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Introduction

In Wireless Sensor Networks (WSN), sensors observe various parameters in physical and environmental situations over a wide geographic area such as humidity, temperature, and pressure. The sensed information is transmitted to the base station or sink via a network. Sensors are operating on battery power, and it is difficult to replace. Hence energy usage of sensor nodes is the primary challenge in sensor networks. Cluster-based partition is a preferable data routing method. Each cluster consists two categories such as cluster head and cluster members. In cluster partitions, sensors are not necessary to transmit its data to the base station or sink individually. Cluster head collects the data from their cluster members and transmits the aggregated data to the sink. Bio-inspired algorithms are used to make the efficient routing from the sensor node to sink. Figure1 represents the basic structure of wireless sensor network.

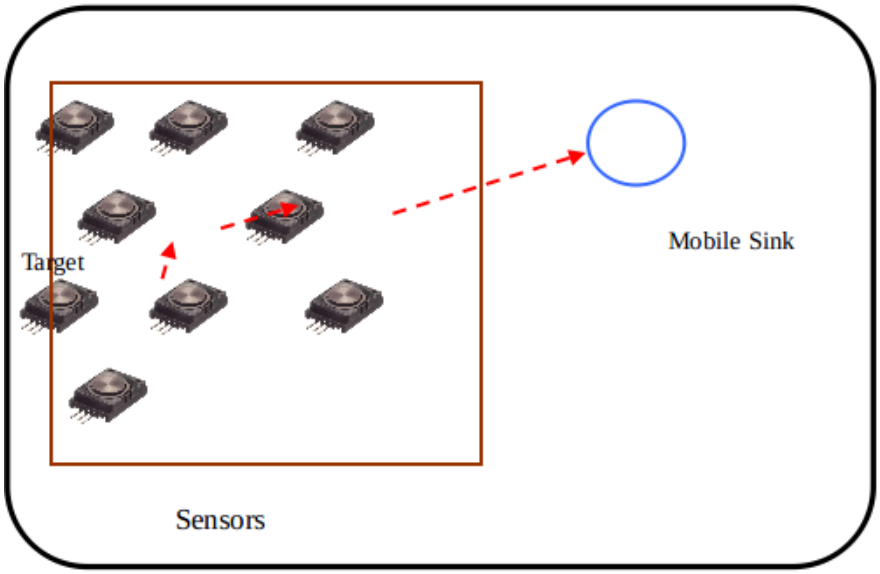

Figure 1: Wireless Sensor Network

Bio-Inspired Algorithms

Ant Colony Optimization

Ants select the shortest path depending on the pheromone chemical deposit in the way from nest to food. Each ant follows the way of previous ants with higher pheromone deposit. This swarm activity of ants improves the routing performance in term of delay. Moreover, energy consumption of each sensor can also be reduced according to the foraging activity of real ants. Swarm intelligence behavior significantly improves network lifetime and packet delivery ratio.

Particle Swarm Optimization

Particle swarm optimization is an effective, simple, and efficient algorithm for optimization. PSO compares the fitness of particles to select the cluster head depending on the higher fitness value. Reduced energy consumption is obtained through the fitness evaluation.

Cuckoo Search Algorithm

Cuckoo search algorithm depends on the selection of the best routing solution to achieve the network lifetime and reduced energy consumption. It is a probabilistic method for selecting the cuckoo's egg from host bird eggs. Cuckoo drops their eggs in the host birds nest, and both are more similar to see. If the host bird identifies the difference of egg, it throws away or rebuilds their nest in another place. Cuckoos egg represents the best routing solution. CSA leads the higher energy conservation, and it enhances the network efficiency.

Firefly Algorithm

WSN contains more sensors in large geographic region that can communicate with other sensors and transmit the sensed data to the base station. Minimum energy routing is the most important one during communication. The sensor routing protocols can improve the network lifetime using a firefly routing algorithm. Firefly produces flashes of light in short duration to attract prey or other fireflies. More attractiveness depends on the intensity of light flashes. Fireflies move toward another firefly with high-intensity light. This attractively based routing is used in sensor communication to attain the limited energy consumption.

Bat Algorithm

The main aim of bat algorithm is achieving the packet routing through the optimal paths which depend on the cluster formation and the cluster head selection. Bat algorithm depends on the echolocation based food searching of real bats. Bats make the sound louder and it can adjust its frequency depends on the received echo from prey or obstacles.

Genetic Algorithm

Genetic algorithm motivates the routing methodology of biological evaluation such as crossover and mutation of various fittest chromosomes (solutions). In a genetic algorithm, individuals are selected for crossover (breeding) depending on their fitness amount. By combining these solutions, significantly produce a new individual solution. The new individual represents the new generation. This process is repeated for achieving the more fitness solutions. In sensor networks, it saves more energy and increases the lifetime using reproduction process.

Artificial Algae Algorithm

Artificial algae algorithm (AAA), which is one of the recently developed bio-inspired optimization algorithms, has been introduced by inspiration from living behaviors of microalgae. In AAA, the modification of the algal colonies, i.e. exploration and exploitation is provided with a helical movement.

Chicken Swarm Optimization

A new bio-inspired algorithm, Chicken Swarm Optimization (CSO), is proposed for optimization applications. Mimicking the hierarchal order in the chicken swarm and the behaviors of the chicken swarm, including roosters, hens and chicks, CSO can efficiently extract the chickens' swarm intelligence to optimize problems.

Motivation for using Bio-inspired Algorithms in WSN

The wireless sensor networks have the issues of node deployment, localization, energy-aware clustering, and data aggregation. The Bioinspired algorithms motivate to formulate these routing issues as optimization problems. The conventional optimization techniques consume high energy and lead the energy consumption as a challenging problem when the network size increases. As the bio-inspired algorithms require moderate memory and computational resource, resulting in desirable results, especially in resource-constrained networks.

WSN Deployment

The optimization of WSN deployment is to determine and place the resource constrained nodes with desirable network coverage, connectivity, and energy efficiency. The sparse sensor network unnoticed the events happened in the network, whereas the areas having dense sensor populations suffer from network congestion and high routing delay. The optimal placement of sensor nodes assures a reliable routing service, long network life, and delay tolerant routing. The Bio-inspired algorithms are suitable for the deployment of sensor nodes around a base station. Notably, the PSO algorithms reduce the searching space and improve the network lifetime significantly.

WSN Challenges

- No global ID addressing
- IP-based protocols do not apply
- Stationary nodes
- Constraints on energy, storage and processing capacity
- High redundancy in different sensors' data

Routing Algorithms

Flat Based Routing Protocol

All the nodes are treated equally and have the same functionality.

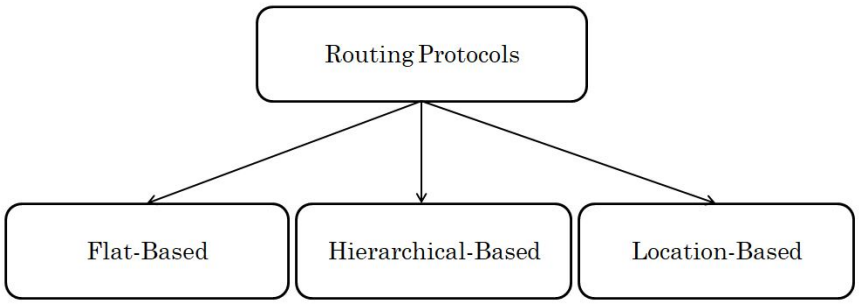

Figure 2: Routing Algorithms

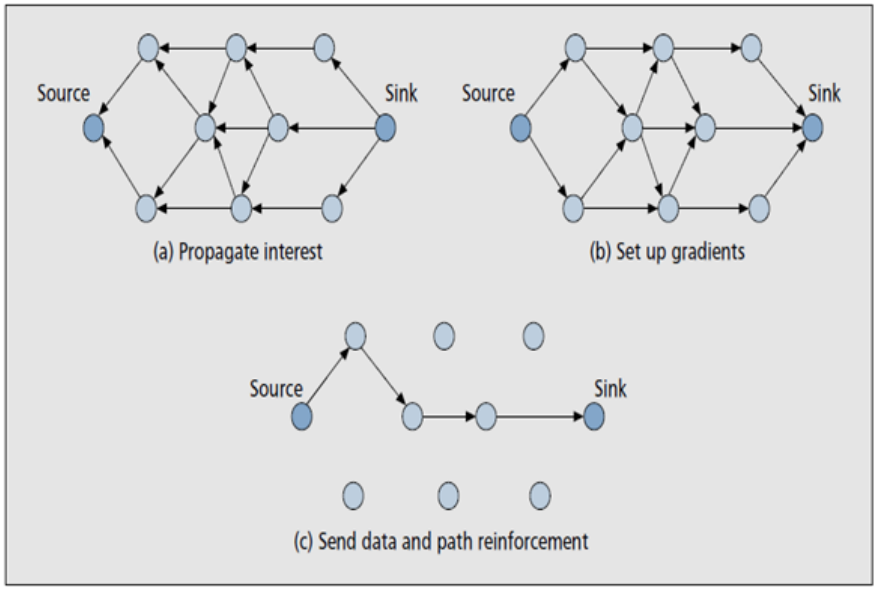

Figure 3: Flat Based Routing Algorithm

Hierarchical Routing

Clustering is a process that divides the network into interconnected sub-structures called clusters.Each cluster has a cluster-head as a coordinator within the sub-structure, which acts as a medium for data transfer between the nodes.Cluster heads communicate with each other by using gateway nodes. The Gateway node has two or more cluster heads as its neighbors or— when the clusters are disjoint—at least one cluster head and another gateway node.

Location Based Routing

Sensor nodes are addressed by means of their locations. The distance between neighboring nodes can be estimated on the basis of incoming signal strengths.Relative coordinates of neighboring nodes can be obtained by exchanging such information between neighbors.To save energy, some location based schemes demand that nodes should go to sleep if there is no activity.More energy savings can be obtained by having as many sleeping nodes in the network as possible.

Routing via Clustering

The communication is the next energy expensive activity in sensor networks. The energy consumption increases exponentially with transmission distance. Thus, it is customary to the data transmission through multiple hops in WSNs. The lifetime of sensor nodes largely depends on the efficiency of data routing from its source to the sink node. Routing refers the determination of routing paths for a packet from a source node to a sink. Mostly, the WSN implements the hierarchical or cluster-based routing for energy efficiency. Each cluster has a node that acts as a cluster leader. Nodes that belong to a cluster forward their data to the cluster leader, which is responsible for sending the data to sink node. However, a node which plays a role of cluster leader for a long duration exhausts its batteries prematurely. To avoid this, the Bio-inspired algorithms select the cluster leader based on the remaining energy.

Energy Efficient Data Aggregation

The efficient trade-off between the data routing hops and data quality is crucial. Data aggregation defines the process of combining the data originating from multiple cluster members and reducing the communication overhead. A principal application of a sensor network is to detect an event. In a centralized network topology, each cluster leader collects local observations from the members and fuses the data without reducing the data quality. The cluster leader nodes act as fusion centers, which is responsible for sending the aggregated data to the sink node. To ensure an extended network lifespan, the Bio-inspired algorithms have provided optimization in several aspects of data aggregation, such as error and noise reduction.

Applications of Wireless Sensor Networks

There are numerous applications of WSNs in industrial automation, traffic monitoring and control, medical device monitoring and in many other areas. Some of applications are discussed below:

Disaster Relief Operation

If an area is reported to have been stricken from some sort of calamity such as wildfire, then drop the sensor nodes on the fire from an aircraft. Monitor the data of each node and construct a temperature map to devise proper ways and techniques to overcome the fire.

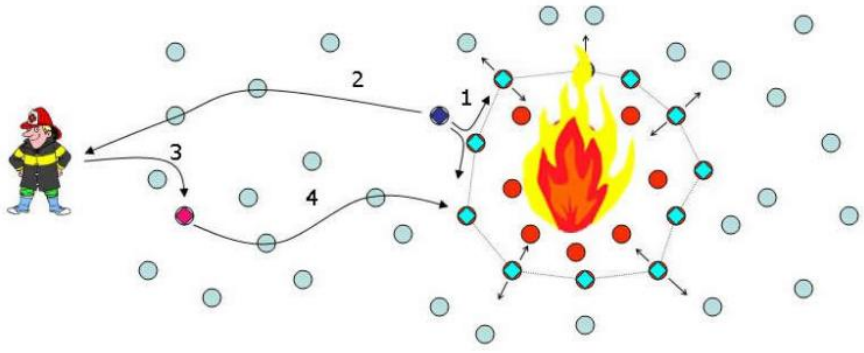

Figure 4: Disaster Relief Operation

Military Applications

As the WSNs can be deployed rapidly and are self organized therefore they are very useful in military operations for sensing and monitoring friendly or hostile motions. The battlefield surveillance can be done through the sensor nodes to keep a check on everything in case more equipment, forces or ammunitions are needed in the battlefield. The chemical, nuclear and biological attacks can also be detected through the sensor nodes.An example of this is the 'sniper detection system' which can detect the incoming fire through acoustic sensors and the position of the shooter can also be estimated by processing the detected audio from the microphone.

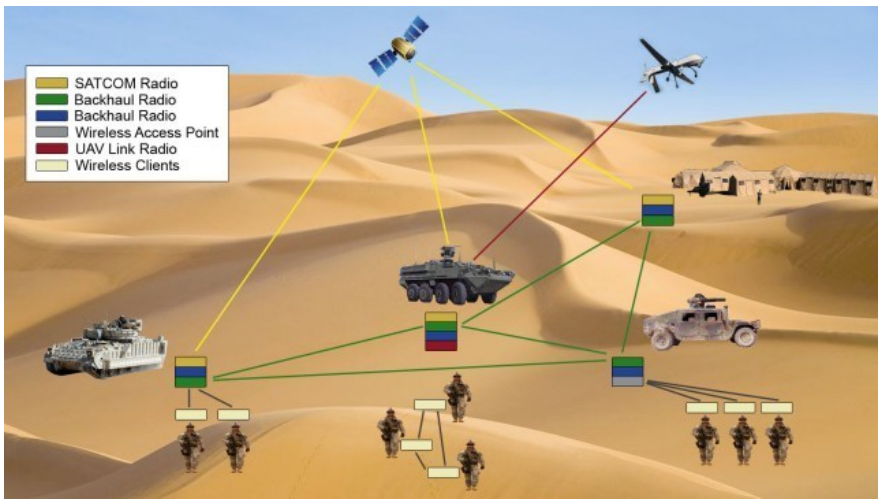

Figure 5: Military Surveillance System

Environmental Applications

These sensor networks have a huge number of applications in the environment. They can be used to track movement of animals, birds and record them. Monitoring of earth, soil, atmosphere context, irrigation and precision agriculture can be done through these sensors. They can also used for the detection of fire, flood, earthquakes, and chemical/biological outbreak etc.A common example is of 'Zebra Net'. The purpose of this system is to track and monitor the movements and interactions of zebras within themselves and with other species also.

Medical Applications

In health applications, the integrated monitoring of a patient can be done by using WSNs. The internal processes and movements of animals can be monitored. Diagnostics can be done. They also help in keeping a check on drug administration in hospitals and in monitoring patients as well as doctors. An example of this is 'artificial retina' which helps the patient in detecting the presence of light and the movement of objects. They can also locate objects and count individual items.

Home Applications

As the technology is advancing, it is also making its way in our household appliances for their smooth running and satisfactory performance. These sensors can be found in refrigerators, microwave ovens, vacuum cleaners, security systems and also in water monitoring systems. The user can control devices locally as well as remotely with the help of the WSNs.

Figure 6: Monitoring of Environmental Conditions

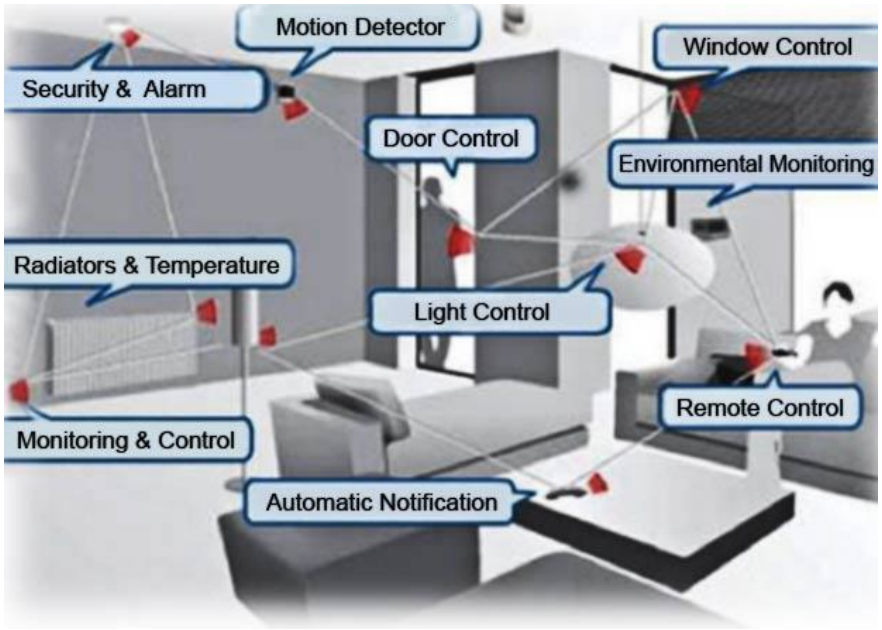

Figure 7: Application of WSN in Homes