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# Particle Swarm Optimization-Based Data Aggregation in Wireless Sensor Network: Proposed PSO-SNAP Protocol

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## ABSTRACT

Wireless sensor networks have battery-operated sensor nodes, which need to be conserved to have prolonged network lifetime. The amount of power consumed for routing sensed data from the sensor node to the sink node is large. Thus, in order to optimize the energy usage in sensor network efficient data aggregation techniques are needed. Particle swarm optimization (PSO) is a speculative and evolutionary computing technique based on swarm intelligence for solving optimization problems in sensor network such as nodes deployment, node scheduling, data clustering, and aggregation. The paper proposes a PSO-based sensor network aggregation protocol (PSO-SNAP) with *K*-means to provide initial centroid. The PSO has been used to find the optimal aggregated value having minimum quantization error. The output of the *K*-means algorithm is used as an initial centroid in PSO. Apart from *K*-means, *K*-medoid and simple average has also been used to provide initial seed to the PSO algorithm and results of all three approaches are compared.

## KEYWORDS

Data Aggregation, Data Clustering, Data Fitness, Energy Conservation, Evolutionary Computing, Particle Swarm Optimization, Quantization Error, Swarm Intelligence

## 1. INTRODUCTION

A wireless sensor network (WSN) consists of large number of sensor nodes with single or multiple sink node assigned near the sensor network. The sink act as a gateway to the internet and other networks, so as to send commands or query to the deployed sensor nodes for periodical collection of sensed data. The data collected in the sensor network is very huge and is highly replicated, thereby making data aggregation necessitated to be applied, so that only the relevant compound data is transmitted to the sink. Data aggregation combines the data together to eliminate similar data and minimize the data load from the sensor network to the base station. The data aggregation improves the bandwidth and reduces power consumption in WSN.

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The data aggregation process includes raw data collection from multiple sensors and then applying programming techniques to convert the raw data into a refined form and then deliver the refined data to end users. Data aggregation reduces the load on sensor nodes, which helps in handling the data with priorities more effectively. The few disadvantages of data aggregation techniques are increased processing delay, stronger hardware requirements, etc. Each data aggregation technique has certain challenges like redundancy, delay, data accuracy and network lifetime. Data aggregation uses functions such as minimum, maximum, average, count, etc. for aggregating data. Because of these issues, the performance of data aggregation techniques gets affected. The various data aggregation methods used in sensor networks (Dhand & Tyagi, 2016) (Patil Nandini & Patil, 2010) (Rajagopalan & Varshney, 2006)(Maraiya et al., 2011) are as follows:

- **Tree-based approach:** This technique constructs an aggregation tree with all the nodes. The tree is a spanning tree, where sensor nodes represent the leaf node and sink node is designated as the root node of the tree. The flow of sensed data moves from sensor nodes to the root. The tree-based approach is not considered fault-tolerant.
- **Cluster-based approach:** In this method, the clusters formation takes place and each cluster is assigned a cluster head. The nodes of the cluster transmit sensed data to the cluster head. The received data at the cluster head is aggregated before sending to the sink. The cluster-based technique is more robust and reduces overall energy consumption by reducing the transmission distance in sensor networks.
- **Multipath Approach:** In this approach, there are multiple paths from sensors to the sink. In case of failure in one path, the sensor node can send data to the base station from some other path, thereby making the system more robust than a tree-based approach. Data aggregation is performed at many points in the network thereby wasting more energy.
- **In-network aggregation:** In a multi-hop network, the data gathered by the sensor is processed at every hop during routing with the purpose of reducing energy consumption. This technique is called in-network aggregation. This results in improved network lifetime.

The lifetime, accuracy and reliability of the cluster and group based approaches are much better in performance than the other data aggregation techniques. Swarm intelligence (SI) techniques are biologically inspired artificial intelligence based evolutionary computing techniques that have recently gained importance in the research community for solving optimization problems. Swarm intelligence based techniques are increasingly applied to optimization problems as they provide better convergence to its solution. SI uses the concepts of division of labor and self-organization to tackle complex problems. The SI is based on the collective behavior of societies of social insects such as ants, bees, wasps, birds and fish. The swarm intelligence techniques are used in different areas such as scheduling, load balancing, clustering, routing and optimization. Some of the swarm intelligence algorithms are Genetic Algorithms (GA), Particle Swarm Optimization (PSO), Artificial Bee Colony (ABC) and Ant Colony Optimization (ACO). PSO technique is inspired by the behavior of the swarm of birds or fish school. In this paper, we have used PSO for doing cluster-based data aggregation in the WSN.

### 1.1. Highlights of Research Contribution

The main contributions of our research are as mentioned below:

- Swarm intelligence is employed for performing data aggregation in wireless sensor network
- PSO-based sensor network aggregation protocol (PSO-SNAP) is proposed with novelty in fitness function
- PSO-SNAP outperformed the existing standard PSO algorithm in terms of quantization error and execution time