International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 06 | June-2016 www.irjet.net p-ISSN: 2395-0072

# Various Optimization techniques used in Wireless Sensor Networks

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**Abstract** -***This paper describes the concept of optimization techniques in Wireless Sensor Networks. Optimization techniques used in wireless sensor networks for minimize energy consumption and for solve routing problems. Energy efficiency, task allocation, node deployment and network lifetime are main constraint in Wireless Sensor Networks. For improving network life time and energy consumption various optimization techniques have been proposed. In this paper describe the various optimization techniques as Fire Fly Optimization (FFO), Genetic Algorithm (GA), and Ant Colony Optimization (ACO). In this paper also compare these optimization techniques.***

***Key Words***: **Wireless Sensor Networks, Routing, Clustering, Optimization Techniques**

## 1. INTRODUCTION

Wireless Sensor Network (WSN) called a wireless sensor and actuator network (WSAN). Wireless sensors are used now days in many applications such as environmental monitoring, Military tracking, Animal tracking traffic analysis, remote sensing etc.
Sensor Wireless sensors networks depends on transmission rate, energy consumption, scheduling of nodes, computation. In wireless sensors mainly these challenges as: limited energy, communication capability, storage, scalability, responsiveness, bandwidth privacy and security. Limited resources are battery power and memory required for data storage. Wireless sensor network have problem of lifetime of networks because when sensors are used in large geographical areas there is difficult to exchange or recharge batteries. Wireless sensor networks collection of several small, battery based sensors and these sensors are connected by each other through nodes. Sensor nodes have ability to communicate with each other and with base station.
Main basic goals of a WSN are to:

(1) Monitor the specific selected area

(2) Record the occurrence of events.

(3) Measure the required parameters.

WSNs deployed in such a method that there is presence of microcontroller which control monitoring, radio transceiver for generating radio waves, wireless sensors for communication with energy source of battery. Wireless sensors need delay free data for less energy consumption. [1]

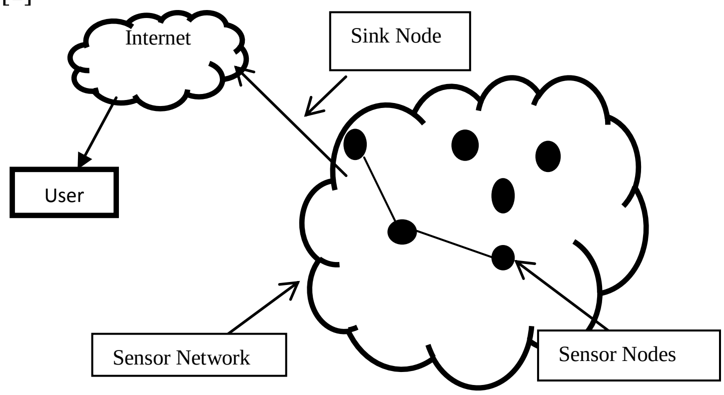


**Fig 1.1 Wireless Senor Network**

Minimum energy consumption increase the network lifetime. Energy Conservation techniques in wireless sensor networks are as-
1. Reduce frequency of data communication from source to destination
2. Reduce amount of data sensed by sensor nodes. [2]
For achieving minimum energy consumption various algorithms are used as clustering protocols, fuzzy logic, neural networks etc.
In this paper Section II describes the related work, Section III Optimization Techniques, Section IV Comparison of optimization Section V describes conclusion.

## 2. Related Work

Prof N.V.S.N describes energy efficient optimization technique using Firefly algorithm. Firefly algorithm depends on the light intensity and distance between nodes. If light intensity more means distance less between nodes. Data send firstly to nearest node so there is less energy consumption. It minimizes intra cluster distance to optimize minimum energy consumption. It improves the performance as compare to LEACH and PSO-C protocols. [3]
Fateh boutekkouk proposes a hybrid approach on heterogeneous network for extend the network lifetime. In this paper proposes combination of two techniques as firefly and chain based routing. In this approach firstly find the optimal clustering with usage of firefly algorithm. After choosing cluster, inside each cluster find best chain based routing. It consumes less energy. [4]

Rajeev Kumar proposes combination of Ant bee colony optimization and Ant colony optimization (ABCACO) which increase the lifetime of networks. Wireless sensor network WSN ABC uses hierarchical clustering. It operates iteratively and decrease the distance between cluster head and base station. It gives better performance as lifetime of networks, scalability as compare to existing algorithms. [5] Varsha Gupta and Shashi Kumar Sharma describe a modified Ant Colony optimization for head selection of cluster based on LEACH protocol. In LEACH-MA method clustering head selection on the basis of distance and energy. [6]
Rejina Parvin proposes Enhanced optimized energy efficient routing protocol (E-OEERP) for prevention of formation of residual nodes. In this paper particle swarm optimization (PSO) and gravitational search algorithm (GSA) are used. During cluster formation some of the nodes are not a member of any cluster. Such nodes are called as residual nodes or individual nodes. These nodes need a high energy for data transmission to base station. PSO forms a cluster on basis of residual energy and plays iterations for prevention of residual nodes. GSA finds the next hop distance. [7]
P.Leela and K.Yogitha proposes an algorithm for increasing network lifetime. Due to higher energy consumption there is use a hybrid clustering approach in which on basis of firefly algorithm cluster are formed and artificial bee colony for less energy consumption. This approach enhance network lifetime. [8]
Snehal Sarangi describes PSO based routing protocol for less energy consumption. In this find optimal path for routing. The path selected on basis of energy consumption. [9]
Banimelhem present genetic-based approach that improved the performance of the LEACH protocol for clustering in wireless sensor networks. The proposed approach utilized the mobility feature of nodes for reducing the communication distances between the base station and cluster heads. Genetic algorithm determines new location for each round. It performs better than LEACH in terms of average remaining energy and network lifetime. [10]
**Need of Optimization:** Optimization is process of creating a perfect design, suitable for functional as required. Optimum means maximum or minimum for certain factors which related with various applications. Network optimization is needed for achieving desired goals as minimize energy consumption and maximize network lifetime. In wireless sensor networks network lifetime, security, energy consumption and node deployment are some challenges for routing. [11]

### 3. Various Optimization Techniques

In WSNs various optimization techniques are used for increase the network lifetime. These techniques are shown in fig 1.2

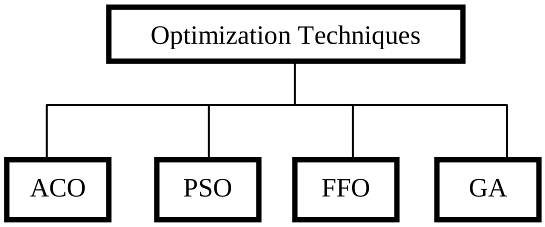


**Fig 1.2 Various Optimization Techniques**

Some of the techniques discussed as below:
**1. Ant Colony Optimization (ACO):** Ant Colony Optimization technique proposed by Darigo and Gambardella in 1997. It is based on ants behavior. It solves the problem of finding optimal path from source to destination on basis of real ants behavior. In starting ants move randomly to find source. When food source found, ants move back to colony. Ants leaving pheromones while moving back to colony that shows path for food. Other ants follow the same path to reach on food source. Pheromone makes a stronger path as many ants move on same path. The amount of pheromone is deposited, which may depend on the quantity and quality of the food. After some time when food sources decreases, the path has no longer pheromones. [12]
It finds optimal and shortest path for data transmission in wireless sensor networks. ACO applied only where source and destination are predefined. It not works well if paths are not symmetric. [13]
Pheromone value is calculated on basis of number of hops from source to destination visited by artificial ant. When node starts receiving data values stores as Destination Address (DA), Next hop (NH), Pheromone value (PH) stores in routing table.

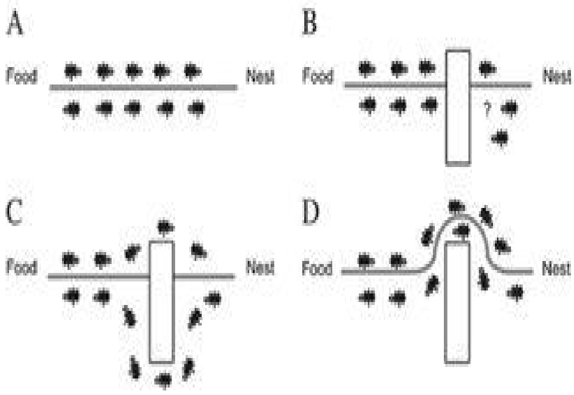


**Fig 1.3 Ant Colony Optimization**

Author presents an optimal-distance based transmission strategy (ODTS) with usage of ACO optimization. It finds the shortest distance between the nodes which consumes less energy. It increases the network lifetime. [14] ACO balances load in Wireless Sensors Networks. [15]

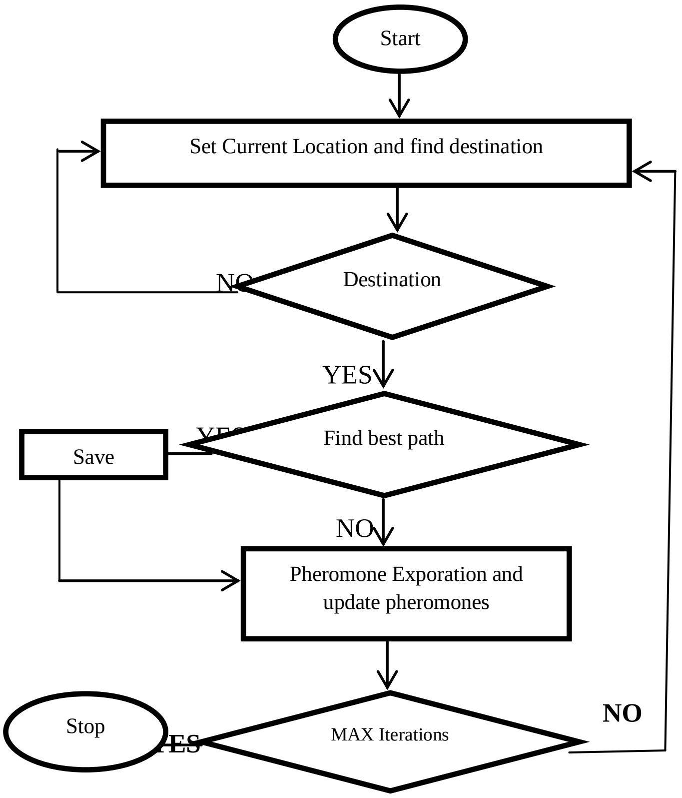


**Fig. 1.4 Flow graph for ACO**

**2. Particle Swarm Optimization (PSO): PSO proposed by** Eberhart and Kennedy in 1995. PSO multiobjective and dynamic optimization. It on the basis of behavior of animals in which there is no head or group leader such as flock of animals. In flock of animals find food randomly which is nearest to food position. Animals inform to each other about position of food. It will happen again and again until food source found. Particle swarm optimization consists of a swarm of particles, where particle represent a potential solution. Every particle is represented by its best position. It calculated on basis of local best position as lbest and global best position gbest.

PSO calculated on basis of

1. Current position of particle.
2. Current velocity of particle.

Each particle velocity and position updated as it changes its position. According to PSO, velocity and acceleration is changed to its *lbest* and *gbest* locations. The first one is *lbest* and the second one is *gbest*. The velocity and position of ach particle is updated according to the following equations.

$V_{id}(new)=w*V_{id}(old)+c1r1(lbest_{id}-X_{id})+c2r2(gbest_{id}-X_{id})$……………….(1)

$X_{id}(new) = X_{id}(old)_{+}V_{id}(old)$…………..(2)

Where $d$ = 1, 2... D, $i$ = 1, 2, ..., N and N indicates the swarm size and $n$ = 1, 2, ... gives denotes the iteration number. r1, r2 are two random numbers. These variables are uniformly distributed in [0, 1] for

Ensuring complete coverage. These also ensure the avoidance of falling into local optima which was a problem of the classical approaches. The inertia weight $w$ manipulates the trade-off between exploration and exploitation abilities of the flying points. Another two important parameters are $c1$ (self-confidence factor) and $c2$ (swarm confidence factor). It has been applied to solve WSN challenges such as optimal deployment, node localization, clustering and data-aggregation. [15]PSO energy aware routing and clustering for wireless sensor network define a new cost function. It also minimizes intra cluster distance between nodes. [16]

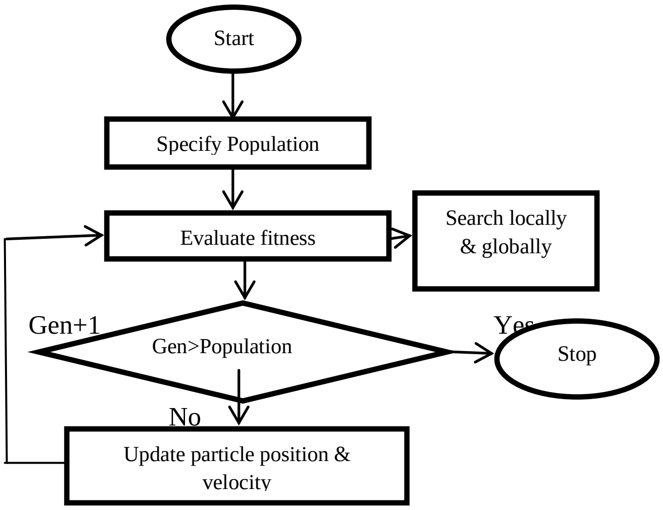


**Fig. 1.5 Flow graph of PSO**

**3. Fire Fly Optimization (FFO):** FFO algorithm is Meta-heuristic algorithms proposed by Dr. Xin She yang at Cambridge University in 2007. It on the basis of flashing behavior of fireflies. It finds the particle position. Firefly optimization mainly depends upon these methods:

1. All fireflies are unisex. These attract to each other on the basis of flash light.
2. Attractiveness of fireflies on basis of light directly proportional to its brightness.
3. If distance between fireflies increases means light intensity decreases.
4. Objective function related to brightness of firefly.

According to inverse square law intensity of light I decrease as distance r between fireflies increases. Intensity (I) inversely proportional to radius as:

$I \alpha 1/r2$

5. Firefly algorithm mainly depends on light intensity and attractiveness. According to inverse square law

$I(r) = I_s/r^2$ where $I_s$ Intensity of source and r radius (distance between fireflies). Light intensity changes with changes in distance as r changes. [17] The Firefly algorithm improve network lifetime and the throughput of the network with selection of CH on basis of residual energy and nodes in cluster coverage selected on basis of distance. [18]

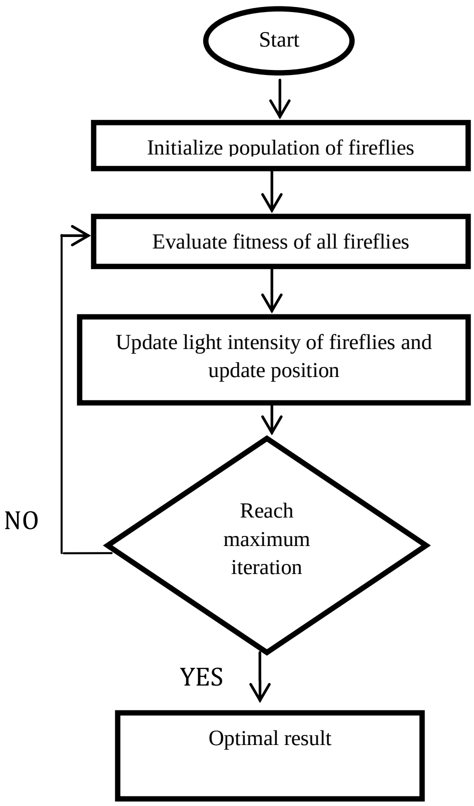


**Fig. 1.6 Flow graph of FFO**

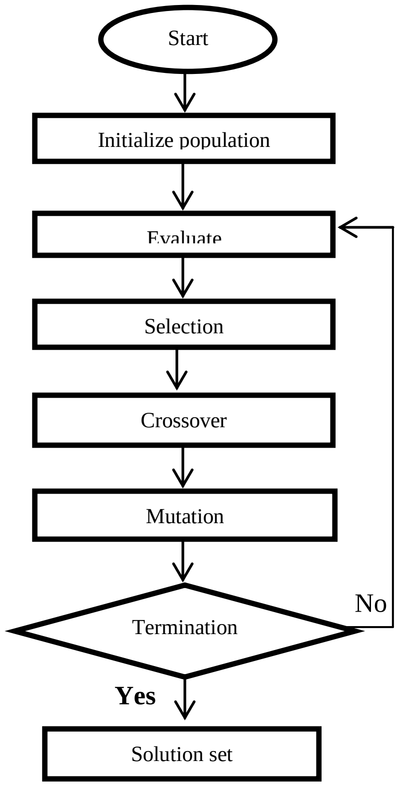


**Fig 1.7 Flow graph of GA**

**4. Genetic Algorithm (GA):** GA is based on Darwinian principles of biological evolution, reproduction and "the survival of the fittest", pioneered. It is developed by Holland and his colleagues in the 1960s and 1970s. GA algorithm related to genetic process of biological organisms. GA mostly used to solve search and optimization problems.GA algorithm consists of a collection of strings which are known as chromosomes. Chromosome describes search space on different points. Chromosomes represent in the form of binary strings as o's and 1's or real numbers. [19]
GA algorithm applied as:
1. Initial population randomly generated in a search space and evaluates fitness value.
2. Population created on basis of these mechanisms as Selection, Crossover, repair and mutation operations.

- Selection select individual (parents) for crossover and mutation.
- Crossover exchange genetic materials between individuals or phenotypes to produce offspring.
- GA handles population and again and again changes it to create a new generation of chromosomes.
- This process is continuing until large number of generations is achieved.

GA in wireless sensor networks find number of clusters and their heads in deployed environment. There is not communication with global optimization process. [20]

| **Parameters** | **ACO** | **PSO** | **FFO** | **GA** |
|---|---|---|---|---|
| **Representation** | Undirected Graph | Dimensions for vector position and speed | Attraction on basis of distance r | In binary form as 0's and 1's, random variables |
| **Operators** | Pheromone updates and trial evaporation | Initial values updates and evaluation. | Light Intensity, attraction | Selection, crossover, mutation |
| **Control Parameters** | number of ants, iterations, pheromone evaporation rate | Particles position, number of particles, Range, weight, number of iterations | Attraction of fireflies, light intensity | Population size, selection procedure, crossover and mutation probability, chromosomes, |

| | | | | |
|---|---|---|---|---|
| **Node Deployment** | Nodes deployed in distributed nature, used in dynamic applications | Centralized nodes deployment used to determine local best and global best position. | Nodes deployed in random manner | Random as well as deterministic node deployment |
| **Clustering and routing** | Find shortest path from source to destination and data transmission better | Select higher energy nodes as CHs in every round and find optimal path | Select nodes in Cluster on basis of distance | Reduce communication distance with formation of number of predefined clusters |
| **Advantages** | 1.Can be used in dynamic applications 2.Better for travelling salesman problem | 1. It determines lbest and gbest position. 2. Inherently continuous, no overlapping and mutation calculation | 1. Effective in multi objective optimization | 1. Handle complex problems and parallelism 2. discrete |
| **Disadvantages** | 1. Local search is not sufficient 2. Consume large amount of energy if more number of paths. | 1.It cannot work well for scattering and optimizing 2. Not work well for non-coordinate system | 1. It works only for randomly deployed nodes. | 1. Dynamic data sets difficult to operate. |

## 3. CONCLUSIONS

Wireless Sensor Networks has limitations such as energy and communication. For prevention of these limitations there is required an optimal energy resources that consume less energy. Various Optimization techniques like ACO, FFO, PSO, GA used for optimization in wireless sensor. These optimization techniques are compared on basis of various parameters.

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