SURVEY ON CLUSTER-HEAD SELECTION USING META-HEURISTICS ALGORITHMS

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Abstract

Wireless Sensor Networks are gaining popularityfor their diverse applications in physical and environmental monitoring by using radio frequency deployed in infrastructures less environment. These networks are composed of sensor nodes that are small, cheap and low in energy. Every sensor node senses its surroundings, produces the required information and transmits it to the central base station (BS). Every node is embedded with non-rechargeable battery. The energy consumption for communicating activities is more when compared to its sensing and computation activities. Once the battery is drained out the node becomes ineffective and is named as the dead node. There is high energy consumption when all the sensing units directly send their generated information to BS which consequently reduces the system's lifespan. Hence to optimize the power consumption of the network, clusters are formed by grouping nearby nodes together or nodes having similar traits. Among the group of nodes a Cluster Head (CH) will be selected to control its activities. The key function of CH is to accumulate the information from their member nodes, and send it to base station.

Keywords:- *Wireless Sensor Network, Cluster heads, Meta-heuristics Techniques.*

Introduction to Wireless Sensor Network-Wireless sensor network is special type of wireless ad-hoc network which consists of small light weighted wireless nodes called sensor nodes, deployed in physical or environmental condition. It is measured by physical parameters such as sound, pressure, temperature, and humidity. These sensor nodes deployed in large or thousand numbers and aggregated to form an ad hoc network capable of reporting to data collection sink i.e. base station[1].Wireless sensor network have various applications like traffic control, military applications, home applications disaster Relief operation etc. However wireless sensor network is a resource constraint if we talk about energy, computation, memory and limited communication capabilities. All sensor nodes in the wireless sensor network are interacts with each other or by intermediate sensor nodes. Each Sensor nodes sometimes called as motes. Each sensor nodes is required to be capable of sensing, processing and communicating the processed data to the neighboring nodes to form a network. Sensor nodes are limited in battery cost, memory and physical size. Nodes are smaller in size and having low cost and formed a connection with wired and wireless network through gateway.

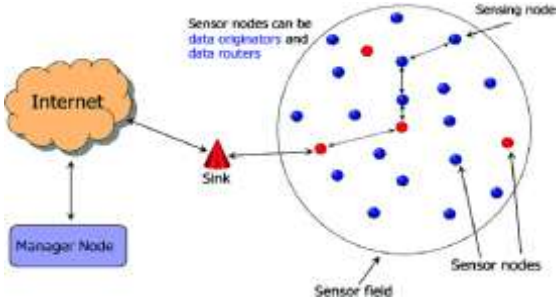

Figure1: Wireless Sensor Network

Cluster-Head(CH) Selection in Wireless Sensor Network

Clustering is one of the important methods for prolonging the network lifetime in wireless sensor networks (WSNs).It involves grouping of sensor nodes into clusters and electing cluster heads (CHs) for all the clusters. CHs collect the data from respective cluster's nodes and forward the aggregated data to base station. Selection of cluster head largely affects WSNs lifetime[2].

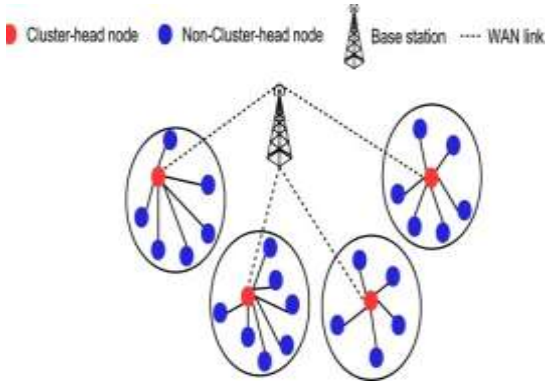

Figure 2:- Cluster-Head(CH) and Non Cluster-Head(NCH)

The WSN is divided into groups called clusters in order to prolong the life of the network .Some of the design considerations in designing Clustering algorithm are:

a)**Storage**: The storage in sensors is very limited and hence it is required to satisfy the storage constraints and query requirement.

b)**Security**: WSN is very vulnerable to the threats and security. Hence while designing clustering protocols security measures must be added to it.

c)**Communication**: Communication in wireless sensor network can increase the reliability and scalability of the network.

d)**Limited Energy**: Sensor networks are limited by the energy.Clustering can reduce the energy consumptions as compared to the direct communication.

e)**Network Lifetime**: The limited energy can lead to the reduction in lifetime. Clustering can reduce the energy consumptions by implementing Intra-cluster communication and multi hop routing schemes.

f)**Quality of Service**: Clustering always focus on energy efficiency but does not pay attention towards the quality. Hence it is always required to generate a quality in clustering algorithm.

Meta-heuristics in Wireless Sensor Network

A meta-heuristic is an algorithm designed to solve a wide range of hard optimization problems without having guaranteedbound and optimality of the problem. The word 'meta',itself represent as these algorithms are 'higher level' heuristics approaches, in contrast with problem-specific. Meta-heuristics are generally applied to a problem for which there is no satisfactory problem-specific algorithm to solve them.Heuristic protocols are based on trial-and-error, learning and adaptation method to find better solutions[3]. It is not possible to expect the best solution in all instances but a good enough or optimal solution is acceptable in a reasonably short period of time. Methods of optimization are not used for their impracticality in complicated real life situation. Nature-inspired meta-heuristic algorithms like Particle Swarm Optimization (PSO), Genetic Algorithm (GA), Ant Colony Optimization (ACO) and Firefly Algorithm (FA) are considers as powerful

algorithms for optimization. In 1989, Goldberg published a well-known book on genetic algorithms. Dorigo(1992) completed his PhD thesis, in which he described his innovative work on ant colony optimization.One pioneer contribution is the proposition of the particle swarm optimization by Kennedy &Eberhart(1995).

The goal of meta-heuristic algorithm is to make use of heuristic approach. Meta-heuristics have been regarded as successful because of four main reasons: simplicity, flexibility, derivation free mechanism, and local optima avoidance. By applying meta-heuristic algorithms we are optimizing the energy consumption in wireless sensor network.

Particle Swarm optimization (PSO) was introduced by Kennedy and Eberhart and mainly intended for simulating the behavior of bird flocking.It is a population based stochastic optimization technique. The algorithm was simplified, effective and efficient optimization techniques. In PSO, each single solution is a 'bird' in search space. A global fitness function is used by all the particles in the swarm .It evaluates the fitness of each particle and have velocity which directs the flying of the particles. The particles fly through the problem space by following the current optimal particle. Each particle's movement is influenced by its local best known position and is also guided toward the best known positions in the search-space, which are updated as better positions are found by other particles.

Step wise Procedure to PSO

1. Initially each particle is declared the initial parameters randomly and is 'flown' through the multi-dimensional search space.

2. During each iterations each particle uses the information about its Local best (Lbest) position and global best(Gbest) position to maximize the probability of moving space that will give the better fitness value.

3. When the fitness value is better than individual fitness value is found than it will be used to replace the individual best fitness value and update its current solution according to the following equations:

$$v_{id}(t)=w*v_{id}(t-1)+c_1\emptyset 1(p_{id}-x_{id}(t-1))+c_2\emptyset_2(p_{gd}-x_{gd}(t-1))$$

$$X_{id}(t)=X_{id}(t)+V_{id}(t+1)$$

Where
v=velocity of the particle
t= time factor;
w=inertia weight lies between 0 and 1
c1, c2=acceleration coefficient lies between 0 and 2
∅1, ∅2=Random numbers between 0 and 1
x=particle position
p_{id}= Particle' best position
p_{gd}= Global best position
Advantages of Particle Swarm Optimization(PSO) algorithm:-

1. It is easy to implement.
2. Only few parameters need to adjust.
3. It is efficient in global search.
4. Good quality solutions are possible because of its ability to escape from local optima.
5. It has quick convergence.

Firefly Algorithm (FA) is an optimization problem is the solution for finding the best solution from all feasible solutions. Firefly algorithm (proposed by Xin-She Yang) is

a multimodal nature inspired meta-heuristic algorithm developed in 2007 at Cambridge University. It is based on flashing behavior of fireflies. Almost every species of fireflies produces unique small rhythmic flashes and the flashes are being produced by a process of bioluminescence. . The function of the flashing light is to attract partners (communication) or attract potential prey and as a protective warning toward the predator.

Formulation of Firefly Algorithm based on the three primary rules of is as follows:-

a. All fire-fly are independent so that one firefly will be attracted to other fireflies

b. Attractiveness is proportional to their brightness,thus for any two flashing fireflies lesser brighter will be move toward the brighter one. If there is no brighter or more attractive firefly one of it will move randomly.

c. The brightness of firefly should be associated by the objective function.

The brightness (I) of a firefly at a particular location x can be chosen as

$$\boldsymbol{I(x) \propto f(x).}$$

The attractiveness β is relative,it should be seen in the eyes of the be order or judged by other fireflies. Thus,it will vary with distance r_{ij} between firefly I and firefly j. So the attractiveness is vary with the degree of absorption i.e the light intensity I(r) varies according to the inverse square law given as

$$\boldsymbol{I(r) = \frac{I_s}{r^2}}$$

Where

I_s =Intensityat the source.

r =distance between fireflies.

As we know the attractiveness is propotional to the light intensity seen by the adjacent fireflies. The attractiveness β of a firefly can now be defines using

$$\boldsymbol{\beta=\beta_0\ e^{-\gamma r^2}}$$

Where

β =attractiveness of firefly

β_0 =attractiveness at r=0

γ =light absorption coefficient

Genetic algorithm (GA) is a meta-heuristic optimization technique, which produces many fruitful results in the engineering field. It is structured yet randomized search technique which primarily works based upon the following three genetic operators called selection, crossover, and mutation.Let us have a look at genetics algorithm terms.

1.Chromosomes:- The initial possible solution to the problem is called chromosomes. All the chromosomes should have the same length and the elements in them are called genes or alleles.

2.Fitness Function:- Fitness function is used to evaluate the chromosomes fitness values and the higher valued chromosomes would produce more offspring than others. Here, in this paper, the fitness value is the sum of various parameters in the given proportion.

Selection: It is the basic genetic operator which reproduces the chromosomes with higher values to the next generation. Various selection techniques like Roulette wheel, rank, steady state, and elitism are there. Depending on the application requirement, any one selection technique can be used.

3.Crossover:-Crossover selects two parent chromosomes and makes them swap part of their genetic information with each other and produces the next generation chromosomes:

Chromosome 1 ... 100000 | 001000 ...

Chromosome 2 ... 000100 | 000001 ...

Off -spring 1 ... 100000 | 000001 ...

Off -spring 2 ... 000100 | 001000 ....

4.Mutation:- After crossover, mutation operator may be applied to the chromosomes. It prevents the GA approach from premature convergence. It is used to search the solution from a whole new place instead of searching for the current better ones:

... 10001000 ...

↓ mutation ...

00010001 ....

Compared with selection and crossover operator, mutation is used with less probability, since it may drastically change the fitness value of a particular solution.

Advantages of Genetic Algorithm (GA):-

1. It can solve every optimization problem which can be described with the chromosome encoding.
2. Genetic algorithms can be easily transferred to existing simulations and models.
3. GA is not dependent on the error surface, so we can solve many problems of multi-dimensional, non-differential, non-continuous, and even non-parametrical nature.

Ant Colony Optimization (ACO) is a recent meta-heuristics approach for solving hard combinatorial optimization problems and an iterativealgorithm. At each iteration, a number of artificial ants areconsidered. The first ACO algorithm is Ant System (AS). Inthe later years, elitist strategy for ant system (EAS), AS_rank,Max-Min AS, ant colony system (ACS) was proposed. The inspiring source of ACO is the pheromone trail laying and following behavior of real ants which use pheromonesas a communication medium. ACO is based on theindirect communication of a colony of simple agents, called (artificial) ants, mediatedby (artificial) pheromone trails. The pheromone trails in ACO serve as adistributed,numerical information which the ants use to probabilistically construct solutions to theproblem being solved and which the ants adapt during the algorithm's execution toreflect their search experience. The main concept of Ant Colony Optimization is to minimize the path and power consumption.

Steps to Construct Ant Colony Optimization algorithm:-

1. Initialization of parameters and reset the pheromones variables.
2. Construct the Ant Solution.
3. Improve the Candidate solutions using Daemon Actions.
4. Update pheromones which make good solution and more desirable for ants.

Advantages of Ant Colony Optimization (ACO) algorithm:

1. Inherent parallelism
2. It can be used in various dynamic applications.
3. Positive Feedback leads to rapid discovery of good solutions.
4. They react quickly to the changes in the environment.

Artificial Bee Colony Optimization (ABC) is a swarm-based artificial intelligence algorithm which is inspired by the intelligent foraging behavior of honey bees. The position of a food source denotes a possible solution to the optimization problem and the nectar

amount of a food source represents the quality of the associated solution. The ABC algorithm has three types of bees: onlookers, scouts, and employed bees .The bee which carries out random search is known as a scout. The bee which is going to the food source and visited by it previously is employed bee. The bee which is waiting on the dance area is an onlooker bee.

Advantages of Artificial Bee Colony (ABC) algorithm:-

1. It has few control parameters, i.e. population size, limit and maximum cycle number.
2. It is simple, flexible and robust.
3. It has fast convergence speed.
4. It can be easily used with other optimization algorithms.

Related Works

ShilpaMahajan and Pushpender Kumar Dhiman[4]proposed the clustering in Wireless Sensor Network based on tiny nodes which has gained a high attention of the researchers due to its various applications in different sectors. The tiny devices, called the sensor nodes are deployed in a harsh area and left unattended to continuously report the parameters of the environment, based on the application. The tiny nodes are constrained by the energy and hence it becomes necessary to consume less energy by using the means of clustering so that the lifetime of the whole network can be prolonged.

P. C. SrinivasaRao ,Prasanta K. Jana &Haider Banka[5]proposed the proper selection of CH nodes plays a vital role to conserve the energy of sensor nodes for prolonging the lifetime of WSNs. In this paper, we propose an energy efficient cluster head selection algorithm which is based on particle swarm optimization (PSO) called PSO-ECHS. The algorithm is developed with an efficient scheme of particle encoding and fitness function. For the energy efficiency of the proposed PSO approach, we consider various parameters such as intra-cluster distance, sink distance and residual energy of sensor nodes. We also present cluster formation in which non-cluster head sensor nodes join their CHs based on derived weight function. The algorithm is tested extensively on various scenarios of WSNs, varying number of sensor nodes and the CHs.

RihamS.Y.Elhabyan&MustaphaC.E.Yagoub [6]described a Two-tier particle swarm optimization protocol for clustering and routing in wireless sensor network. Most of the proposed protocols emphasized on the Cluster Head (CH) selection ignoring how the CHs will send the aggregated data back to the Base Station (BS). Furthermore, they tend to use non-realistic parameters and assumptions. Such examples include the use of infinite transmission range and location awareness. They also used an energy model that is fundamentally flawed for modeling radio power consumption in sensor networks. In this paper, two Linear Programming (LP) formulations to the problems of clustering and routing are presented followed by two proposed algorithms for the same based on Particle Swarm Optimization (PSO). The clustering algorithm finds the optimal set of CHs that maximize the energy efficiency, cluster quality and network coverage. The routing algorithm is developed with a novel particle encoding

scheme and fitness function to find the optimal routing tree that connects these CHs to the BS. These two algorithms are then combined into a two-tier protocol to provide a complete and practical clustering model. The effect of using a realistic network and energy consumption model in cluster-based communication for WSN will be investigated.

AliNorouzi ,Faezeh Sadat Babamir&AbdulHalimZaim[7] proposed A New Clustering Protocol for Wireless Sensor Networks Using Genetic Algorithm Approach . The optimization of the lifetime and energy consumption of Wireless Sensor Networks (WSNs).These two competing objectives have a deep influence over the service qualification of networks and according to recent studies, cluster formation is an appropriate solution for their achievement. To transmit aggregated data to the Base Station (BS), logical nodes called Cluster Heads (CHs) are required to relay data from the fixed-range sensing nodes located in the ground to high altitude aircraft. This study investigates the Genetic Algorithm (GA) as a dynamic technique to find optimum states. It is a simple framework that includes a proposed mathematical formula, which increasing in coverage is benchmarked against lifetime.

Vipin Pal, Yogita, Girdhari Singh & R P Yadav[8] proposed Cluster Head Selection Optimization Based on Genetic Algorithm to Prolong Lifetime of Wireless Sensor Networks. Clustering approaches prolong the network lifetime with the load balanced network. To achieve load balancing clustering algorithm rotate the role of cluster head among the nodes so, cluster head selection process is pivotal for clustering algorithms. Work of this paper presents a genetic algorithm based cluster head selection for centralized clustering algorithms to have a better load balanced network than the traditional clustering algorithm. Simulation shows that the proposed solution finds the optimal cluster heads and has prolonged network lifetime than the traditional clustering algorithms.

B. Baranidharan and B. Santhi[9]proposed Genetic Algorithm Based Energy Efficient Clustering Hierarchy in Wireless Sensor Networks. The parameters chosen for clustering should be appropriate to form the clusters according to the need of the applications. Some of the well-known clustering techniques in WSN are designed only to reduce overall energy consumption in the network and increase the network lifetime. These algorithms achieve increased lifetime, but at the cost of overloading individual sensor nodes. Load balancing among the nodes in the network is also equally important in achieving increased lifetime. First Node Die (FND), Half Node Die (HND), and Last Node Die (LND) are the different metrics for analysing lifetime of the network. In this paper, a new clustering algorithm, Genetic Algorithm based Energy efficient Clustering Hierarchy (GAECH) algorithm, is proposed to increase FND, HND, and LND with a novel fitness function. The fitness function in GAECH forms well-balanced clusters considering the core parameters of a cluster, which again increases both the stability period and lifetime of the network.

M.S. Manshahia [10] proposed a Firefly Based Energy Efficient Routing in Wireless Sensor Networks. The key challenge is to develop an algorithmic rule which might realize the optimized route on

the idea of parameters like residual energy, range of retransmissions and the distance between source and destination. The Firefly algorithm rule is implemented in this paper that relies on the attractiveness issue of the firefly for energy efficient routing in WSN.

Madhusudhanan Baskaran and Chitra Sadagopan [11] proposed a Synchronous Firefly Algorithm for Cluster Head Selection in WSN. Cluster-based approaches use some nodes as Cluster Heads (CHs) and organize WSNs efficiently for aggregation of data and energy saving. A CH conveys information gathered by cluster nodes and aggregates/compresses data before transmitting it to a sink. However, this additional responsibility of the node results in a higher energy drain leading to uneven network degradation. Low Energy Adaptive Clustering Hierarchy (LEACH) offsets this by probabilistically rotating cluster heads role among nodes with energy above a set threshold. CH selection in WSN is NP-Hard as optimal data aggregation with efficient energy savings cannot be solved in polynomial time. In this work, a modified firefly heuristic, synchronous firefly algorithm, is proposed to improve the network performance.

Prof. N.V.S.N Sarma and Mahesh Gopi[12] proposed Implementation of Energy Efficient Clustering Using Firefly Algorithm in Wireless Sensor Networks.Maximizing the network lifetime by decreasing the energy consumption of the entire sensor nodes and load balancing are the main challenges in the research of the routing protocols in WSNs. Energy efficient clustering for wireless sensor networks using Firefly algorithm is implemented at the base station. A new cost function has been defined to minimize the intra-cluster distance to optimize the energy consumption of the network.

Satyanarayana Mummanaand Kuda Nageswara Rao[13]**proposed** Survey on Optimizing Cluster-Head selection in Wireless Sensor Networks using Hybrid Meta heuristic algorithms. Hybrid meta-heuristics has end up prominent value of the discipline concerning optimization (in WSN) for the researcher. The excellent effects discovered because of deep real-life and classical optimization problems are arrived through hybrid Meta -heuristic optimizing algorithms. This composition critiques a countless popular hybridization processes then classifies to them among view concerning one of a kind qualities. Specifically as because of low-level hybrids of different meta-heuristics, a unified discriminate based on a common region template is depicted. Which helps in conformity with mix the distinct homes of a singular soloist in accordance with enhance the effectively then utility about the hybrid algorithm. In this land survey about hybrid meta-heuristics because cluster adviser selection we grant an overview of incomplete regarding the strong then representative developments between the subject on Wi-fisensor networks.

Swati Sharma, KanikaSharma[14] proposed Improvement of Network Lifetime using Ant Colony Optimization in Wireless Sensor Network. Network lifetime is the essential parameter of efficient wireless sensor network. This can be achieving by the using different localization and routing algorithm. In this paper, we propose the hybridization of Support Vector Machine (SVM) and Ant

colony Optimization (ACO). SVM is the supervised learning model, which is used to trained the dataset points and classification them into two class that is dead nodes and alive nodes. Whereas ACO, select optimal or shortest path among all adjacent possible path from source node to destination node for data transmission. The proposed technique improves the network lifetime as well as detects failure nodes in wireless sensor network. The proposed work compared with Artificial Bee Colony (ABC) and Particle Swarm Optimization algorithm (PSO) at different nodes.

Husna Jamal Abdul Nasir, Ku Ruhana Ku-Mahamud and EijiKamioka[15] proposed Ant Colony Optimization approaches in Wireless Sensor Network. WSN is part of a distributed system where elements such as routing, load balancing, energy efficiency, node localization, time synchronization,data aggregation and security need to be addressed to improve its efficiency, robustness, extendibility, applicability and reliability. Despite multiple approaches proposed to improve all these aspects, there is still room for improvement in order to enhance the capability of WSN in terms of routing and energy efficiency. Ant Colony Optimization (ACO) is one of the approaches used to extend WSN capabilities because its heuristic nature is very suitable with distributed and dynamic environments.

Fahad S. Abu-Mouti, Mohamed E. El-Hawary[16]proposed overview of Artificial Bee Colony (ABC) Algorithmand Its ApplicationsReal-world optimization problems are very difficultand have high degrees of uncertainty. Conventional optimization algorithms have some limitations (i.e., local solution attainment and/or divergence) in solving such problems. On the other hand, meta-heuristic algorithms prove to be competent in outperforming deterministic algorithms, especially when the complexity of the problem increases. Practitioners have utilized those unconventional algorithms for the past few decades. It presents an overview of the literature employing the Artificial Bee Colony (ABC) algorithm in their solution approach. The ABC algorithm is a recently introduced population-based meta-heuristic optimization technique inspired by the intelligent foraging behavior of honeybee swarms.

Dervis Karaboga, Selcuk Okdem ,Celal Ozturk[17] proposed Cluster Based Wireless Sensor Network Routings using Artificial Bee Colony Algorithm. Here we propose a novel hierarchical clustering approach for wireless sensor networks to maintain energy depletion of the network in minimum using Artificial Bee Colony Algorithm which is a new swarm based heuristic algorithm. We present a protocol using Artificial Bee Colony Algorithm, which tries to provide optimum cluster organization in order to minimize energy consumption. In cluster based networks, the selection of cluster heads and its members is an essential process which affects energy consumption.

CONCLUSIONS

A Wireless Sensor Network (WSN) comprises of a huge amount of light weighted sensors with limited battery and computational activities. The deployed sensors can communicate with each other, collect the data and transmit it to the base

station through wireless transmission. The important factor in WSN is the consumptions of energy which in turn increases the network's lifetime. A Clustering algorithm is employed to increase the network lifespan thereby reducing costs and energy. In this paper, various techniques are suggested for clustering nodes in WSNs and meta-heuristic protocols are also used for increasing the efficacy as well aslife time of the network along with the clustering techniques.

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