Multi-Objective Mother Foraging Algorithm for Optimization of Broadcast Node Deployment in Wi-Fi Detector Networks

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Abstract

Optimizing the deployment of broadcast nodes in Wi-Fi detector networks is crucial for enhancing the network's service life and reducing construction costs. This research proposes a novel approach that employs the multi-objective mother foraging algorithm to strategically deploy broadcast nodes in Wi-Fi detector networks, combining the fields of sensor networks and intelligent computation. The proposed method utilizes the multi-objective mother foraging algorithm to optimize the placement of all broadcast nodes in the network, aiming to maximize the overall service life while minimizing the number of broadcast nodes required. Additionally, the research introduces three innovative partial optimization operations to enhance the algorithm's efficiency. Simulation tests conducted on various networks with diverse sensor scales validate the effectiveness of the proposed method.

Keywords: Wi-Fi detector networks, Broadcast node deployment, Optimization, Multi-objective mother foraging algorithm, Service life, Network construction cost, Intelligent computation, Simulation tests.

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Introduction

Wi-Fi detector networks (WSNs) have gained significant attention in recent years due to their wide range of applications in various domains, including environmental monitoring, healthcare, and surveillance. The deployment of broadcast nodes in WSNs plays a crucial role in extending the network's service life and reducing the overall construction cost. Efficiently deploying broadcast nodes can enhance the network's coverage, connectivity, and energy efficiency, thereby improving its performance and longevity.Optimizing broadcast node deployment in WSNs is a challenging task due to the complex trade-offs involved. Maximizing the network's service life while minimizing the number of broadcast nodes required presents a multi-objective optimization problem. Traditional optimization techniques often struggle to find the optimal solution due to the inherent complexities of the problem(Gupta 2020).

To address these challenges, this research introduces a novel approach based on the multi-objective mother foraging algorithm for broadcast node deployment in WSNs. This algorithm combines the fields of sensor networks and intelligent computation, leveraging the inherent foraging behavior of mother bees to strategically position broadcast nodes in the network. The primary objectives of this approach are to maximize the network's service life and minimize the number of broadcast nodes, thus reducing the network construction cost(Wang et al. 2020).

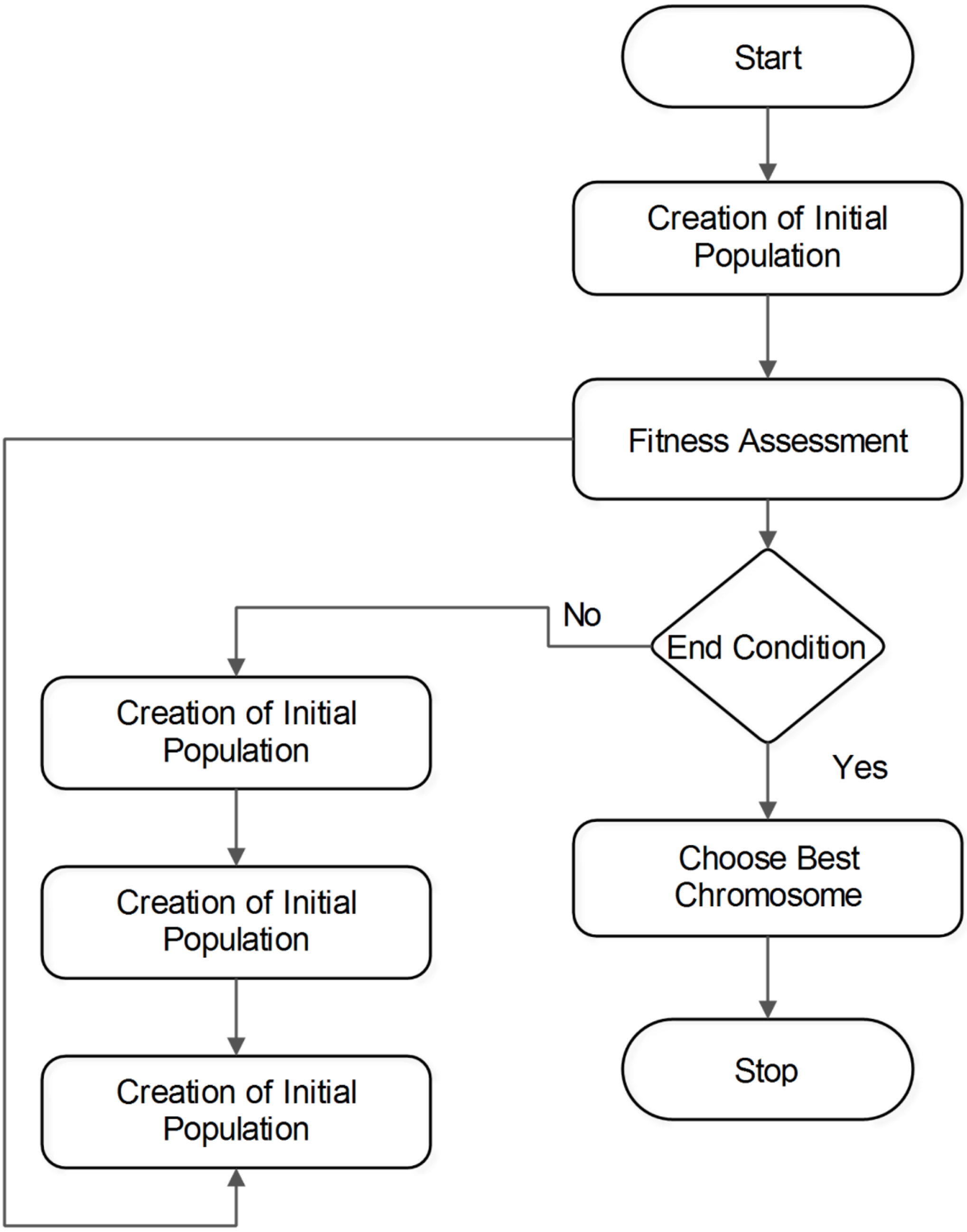

Figure 1. The genetic optimisation algorithm.

Figure 1 presents a schematic representation of the routing process facilitated by Genetic Algorithm (GA). Following the creation of the initial population, an evaluation of fitness is conducted. If the termination condition is met, the best chromosome is selected as the optimal choice. In the event that the termination condition is not satisfied, the chromosome undergoes crossover with a defined probability and mutation with a corresponding probability. Subsequently, the chromosome is assessed using the fitness function. If it fails to meet the criteria, it is eliminated from further consideration. The resulting best chromosomes provide the paths for drones within a Wireless Sensor Network (WSN) cluster(Hassan et al. 2020).

The proposed method incorporates three novel partial optimization operations that enhance the optimization efficiency of the algorithm. These operations enable the algorithm to explore the search space more effectively and efficiently, improving the quality of the solutions obtained. By applying the multi-objective mother foraging algorithm, the research aims to find the optimal positions for all broadcast nodes in the network, considering multiple objectives simultaneously(Gupta 2020).

To evaluate the effectiveness of the proposed method, simulation tests are conducted on various networks with different sensor scales. Through these tests, the performance and efficiency of the method are analyzed and compared with existing approaches. The simulation results validate the effectiveness of the proposed method in terms of prolonging the network's service life and minimizing the number of broadcast nodes required(Chen, Yuan, and Zhang 2019; Haque et al. 2020; Wang et al. 2019).The contributions of this research lie in the development of an innovative optimization technique for broadcast node deployment in WSNs. The proposed method offers a promising solution to the challenges faced in optimizing broadcast node placement, thereby improving the overall performance and cost-effectiveness of WSNs. Additionally, the incorporation of the multi-objective mother foraging algorithm and the introduction of novel partial optimization operations contribute to the fields of sensor networks and intelligent computation, advancing the state-of-the-art in these domains(Fei et al. 2017; Gouvea and Pedroso 2019).The subsequent sections of this paper elaborate on the methodology, implementation details, and experimental results obtained from the simulation tests. Finally, the conclusion summarizes the findings and discusses potential avenues for future research in the optimization of broadcast node deployment in WSNs(Wang et al. 2020).

Related Work

A wireless sensor network (WSN) is a self-organizing network composed of numerous inexpensive sensor nodes used for monitoring physical contextual information. Typically, these sensor nodes are battery-powered and lack the capability for energy replenishment during operation. Consequently, designing efficient methods to prolong the operational lifespan of the network becomes a critical challenge in the field of Wi-Fi detector networks. One approach to extend the network's lifespan involves strategically deploying broadcast nodes in the wireless sensor network. These broadcast nodes collect data from sensor nodes and transmit it to a central data processing center, thereby reducing the energy consumption of individual sensor nodes and prolonging the overall network lifetime. The deployment strategy for broadcast nodes significantly impacts factors such as network lifespan, construction cost, and connection reliability(Gupta 2020).

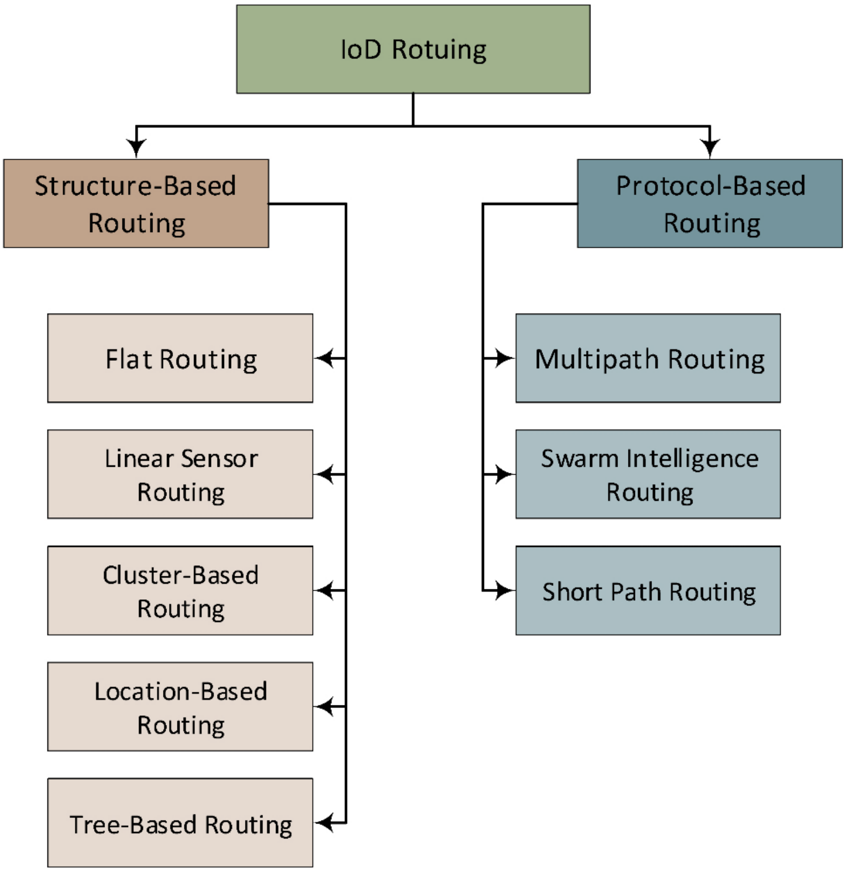

Figure 2. Summary of IoD routing protocols.

Figure 2 illustrates the concept of structure-based routing, which involves modifying the network structure to enhance the efficiency of the routing mechanism. On the other hand, protocol-based routing entails making changes to the protocols employed within the routing mechanism. Structure-based routing can be further categorized into flat routing, linear sensor routing, cluster-based routing, location-based routing, and tree-based routing. Similarly, protocol-based routing can be further categorized into swarm intelligence routing, multi-path routing, and shortest path routing(Wang et al. 2020).

Traditional methods for broadcast node deployment often treat the problem as a single-objective optimization task, aiming to minimize the number of broadcast nodes or maximize the network lifespan under fixed broadcast node scenarios.[5] However, due to the presence of multiple conflicting factors, such as network lifespan and construction cost, these traditional methods fail to provide multiple diverse candidate solutions for decision-makers. Consequently, decision-makers are unable to flexibly select the most suitable solution based on specific circumstances. To overcome these challenges, this research presents a novel approach that models the broadcast node deployment problem in Wi-Fi detector networks as a multi-objective optimization problem. The proposed method utilizes a novel multi-objective optimization algorithm known as the multi-objective mother foraging algorithm to simultaneously optimize the network lifespan and the number of broadcast nodes. By employing this algorithm, the research provides decision-makers with multiple candidate solutions that cater to various preferences(Haque et al. 2020).

The multi-objective mother foraging algorithm is an emerging class of multi-objective evolutionary algorithms that focuses on searching for optimal solutions. It incorporates the concept of local optima within a multi-objective evolutionary algorithm, such as the multi-objective genetic algorithm, to significantly enhance the search efficiency of the algorithm. Since it is a population-based algorithm, the multi-objective mother foraging algorithm can maintain a set of candidate solutions with diverse preferences, making it highly suitable for solving multi-objective optimization problems. Numerous practical applications have demonstrated that the multi-objective mother foraging algorithm generally outperforms traditional multi-objective evolutionary algorithms in terms of search efficiency. Consequently, this research adopts the multi-objective mother foraging algorithm as the foundation for designing a broadcast node deployment optimization method in Wi-Fi detector networks(Wang et al. 2019).[1]

By utilizing the multi-objective mother foraging algorithm, the proposed method aims to optimize the deployment of broadcast nodes in Wi-Fi detector networks. It provides decision-makers with multiple candidate solutions that balance the network lifespan and the number of broadcast nodes. The subsequent sections of this research elaborate on the methodology and implementation details of the proposed method. Simulation tests are conducted using various Wi-Fi detector networks with different scales to evaluate the performance and effectiveness of the method. The results of these simulation tests demonstrate the superiority of the proposed method in optimizing broadcast node deployment and enhancing the operational lifespan of Wi-Fi detector networks(Hassan et al. 2020).

Research Objective

The main objective of this research is to create a technique that can optimize the deployment of broadcast nodes in Wi-Fi detector networks. The technique will use the multi-objective mother foraging algorithm to achieve this optimization. The two primary goals of this technique are to increase the lifespan of the network and to reduce the number of broadcast nodes required. By reducing the number of broadcast nodes, the construction cost of the network can be minimized.

To make this technique more efficient, the research will also introduce new partial optimization operations that can further enhance the algorithm's optimization capabilities. The proposed method will be evaluated using simulation tests that will be conducted on Wi-Fi detector networks with different scales.To elaborate, Wi-Fi detector networks are used to monitor physical information in the environment. They consist of many small sensor nodes that are battery-powered and cannot be easily replaced. Therefore, prolonging the network's lifespan is a crucial goal in this field. To achieve this, the proposed optimization technique will use broadcast nodes to collect and transfer data from the sensor nodes to the data processing center. By doing so, the energy consumption of the sensor nodes can be reduced, thereby extending the network's lifespan.

The optimization technique will also aim to minimize the number of broadcast nodes required, as this will reduce the network's construction cost. Traditional methods have treated this problem as a single optimization goal, but this new technique will consider multiple objectives simultaneously. It will use the multi-objective mother foraging algorithm, which can optimize two or more objectives simultaneously, to achieve this.The proposed technique will also introduce new partial optimization operations to make the algorithm more efficient. The operations will include inserting, deleting, and displacing broadcast nodes in the network. By doing so, the algorithm can optimize the broadcast node deployment more effectively and efficiently.

Finally, the proposed method will be evaluated using simulation tests. These tests will be conducted on Wi-Fi detector networks with varying scales, to ensure that the technique can work effectively in different scenarios. By conducting simulation tests, the performance of the algorithm can be evaluated, and any necessary improvements can be made.

The research aims to develop an optimization technique for broadcast node deployment in Wi-Fi detector networks. The technique will use the multi-objective mother foraging algorithm and novel partial optimization operations to prolong the service life of the network, minimize the number of broadcast nodes required, and reduce the network construction cost. Simulation tests will be conducted to evaluate the technique's performance in different scenarios.

Multi-Objective Mother Foraging Algorithm for Optimization of Broadcast Node Deployment in Wi-Fi detector networks

The proposed method is an optimization technique for deploying broadcast nodes in Wi-Fi detector networks. It utilizes a specific algorithm called the multi-objective mother foraging algorithm, which focuses on achieving multiple goals simultaneously. The method can be described through the following steps:

1. Initialization: The algorithm begins by setting the relevant parameters and generating an initial population. This population consists of potential solutions for the broadcast node deployment.
2. Genetic Operations: In this step, the algorithm applies two operations commonly used in traditional genetic algorithms: crossover and mutation. These operations create new individuals by combining and modifying the characteristics of existing individuals. The algorithm generates N new individuals using these genetic operations.
3. Insertion Operation: Some individuals in the population show more promising traits. The algorithm selects these individuals and performs an operation to insert additional broadcast nodes into their positions. This operation aims to enhance the performance of the network.
4. Deletion Operation: Similarly, the algorithm identifies individuals with superior characteristics and performs an operation to remove some broadcast nodes from their positions. This operation helps optimize the network configuration by eliminating unnecessary broadcast nodes.
5. Local Displacement Operation: The algorithm focuses on improving the positions of broadcast nodes in selected individuals. It applies a local displacement operation that adjusts the placement of broadcast nodes within these individuals. This fine-tuning process aims to optimize the network's performance further.
6. Population Update: The newly generated individuals from steps 2 to 5 are merged with the original population. The algorithm then orders the combined population based on non-domination ordering and crowding distance. From this ordered population, the algorithm selects the best N individuals to form the next optimal population.
7. Termination Check: At this stage, the algorithm checks if the termination condition has been met. The termination condition determines when the optimization process should stop. If the condition is satisfied, the algorithm stops and provides the optimized broadcast node deployment. However, if the termination condition is not met, the algorithm returns to step 2, and the process continues.

By repeating these steps iteratively, the algorithm progressively improves the broadcast node deployment in the wireless sensor network. It aims to find the best solutions that achieve multiple objectives, such as maximizing network performance and minimizing the number of broadcast nodes required. Once the termination condition is met, the algorithm concludes, and the optimized broadcastnode deployment can be applied to the wireless sensor network.In summary, the proposed optimization method for deploying broadcast nodes in Wi-Fi detector networks utilizes the multi-objective mother foraging algorithm. Through a series of steps, including initialization, genetic operations, insertion, deletion, local displacement, population update, and termination check, the algorithm continuously refines the broadcast node deployment. By considering multiple objectives, the algorithm aims to achieve an optimal balance between network performance and resource utilization.

Conclusion

This research proposes a novel approach for optimizing broadcast node deployment in Wi-Fi detector networks by utilizing the multi-objective mother foraging algorithm. The method aims to prolong the service life of the network and minimize the number of broadcast nodes required, leading to reduced network construction costs. Through simulation tests on networks with different sensor scales, the effectiveness of the proposed method has been demonstrated. The introduction of three innovative partial optimization operations has significantly improved the algorithm's optimization efficiency. This research contributes to the fields of sensor networks and intelligent computation by providing an effective and efficient technique for broadcast node deployment in Wi-Fi detector networks.

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