clustering routing protocol which is proven to be better compared to other such algorithms. This work elaborately compares two important clustering protocols, namely LEACH and LEACH-C (centralized), using NS2 tool for several chosen scenarios, and analysis of simulation results against chosen performance metrics with latency and network lifetime being major among them..

3. Methodology:

In wireless sensor networks, nodes are deployed randomly, i.e. positions of nodes are not pre-engineered. Most of the energy of nodes is dissipated due to communication between two nodes and it depends on the distance between them. Both sending and receiving of data consumes energy.

For sending m bit data over a distance d, the total energy consumed by a node is as follows:

$$ET x(m, d) = ET x{-}elec(m) + ET x{-}amp(m, d) \quad (1)$$

$$ET x(m,d) = \begin{cases} m\times Eelec+(m\times Ef s\times d2) & d < dcrossover \\ m\times Eelec+(m\times Eamp\times d4) & d \geq dcrossover \end{cases} \quad (2)$$

where dcrossover is crossover distance, while the energy consumption for receiving that message is given by:

$$ERx(m) = m \times Eelec \quad (3)$$

Considered network model for proposed scheme assumes energy required for running the transmitter and receiver electronic circuitry Eelec as 50nJ/bit and for acceptable SNR required energy for transmitter amplifier for free space propagation Ef s as 100pJ/bit/m2 and for two ray ground Eamp as 0.0013pJ/bit/m4. The crossover distance dcrossover is considered 87m.

Proposed Genetic Algorithm for Cluster Head Selection

Population- Population includes numerous character solutions for the trouble. Larger the scale of population, higher is the accuracy of set of rules. Length of person depends upon wide variety of nodes in network as a 1 in character represents node as cluster head whilst a zero way nodes is member node. Initial populace is generated randomly.

Fitness Function- Survivability of an individual depends upon its fitness value. Fitness fee of each person is calculated in accordance a fitness function. In our work, health function consists of following three parameters.

– Remaining Energy (E)
– Number of Cluster Heads (CH)
– Total Intra-cluster Communication Distance (IC)
– Total Distance from Cluster Heads to Base Station (BSD)

Value of last to parameters depends upon first. Less number of cluster heads has less total distance from cluster heads to base station but has high total intra-cluster communication distance. While high number of cluster heads has less total intra-cluster communication distance but has more total distance from cluster heads to base station.

After scaling the fitness function, we have fitness function as:

$$Fitness= E+(N-CH)+IC/N+BSD/N \quad (4)$$

where N is total number of nodes in network. Fitness function shows that there is more emphasis on decreasing total distance from cluster heads to base station.

• Selection- Selection is the process of choosing individuals from current population for new population. The purpose of the selection process in a genetic algorithm is to give more reproductive chances to those population members that are better fit. The selection procedure may be implemented in a number of ways like Roulette Wheel selection, Tournament selection, Boltzmann selection, Rank selection, Random selection, etc. In this work Roulette Wheel selection procedure is applied to select chromosomes for generating new population.

• Crossover- In this work, one-point crossover method is used. The crossover operation takes place between two chromosomes with probability specified by crossover rate. These two chromosomes exchange portions that are separated by the crossover point. The following is an example of one point crossover.

Individual 1	1	1	1	0	**0**	**1**	**1**	**1**	**0**
Individual 2	0	1	0	1	**1**	**0**	**0**	**1**	**0**

After crossover, two offspring are created as below:

Offspring 1	1	1	1	0	**1**	**0**	**0**	**1**	**0**
Offspring 2	0	1	0	1	**0**	**1**	**1**	**1**	**0**

• Mutation- The mutation operator is applied to each bit of a chromosome with a probability of mutation rate.
After mutation, a bit that was 0 changes to 1 and vice versa.

Before Mutation	1	1	**1**	0	0	1	1	1	0
After Mutation	1	1	**0**	0	0	1	1	1	0

4. Result and Discussion:

In this chapter we have discussed a WSN energy saving approach for the developed LEACH model with cluster heads selection strategy based on genetic algorithm with flexible number of cluster heads in eachround. The WSN considered here is assumed to be scattered in an area of 100x100 m2 field with 100 nodes randomly distributed in this area as shown in figure 2.

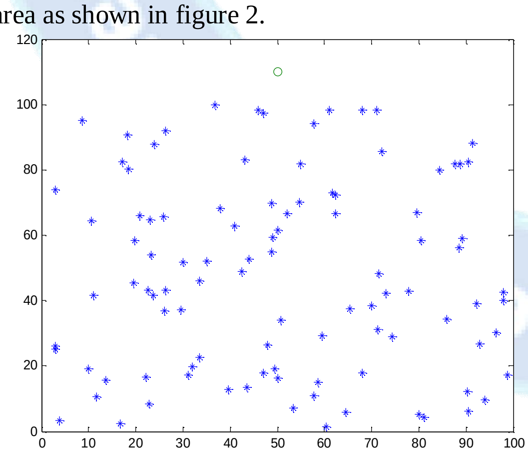

Fig 2. WSN network with 100x100 m^2 area with randomly distributed 100 nodes.

In fig 2 the base station is located in the position x=50,y-120 in the middle top of the area and shown as 'o' circle and sensor nodes are shown as blue '*' asterisk markers. We have considered a strategy named as LEACH GA. We have developed MATLAB programming based WSN network characteristics and working development of proposed scheme for efficient performance. This chapter presents key concept of proposed algorithm layout and results for WSN network model. In order to enhance some features like clustering process, stability period and network life-time for optimized performance of WSNs proposed in this model. According to this approach sensor nodes are deployed in the territory. In order to acquire better clustering the partition of the network is done into four quadrants. Doing such sort of partitioning better coverage of the whole network is achieved. Additionally, exact distribution of nodes in field is also well defined.

The algorithm is run for several times at different allowable of CH limit in each cluster the nodes which has residual energy less than zero are considered as dead nodes and remaining nodes are considered as alive in each round the number of alive and dead nodes is updated and plotted in fig 3.

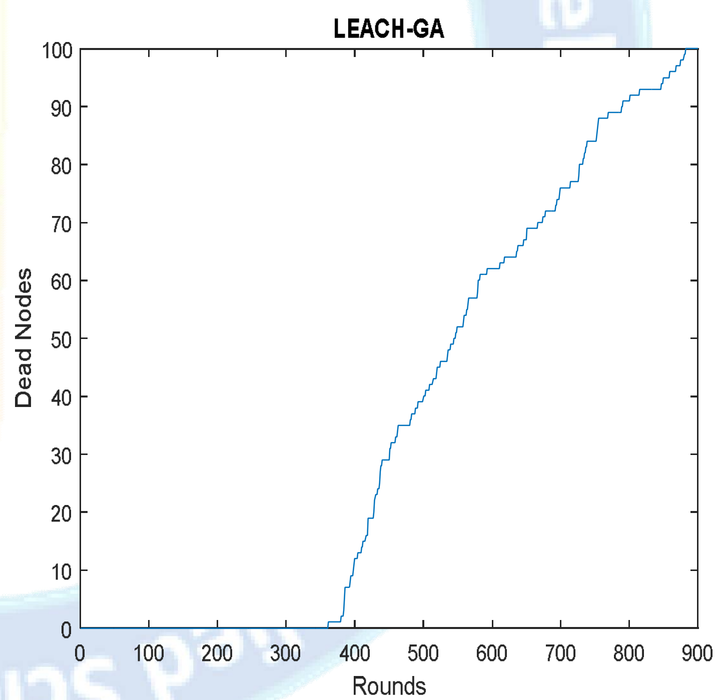

Fig. 3. Number of Dead Nodes plot with respect to rounds.

Figure 4 represents the packet sent to base station by the optimized cluster head set in every round.

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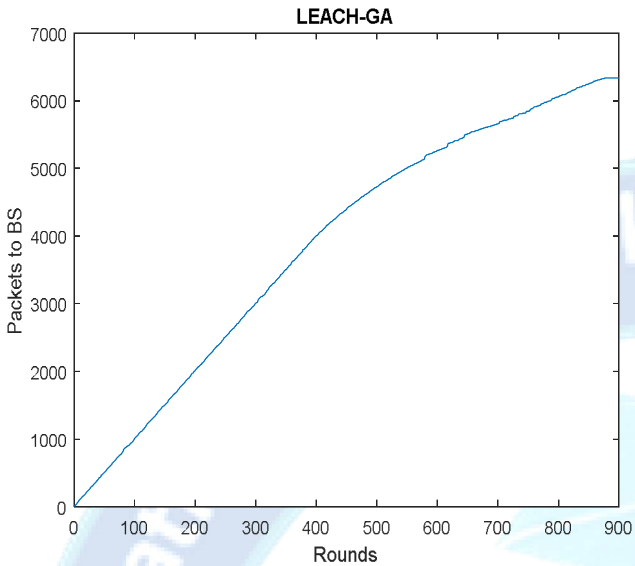

Fig. 4. Packet Send to BS plot with respect to rounds.

Figure 5 demonstrates the flexibility in number of cluster heads selection in every round. It is always focused to keep minimum number of cluster heads. Here it can be observed that maximum number of cluster heads is not exceeded than the 20.

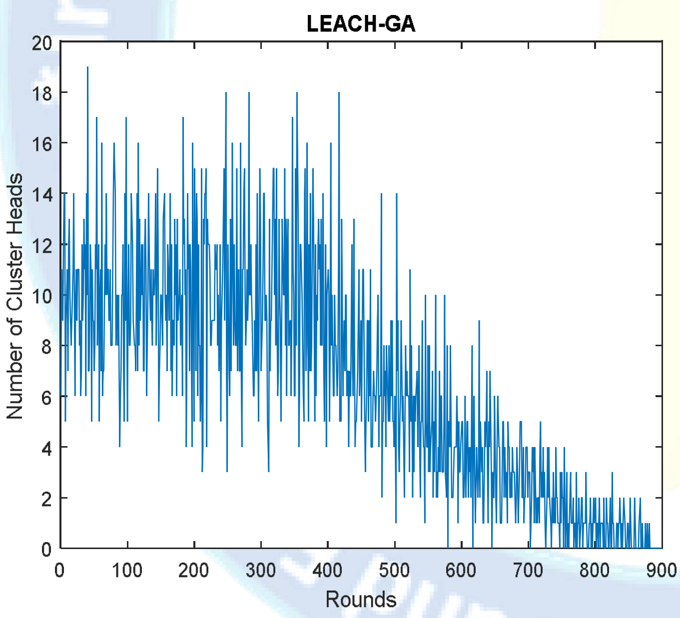

Fig. 5. Number of Cluster Heads Nodes plot with respect to rounds.

The cluster heads in each round after selection receives data from sensor nodes. This is considered as packet to CH. The figure 6 demonstrates the plot pf packet received by CHs in each round.

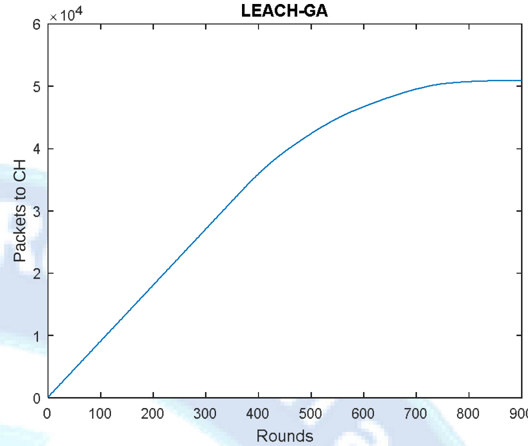

Fig. 6. Packet Send to CH plot with respect to rounds.

The figure 7 shows that the proposed flexible cluster head population per cluster is capable of giving higher life time than basic LEACH approach. We get higher life time, stability period and more packet sending to the base station by the implemented algorithm of proposed scheme as shown in figure 2 to 7 for representing alive nodes, dead nodes, packets send to CH and packets send to base station wrt to no. of rounds.

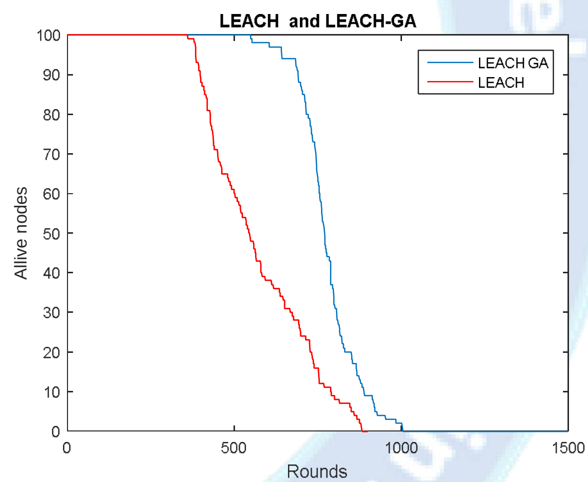

Fig. 7. Number of Alive Nodes plot with respect to rounds for LEACH and LEACH-GA

In figure 7 it can be easily demonstrated that the lifetime obtained in simple LEACH model is less than the LEACH GA model.

5. Conclusion:

We developed our proposed strategy named as LEACH GA. Partition of a WSN into clusters gives very efficient energy utilization for the nodes. Through this area division optimum number of CHs is generated in this way transmission load of on the sending sensor is minimized. In conventional clusters based approach the area is of arbitrary in size and cluster may be located in far away. Due to this dynamic cluster establishment in farther nodes faces high energy drainage and WSN performance is degraded. In our improved LEACH GA WSN the partitioning is in sub-sectors and clusters formed within the optimized CH sets with more deterministic way. The proposed clustering algorithm for WSNs gives useful energy utilization. Load balancing in between WSN node is the key importance hence it strictly improves stability period and network life-time. In future heterogeneous networks and protocol design can be proposed that are capable of best distribution. The work can be extended to enhance existing protocol such that more robust and optimized results can be achieved. The improvement of other network parameters seems to be an attractive choice of WSNs by extending and enhancing different network quality parameters. Other protocols can also be considered in terms of mobility and packets loss.

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