AI WIRELESS BANDWIDTH OPTIMIZATION

A PROJECT REPORT

Submitted by

SIVAMURUGAN M (TKM21MCA-2033)

to

The APJ Abdul Kalam Technological University

In partial fulfillment of the requirements for the award of the degree of

MASTER OF COMPUTER APPLICATION

Thangal Kunju Musaliar College of Engineering
Kerala

DEPARTMENT OF COMPUTER APPLICATIONS

MAY 2023

DECLARATION

I undersigned hereby declare that the project report on **AI WIRELESS BANDWIDTH OPTIMIZATION**, submitted for partial fulfillment of the requirements for the award of degree of Master of Computer Application of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by me under supervision of Prof. Vaheetha Salam. This submission represents my ideas in my own words and where ideas or words of others have been included,I have adequately and accurately cited and referenced the original sources. I also declare that I have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in our submission. I understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other University..

Kollam

19-05-2023

SIVAMURUGAN M

DEPT. OF COMPUTER APPLICATIONS

TKM COLLEGE OF ENGINEERING KOLLAM

2022 - 23

CERTIFICATE

This is to certify that the report entitled **AI WIRELESS BANDWIDTH OPTIMIZATION** submitted by **SIVAMURUGAN M** (TKM21MCA-2033) to the APJ Abdul Kalam Technological University in partial fulfillment of the Masters degree in Computer Application is a bonafide record of the project work carried out by him under our guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

Internal Supervisor | Head of the Department | External Examiner

Acknowledgement

First and foremost I thank GOD almighty and my parents for the success of this project. I owe sincere gratitude and heart full thanks to everyone who shared their precious time and knowledge for the successful completion of my project.

I am extremely grateful to **Dr. Fousia M Shamsudeen**, Head of the Department, Department of Computer Applications, for providing me with best facilities.

I would like to thank my coordinator and project guide **Prof. Vaheetha Salam**, Department of Computer Applications, who motivated me throughout the project .

With a profound sense of gratitude, I would like to express my heartfelt thanks to my advisor **Prof. Natheera Beevi M**, Department of Computer Applications, for her expert guidance, cooperation, and immense encouragement.

I profusely thank all other faculty members in the department and all other members of TKM College of Engineering, for their guidance and inspirations throughout my course of study.

I owe my thanks to my friends and all others who have directly or indirectly helped me in the successful completion of this project.

SIVAMURUGAN M

ABSTRACT

AI WIRELESS BANDWIDTH OPTIMIZATION, is crucial in wireless networks to maximize throughput, minimize latency, and enhance overall network performance. In this study, we explore the application of two nature-inspired optimization algorithms, namely Whale Optimization Algorithm (WOA) and Particle Swarm Optimization Algorithm (PSO), to optimize the bandwidth allocation in wireless networks.

The objective of the study is to improve the network's bandwidth utilization by finding an optimal allocation scheme for different network resources. The WOA and PSO algorithms are selected due to their ability to efficiently search large solution spaces and find near-optimal solutions.

The proposed methodology involves several steps. Firstly, an objective function is defined, which quantifies the desired performance metric, such as maximizing throughput or minimizing latency. The algorithms are then initialized with appropriate parameters, including the number of whales or particles, maximum iterations, and solution space boundaries.

The population of potential solutions is randomly initialized, and the fitness of each solution is evaluated by calculating the objective function value. The best solution found so far is tracked and updated whenever a better solution is discovered. The algorithms' specific update equations and search operators are applied iteratively to guide the search towards promising solutions.

The optimization process continues until a termination condition is met, such as reaching the maximum number of iterations or achieving a satisfactory solution. The algorithm's performance is assessed by analyzing the obtained results, including the best solution found and its corresponding fitness value.

By leveraging the WOA and PSO algorithms, this study aims to provide an effective approach for optimizing bandwidth allocation in wireless networks. The proposed methodology can contribute to enhancing network performance, reducing congestion, and improving user experience by efficiently utilizing available resources.

Contents

List of Figures

Chapter 1

Introduction

AI WIRELESS BANDWIDTH OPTIMIZATION, have emerged as promising solutions for addressing the bandwidth optimization challenges in wireless networks. With the exponential growth in data demand and the limited availability of spectrum resources, efficient allocation of bandwidth has become a critical factor in ensuring optimal network performance and meeting user expectations. In this study, we investigate the utilization of two state-of-the-art metaheuristic algorithms, the Whale Optimization Algorithm (WOA) and Particle Swarm Optimization (PSO), in MATLAB, to optimize the allocation of bandwidth in wireless networks.

The Whale Optimization Algorithm (WOA) mimics the hunting behavior of whales in the ocean. By simulating the interactions of whales, the algorithm seeks to find the best allocation of bandwidth resources in a wireless network. Through this iterative process, the algorithm converges towards an optimal solution that maximizes the network's performance.

Particle Swarm Optimization (PSO), on the other hand, is inspired by the social behavior of bird flocking or fish schooling. This collective intelligence allows the algorithm to explore the solution space and converge to an optimal solution for bandwidth allocation in the wireless network.

1.1 Problem Statement

The drawbacks of the currently existing model:

- Variable convergence speeds, leading to longer optimization times in certain cases.
- Potential premature convergence, resulting in suboptimal solutions before fully exploring the solution space.
- Challenges in determining optimal parameter values, leading to suboptimal performance.
- Limited exploration and exploitation capabilities, potentially getting stuck in local optima or inadequate exploration of the solution space.

1.2 Objective

The goal is to accomplish the following:

- The primary goal is to optimize the allocation of bandwidth resources in the wireless network.
- The objective is to enhance the overall performance of the wireless network by allocating the available bandwidth in an optimal manner.
- The goal is to efficiently utilize the limited bandwidth resources in the wireless network.
- Compare the performance of the Whale Optimization Algorithm (WOA) and Particle Swarm Optimization (PSO) in the context of bandwidth optimization.
- Based on the results and analysis, provide valuable insights and recommendations for further research in the field of bandwidth optimization in wireless networks.

Chapter 2

Literature Survey

Literature review is that the comprehensive study and interpretation of literature that relates to a selected topic.When doing a literature review, research questions are defined, and then relevant literature is sought for and analysed to address these issues. By reanalyzing the study's data, it is possible to acquire fresh insights, which is an advantage of literature reviews. A literature review is both a summary and an explanation of the complete and current state of information on a topic as contained in academic books and journal articles. There are two types of literature reviews you may be required to write in college: one is written as a stand-alone assignment in a course, while the other is done as an introduction to or preparation for a longer piece of writing, typically a thesis or research report. The primary objective and perspective of your review, as well as the hypothesis or thesis argument you develop, depend on the type of review you are writing. You can learn the distinctions between these two types by reading published literature reviews or the introductory chapters of theses and dissertations in your subject area. Note the framework of their arguments and the manner in which they approach the issues.

2.1 Purpose of the Literature Review

1. It chooses top-notch research papers or studies that are pertinent, significant, important, and valid and summarises them into a single comprehensive report to provide readers with quick access to information on a certain issue.

2. By requiring them to describe, assess, and compare original research in this particular field, it gives researchers who are starting their research in a new area a great place to start.

3. It makes sure that researchers don't repeat already completed studies.

4. It can indicate potential directions for future research or suggest topics to concentrate on.

5. It emphasises the important findings.

6. It points up gaps, discrepancies, and inconsistencies in the literature.

7. It offers a helpful critique of the methods and strategies used by other researchers.

2.2 Related Works

2.2.1 Wireless Network

A wireless network, also known as a Wi-Fi network, is a type of computer network that allows devices to connect and communicate without the need for physical wired connections. It enables devices such as computers, smartphones, tablets, and other network-enabled devices to access the internet or share resources and information with each other. Bandwidth Optimization of Wireless Networks Using Artificial Intelligence Technique [1] is a critical aspect of ensuring efficient and reliable wireless communication, especially with the increasing demand for high-speed connectivity. Artificial intelligence (AI) techniques have emerged as powerful tools for enhancing bandwidth optimization in wireless networks. By leveraging machine learning and deep learning algorithms, AI can analyze large amounts of data and make intelligent decisions to optimize network performance. AI can also optimize Quality of Service (QoS) parameters such as latency, throughput, and packet loss by continuously monitoring network conditions and adapting resource allocation and routing decisions in real-time. In addition, AI can analyze interference patterns and dynamically adjust transmission parameters to minimize interference and maximize available bandwidth. AI techniques provide powerful tools for optimizing bandwidth in wireless networks, contributing to faster, more reliable, and more sustainable wireless communication in various applications and scenarios. Wireless networks throughput enhancement using artificial intelligence [2] have undergone significant advancements in recent years, enabling seamless connectivity and high-speed data transmission. To further enhance the throughput and efficiency of these networks, artificial intelligence (AI) is emerging as a powerful tool. AI algorithms and techniques can analyze and optimize various aspects of wireless networks, leading to improved throughput and better user experiences. AI is revolutionizing wireless networks by enhancing throughput and efficiency. Through intelligent spectrum management, resource allocation, and beamforming optimization, AI algorithms can dynamically adapt to network conditions, resulting in faster, more reliable connections and improved user experiences. As wireless technology continues to evolve, the integration of AI promises to play a vital role in shaping the future of wireless networks.

Dynamic-grouping bandwidth reservation scheme for multimedia wireless networks [3] is a bandwidth reservation scheme designed for multimedia wireless networks, aiming to optimize the allocation of network resources for multimedia applications. This scheme utilizes a dynamic grouping mechanism to efficiently manage the available bandwidth based on the specific requirements of different multimedia services. By grouping similar multimedia flows together, the scheme maximizes the utilization of the wireless network resources while minimizing interference and congestion. The dynamic-grouping bandwidth reservation scheme for multimedia wireless networks offers an efficient and adaptive approach to manage network resources. By dynamically grouping multimedia flows and adjusting the bandwidth allocation based on real-time conditions, it enables the network to accommodate the diverse requirements of multimedia services while maintaining optimal performance and user experience. Gigabit Fidelity (GIFI) as future wireless technology in Nigeria [4] is an advanced wireless technology that holds significant promise for the future of wireless communication in Nigeria. It is expected to revolutionize the way data is transmitted, offering ultra-fast speeds and improved network reliability. GIFI aims to provide users with gigabit-level connectivity, allowing for seamless streaming, faster downloads, and enhanced overall internet experiences. GIFI's enhanced reliability is another notable feature. It utilizes advanced signal processing techniques and intelligent beamforming to mitigate interference and improve signal strength, thereby minimizing disruptions in connectivity. This is particularly beneficial in densely populated urban areas where network congestion and signal interference are common issues. Gigabit Fidelity (GIFI) holds great promise as a future wireless technology in Nigeria. With its ability to deliver gigabit speeds wirelessly, increased network capacity, improved reliability, and potential for driving innovation, GIFI has the potential to transform the digital landscape of Nigeria and bridge the connectivity gap across the country. However, successful implementation will require significant investment and strategic planning to ensure widespread coverage and accessibility for all Nigerians.

Machine learning paradigms for next-generation wireless networks [5] are poised to revolutionize next-generation wireless networks by providing intelligent solutions to address the complex challenges they face. One of the key paradigms is supervised learning, where models are trained on labeled data to make accurate predictions or classifications. In wireless networks, this can be used for tasks such as channel estimation, interference detection, and resource allocation. Another important paradigm is unsupervised learning, which enables the discovery of hidden patterns and structures in data without the need for explicit labels. This can be applied to tasks like anomaly detection, clustering, and network optimization. Reinforcement learning, a paradigm focused on decision-making, has significant potential in optimizing wireless network performance through learning and adapting to dynamic environments. It can be used to optimize power control, routing, and scheduling strategies. Additionally, transfer learning allows models trained on one wireless network to be applied to another, leveraging pre-existing knowledge and reducing the need for extensive training data. Finally, federated learning enables collaboration among multiple edge devices to collectively train models while preserving data privacy, making it suitable for resource-constrained and privacy-sensitive wireless networks. By harnessing these machine learning paradigms, next-generation wireless networks can become more intelligent, adaptive, and efficient, ultimately enhancing user experience and enabling a wide range of innovative applications.

2.2.2 Bandwidth Allocation

Optimization refers to the process of making something as effective, efficient, or functional as possible. It involves finding the best solution or approach to a problem within given constraints and objectives. Optimization is applicable in various fields, including mathematics, engineering, computer science, economics, and business. The Whale Optimization Algorithm [6] is a nature-inspired metaheuristic optimization algorithm that draws inspiration from the hunting behavior of humpback whales. The algorithm aims to solve complex optimization problems by mimicking the social interactions and hunting strategies of these marine creatures. In the WOA, potential solutions are represented as individuals or ”whales” in a search space, and their positions are updated iteratively based on the behavior of whales in nature. The algorithm consists of three main phases: encircling prey, bubble-net feeding, and search for prey. During the encircling prey phase, whales surround the most promising solution in the search space. In the bubble-net feeding phase, they cooperate and create a spiral pattern to narrow down the search space further. Finally, in the search for prey phase, whales explore new regions of the search space in a more random manner. Through these phases, the WOA balances exploration and exploitation to efficiently converge towards optimal solutions. The algorithm has shown promising performance in various optimization tasks, demonstrating its effectiveness in solving real-world problems efficiently and effectively. Whale Optimization Algorithm With Applications to Resource Allocation in Wireless Networks [7] is a nature-inspired metaheuristic algorithm that draws inspiration from the social behavior of humpback whales. It was originally proposed as a method for solving optimization problems and has found applications in various domains, including resource allocation in wireless networks. In wireless networks, resource allocation using WOA has demonstrated promising results, improving network performance metrics such as throughput, latency, and energy efficiency. It has been applied to various scenarios, including cognitive radio networks, 5G and beyond networks, and Internet of Things (IoT) deployments. The Whale Optimization Algorithm presents a novel and effective approach for resource allocation in wireless networks. By leveraging the social behavior of humpback whales, the algorithm provides a nature-inspired optimization framework that can enhance network efficiency and performance in a variety of wireless communication scenarios.

Optimum bandwidth allocation in wireless networks using differential evolution [8] is a crucial aspect of achieving efficient and reliable communication. One effective approach to address this challenge is the utilization of differential evolution, a metaheuristic optimization algorithm. Differential evolution leverages the principles of genetic algorithms to find the best possible allocation of bandwidth resources in wireless networks. By iteratively evolving a population of candidate solutions, the algorithm aims to maximize the network's overall performance while considering various constraints and objectives. Differential evolution operates by evaluating the fitness of each solution based on a defined objective function that captures the network's requirements and goals, such as maximizing throughput, minimizing latency, or balancing resource utilization. Through the iterative process of mutation, crossover, and selection, the algorithm explores the solution space to converge towards an optimal bandwidth allocation configuration. This approach offers a powerful and flexible means to optimize wireless networks, considering factors such as channel conditions, traffic patterns, and user demands. By applying differential evolution for bandwidth allocation in wireless networks, it becomes possible to enhance network performance, improve quality of service, and effectively manage available resources, ultimately leading to a more efficient and reliable wireless communication system. LORA: Learning to Optimize for Resource Allocation in wireless networks with few training samples [9] is a cutting-edge approach in the field of wireless network optimization, specifically designed to address resource allocation challenges with limited training samples. Resource allocation plays a critical role in optimizing the performance of wireless networks, ensuring efficient utilization of available resources such as spectrum, power, and bandwidth. However, traditional optimization methods often require a large amount of training data, which may not always be feasible or readily available. LORA tackles this issue by leveraging machine learning techniques to learn and adapt resource allocation strategies with only a few training samples. It employs advanced algorithms that can effectively capture the underlying patterns and relationships between network parameters and resource allocation decisions, allowing for efficient decision-making even with limited training data.

A bandwidth allocation using genetic algorithm to providing solution for optimization problem in wireless mesh network [10] is a powerful solution for optimizing wireless mesh networks (WMNs). WMNs consist of interconnected nodes that communicate wirelessly, forming a decentralized network. The efficient allocation of limited bandwidth resources is crucial to ensure optimal network performance and user satisfaction. Traditional optimization methods may struggle with the complexity and dynamic nature of WMNs, making genetic algorithms an appealing approach. By leveraging the genetic algorithm's ability to handle complex and dynamic optimization problems, bandwidth allocation in WMNs can be significantly improved. The GA provides a flexible and adaptive approach that optimizes the allocation of limited resources, considering factors specific to each network scenario. As a result, WMNs can achieve enhanced performance, reduced interference, and improved overall network efficiency, leading to better user experiences in a wide range of applications, from internet access in rural areas to smart city deployments and industrial IoT networks.

2.2.3 Wireless Sensor

A wireless sensor is a device that is designed to collect data from its environment and transmit it wirelessly to a central location or another device for further analysis or monitoring. Comparative analysis of computer network protocols in wireless communication technology [11] relies on various computer network protocols to facilitate efficient and reliable data transmission. A comparative analysis of these protocols reveals their strengths and weaknesses in different scenarios. Cellular networks employ protocols like 3G, 4G, and 5G, which enable wireless communication over longer distances. These protocols provide wide coverage and support high-speed data transfer, making them suitable for internet connectivity on mobile devices. However, cellular networks can be affected by network congestion and may require additional infrastructure for optimal performance. The choice of computer network protocol in wireless communication technology depends on the specific requirements of the application. Wi-Fi provides high-speed connectivity within a limited range, Bluetooth is suitable for short-range device connections, cellular networks offer wide coverage and high-speed internet access, and Zigbee excels in low-power, low-data-rate applications. Understanding the strengths and limitations of these protocols allows for informed decision-making when designing wireless communication systems. Quality of service concerns in wireless and cellular networks [12] are crucial for ensuring a satisfactory user experience. These concerns revolve around several key factors. First and foremost is network reliability. Wireless and cellular networks need to provide a reliable connection to ensure consistent communication and data transfer without interruptions or drops in signal strength. Second, bandwidth management is crucial for allocating network resources effectively. QoS mechanisms prioritize certain types of traffic, such as voice or video calls, to prevent congestion and ensure smooth transmission. Additionally, latency, or the delay between sending and receiving data, is a critical aspect of

QoS. Low latency is essential for real-time applications like online gaming and video streaming. Moreover, network security plays a significant role in QoS. Robust security measures protect against unauthorized access, data breaches, and other cyber threats, ensuring a safe and reliable network environment. Finally, scalability is a concern as wireless and cellular networks need to accommodate an increasing number of devices and users without sacrificing performance. Addressing these QoS concerns is vital to deliver a seamless and satisfactory user experience in wireless and cellular networks.

Optimization techniques in wireless sensor networks: A survey [13] play a crucial role in enhancing the performance and efficiency of wireless sensor networks (WSNs). This survey provides a comprehensive overview of various optimization approaches employed in WSNs. The survey explores optimization approaches for data dissemination, time synchronization, and security in WSNs. It examines protocols and algorithms that ensure reliable and timely data delivery, synchronize the activities of sensor nodes, and provide secure communication channels. The survey concludes by highlighting open research challenges and future directions in the field of optimization for WSNs. It emphasizes the need for novel algorithms and protocols to address the unique requirements and constraints of WSNs, as well as the integration of emerging technologies such as machine learning and artificial intelligence to further enhance optimization techniques in wireless sensor networks. Wireless sensor network coverage optimization based on whale group algorithm [14] have gained significant attention in various fields, such as environmental monitoring, surveillance, and healthcare. However, optimizing the coverage of WSNs is a crucial challenge to ensure efficient and reliable data collection. In recent years, researchers have been exploring novel algorithms to address this issue, and one such promising approach is the Whale Group Algorithm (WGA). The WGA is inspired by the behavior of humpback whales in finding food sources, where they cooperate in groups to maximize their foraging efficiency. This algorithm mimics the whales' communication and movement patterns to optimize the coverage of WSNs. The Whale Group Algorithm presents a unique and promising solution for optimizing the coverage of wireless sensor networks. By emulating the cooperative behavior of whale groups, this algorithm aims to enhance coverage efficiency and reduce redundancy, leading to improved data collection and monitoring capabilities in various applications.

Chapter 3

Methodology

AI WIRELESS BANDWIDTH OPTIMIZATION, one approach is to use optimization algorithms such as the Whale Optimization Algorithm (WOA) and Particle Swarm Optimization Algorithm (PSO). These algorithms are based on the principles of natural selection and swarm intelligence, respectively. They can explore the solution space efficiently and converge to a global optimal or near-optimal solution.

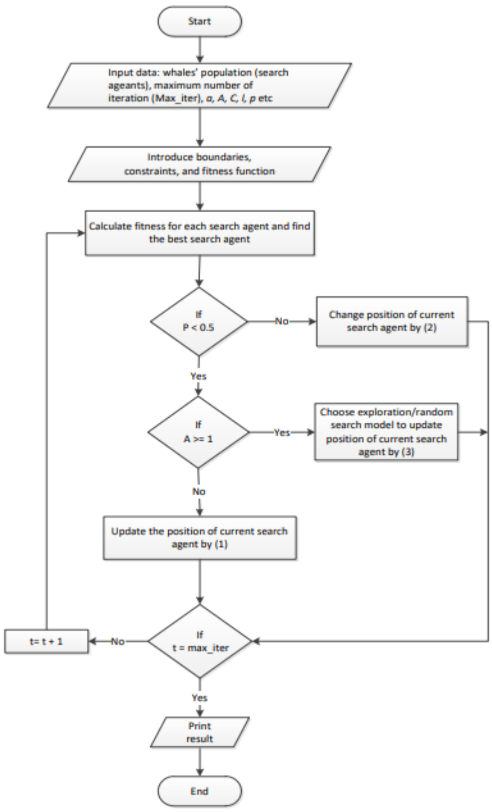

Figure 3.1: The flowchart of WOA

The methodology for using WOA and PSO to optimize the bandwidth of a wireless network involves several steps. First, the problem is clearly defined, and the specific objective to optimize is determined, such as throughput, interference, or signal-to-noise ratio. Then, the problem is formulated as a mathematical optimization problem, where decision variables represent the bandwidth allocation parameters and constraints are specified. Algorithm-specific parameters are set, including the number of whales or particles, maximum iterations, convergence criteria, and other parameters. An initial population of potential solutions is generated, and the fitness or objective function is evaluated for each solution.

3.0.1 Load bandwidth data

Load the bandwidth data from a CSV file. This file contains information about the available bandwidth for each channel in the network. The readmatrix function is used to read the data from the file, skipping the header line, and store it in the bandwidth variable. The dimensions of bandwidth are determined to obtain the number of nodes (nNodes) and channels (nChannels) in the network. The data is then reshaped into a 10 by 25 matrix, where each row represents a node and each column represents a channel.

3.0.2 Reshaping the bandwidth data

The bandwidth data is reshaped using the transpose operator ’ to convert it from a 25 by 10 matrix (assuming the original data was arranged in that format in the CSV file) to a 10 by 25 matrix. This reshaping is done to match the dimensions of the population matrices used in the optimization algorithms.

3.0.3 Define objective function

Defines the objective function named objectiveFunction. This function takes a vector x as input, representing the bandwidth allocation for each node. It calculates the fitness of the allocation by computing the squared sum of the element-wise multiplication of x and the bandwidth matrix. The objective function aims to maximize the allocated bandwidth while minimizing interference between channels and maximizing overall network performance.

3.0.4 Initialize algorithm parameters

Set the parameters specific to the WOA and PSO algorithms. These parameters control the behavior and performance of the optimization algorithms. For WOA, parameters include the number of whales, maximum iterations, and the exploration and exploitation coefficients. For PSO, parameters include the number of particles, maximum iterations, and the cognitive and social acceleration coefficients.

3.0.5 Initialize variables for best solutions

Variables bestwhale and bestwhalefitness are initialized to store the best solution found by the WOA algorithm. Similarly, bestparticle and bestparticlefitness are initialized to store the best solution found by the PSO algorithm. Initially, these variables are set to empty and infinity, respectively, indicating that no best solution has been found yet.

3.0.6 WOA algorithm implementation

Apply the WOA algorithm to optimize the bandwidth allocation. The WOA algorithm involves iteratively updating the positions of the whales based on their fitness and certain equations defined in the algorithm.

3.0.7 Update Best Solution (WOA)

After each iteration of the WOA algorithm, the code iterates over each whale in the population and calculates its fitness using the objective function. If the fitness of a whale is better (smaller) than the current best fitness.

3.0.8 PSO algorithm implementation

Similar to the WOA algorithm, apply the PSO algorithm to optimize the bandwidth allocation. The PSO algorithm involves iteratively updating the velocities and positions of the particles based on their fitness and certain equations defined in the algorithm.

3.0.9 Update Best Solution (PSO)

After each iteration of the PSO algorithm, the code iterates over each particle in the population and calculates its fitness using the objective function. If the fitness of a particle is better (smaller) than the current best fitness (bestparticlefitness), the particle and its fitness are updated as the new best solution.

3.0.10 Retrieving the best solutions found

After the WOA and PSO algorithms have completed, the code retrieves the best solutions found by multiplying the best whale and particle solutions with the bandwidth data.

3.0.11 Displaying and plotting the allocated bandwidth

The code displays the allocated bandwidth for both algorithms using the disp function. Then, it plots the allocated bandwidth for each algorithm using the plot function and creates a figure with two subplots for comparison.

3.1 Algorithm

3.1.1 Whale Optimization Algorithm

The Whale Optimization Algorithm (WOA) is a metaheuristic optimization algorithm inspired by the hunting behavior of humpback whales. It was proposed by Seyedali Mirjalili in 2016. The algorithm is designed to solve optimization problems by mimicking the social and hunting behaviors of humpback whales. The WOA algorithm is based on the idea that humpback whales encircle their prey in a shrinking spiral trajectory while emitting a series of sound waves to communicate with each other. The WOA algorithm utilizes different equations and parameters to control the movement and update of the whale positions. The equations and parameters are problem-specific and need to be defined based on the optimization problem at hand. The Whale Optimization Algorithm has been applied to various optimization problems, including engineering design, image processing, data clustering, and feature selection, among others. It is a population-based algorithm that can effectively explore the search space and has shown promising results in many applications.

Overview of how WOA works:

1. Initialization: Initialize a population of whales randomly within the search space.
2. Encircling Prey: Randomly select a whale from the population, and then update its position towards a better solution based on a defined equation. This step simulates the encircling behavior of a whale.
3. Bubble-net Feeding: Randomly select another whale, and update its position by attracting it towards the best solution obtained so far. This step mimics the bubble-net feeding behavior of humpback whales.
4. Search for Prey: Randomly select another whale, and update its position randomly within the search space. This step represents the exploration behavior of humpback whales.
5. Update the Best Solution: Track the best solution obtained so far during the iterations.
6. Repeat Steps 2-5: Iterate these steps until a termination criterion is met (e.g., reaching a maximum number of iterations or achieving a satisfactory solution).

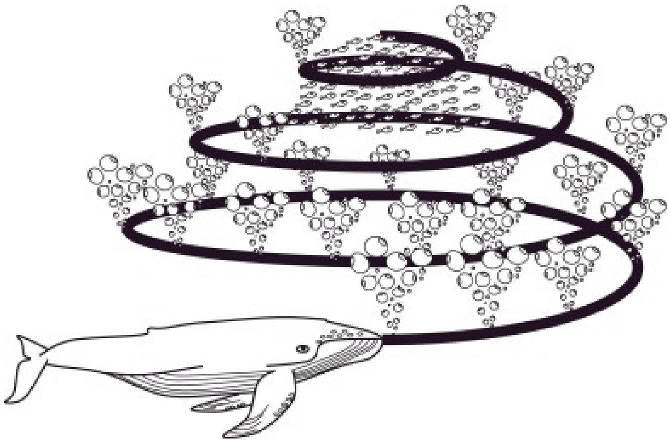

Figure 3.2: WOA

3.1.2 Particle Swarm Optimization

Particle Swarm Optimization (PSO) is a population-based stochastic optimization algorithm that was inspired by the collective behavior of bird flocking or fish schooling. It was first introduced by Eberhart and Kennedy in 1995. PSO is commonly used to solve optimization problems, particularly in continuous search spaces. The basic idea behind PSO is to simulate the social behavior of a group of particles, referred to as a swarm, in the search space. Each particle represents a potential solution to the optimization problem and moves through the search space by adjusting its position based on its own experience and the experiences of its neighboring particles. The PSO algorithm relies on two key parameters: the cognitive parameter (c1) and the social parameter (c2). These parameters control the influence of the particle's personal best and the global best on its movement, respectively. They can be tuned to balance exploration and exploitation in the search process. PSO has been widely applied to various optimization problems, including function optimization, engineering design, data clustering, and neural network training. It is relatively easy to implement, computationally efficient, and can find good solutions for many optimization problems. However, it may suffer from premature convergence or getting trapped in local optima in some cases.

Overview of how PSO works:

1. Initialization: Randomly initialize a swarm of particles with random positions and velocities within the search space. Each particle also has a personal best position (pbest) initialized as its current position.

2. Evaluation: Evaluate the fitness or objective value of each particle based on its current position.

3. Update personal best: Update the personal best position (pbest) for each particle if its current position has a better fitness value than its previous personal best.

4. Update global best: Identify the particle in the swarm with the best fitness value among all the personal bests and update the global best position (gbest).

5. Update velocities and positions: Update the velocity of each particle based on its current velocity, its distance to the pbest, and the distance to the gbest. The new velocity affects the direction and magnitude of the particle's movement. Update the position of each particle based on its new velocity.

6. Termination criterion: Check if the termination criterion is met. This can be a maximum number of iterations, reaching a satisfactory solution, or a certain level of convergence.

7. Repeat steps 2 to 6 until the termination criterion is satisfied.

3.2 System Architecture

The system architecture for bandwidth optimization of a wireless network using WOA and PSO in MATLAB involves defining the problem and optimization objective, creating a network model, implementing WOA and PSO algorithms, and iterating the optimization process. The best solution is selected based on fitness, and results are analyzed. Performance comparison is done between optimized and initial configurations. MATLAB environment is used for implementation, and visualization and reporting are performed.

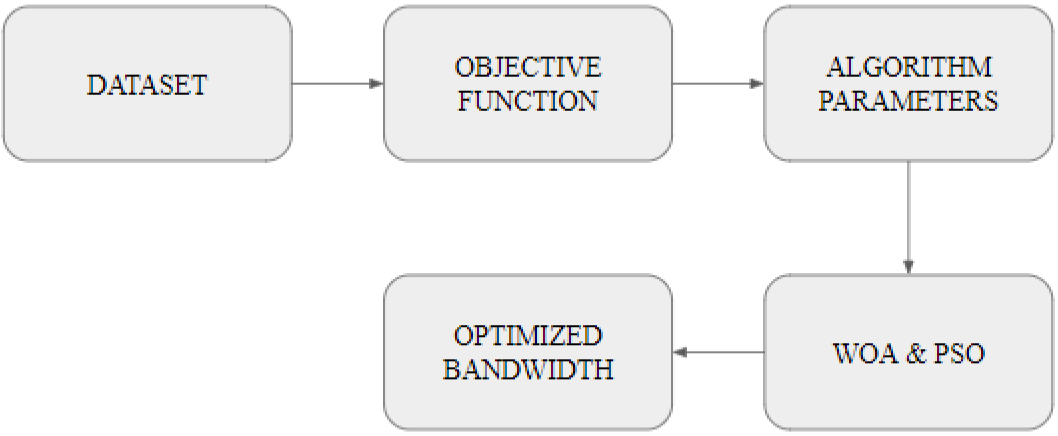

Figure 3.3: System Architecture

3.2.1 Dataset

Bandwidth.csv is the dataset used in this project. The dataset consists of different bandwidth values of different nodes from different time, which will be used to evaluate the optimal value.

3.2.2 Building the models

An objective function is formulated to quantify the optimization goal.

- objectiveFunction = @(x) sum((x,*'bandwidth').^{2})

The WOA and PSO algorithms are implemented, initializing the populations, updating positions, and evaluating fitness based on the objective function. The optimization loop iterates, updating positions, evaluating fitness, and tracking the best positions found. The best solution is extracted based on the highest fitness value. Visualization techniques are used to present results.

- nWhales = 50
- nParticles = 50
- nIterations = 100

3.2.3 Testing the model

After testing, the Whale Optimization Algorithm (WOA) gave a more optimal value compared to the Particle Swarm Optimization algorithm (PSO).

3.3 Software Requirements and Specifications

The software used for the project is MATLAB

3.3.1 MATLAB

MATLAB is a high-level programming language and environment designed for numerical computation, data analysis, and visualization. It stands for ”MATrix LABoratory” and was developed by MathWorks. MATLAB allows users to perform various mathematical and scientific tasks efficiently, including matrix operations, algorithm development, statistical analysis, simulation, and modeling. MATLAB is widely used in academia, engineering, finance, and many other fields where numerical computation and data analysis are essential. Its user-friendly interface, extensive documentation, and large community make it a popular choice for scientific and technical computing tasks.

Features:

1. Interactive Environment: MATLAB provides an interactive environment where you can execute commands and see the results immediately. It has a command-line interface, as well as a graphical user interface (GUI) known as the MATLAB Desktop.

2. Numerical Computing: MATLAB excels in numerical computing and offers a comprehensive set of mathematical functions for linear algebra, optimization, signal processing, curve fitting, and more. It supports complex number arithmetic and provides built-in support for vectors and matrices.

3. Data Analysis and Visualization: MATLAB includes powerful tools for data analysis, exploration, and visualization. It provides functions for importing and exporting data from various file formats, as well as tools for manipulating, filtering, and transforming data. MATLAB also offers plotting and graphing capabilities for creating 2D and 3D visualizations.

4. Algorithm Development: MATLAB provides a flexible environment for developing algorithms and creating applications. It supports script files, function files, and object-oriented programming, allowing you to organize your code efficiently. MATLAB also provides a rich set of libraries and toolboxes that extend its functionality for specific application domains.

5. Simulations and Models: MATLAB includes features for simulation and model-based design. It provides tools for building dynamic systems, performing simulations, and analyzing the behavior of systems. MATLAB also supports the creation of Simulink models, which is a graphical environment for designing and simulating dynamic systems.

6. Integration and Deployment: MATLAB can be integrated with other programming languages, such as C, C++, and Python. It supports interoperability through APIs and provides tools for creating standalone executables, deploying applications as web services, or generating code for embedded systems.

3.4 Hardware and Experimentation Environment

The hardware used for this experiment includes Windows 11 Home 64-bit OS, x64-based processor, Intel(R) Core (TM) i7-8565U CPU @ 1.80GHz, 1992 Mhz, 4 Core(s), 8 Logical Processor(s), 16 GB RAM.

The experimental environment was prepared by using MATLAB.

Chapter 4

RESULT AND DISCUSSION

The primary quality control method used in software development is testing. Following the coding stage, testing purposes are served by running the accessible computer programmes. Testing must find flaws made during the earlier phase as well as those introduced during development. So, the purpose of testing is to find programme requirements, design, or coding flaws.

- A programme is tested by being run with the goal of identifying any errors.
- A excellent test case is one that has the highest chance of spotting an error that hasn't been identified yet.
- A test that finds an error that hasn't been found yet is successful.

Our objective is to develop tests that systematically uncover many sorts of issues with minimal time and effort. Testing indicates that software functionalities appear to operate as expected and that performance criteria appear to have been met. The information acquired during testing is an excellent predictor of programme reliability and a partial indicator of software quality as a whole. Testing has one drawback, however: it can only demonstrate the presence of software defects, not their absence.

4.1 Testing and it's types used

The main task following software development is to determine whether the experimental results and the actual results agree. Testing is the process in question. It is employed to ensure that the created system is free from errors.Testing's primary purpose is to find errors and missing operations by running the software. Additionally, it makes sure that the developer satisfies all of the project's goals. Testing's objective is to determine is to identify defects in the developed software as well as ways to increase its correctness, usability, and efficiency. It seeks to gauge a software program's performance, functionality, and specification. The developed programme is put through tests, and the outcomes are compared to the required documentation. Debugging is carried out when there are too many faults that have happened. After debugging, the software is once more tested to make sure there are no errors. Unit testing, integration testing, and system testing are the main testing methodologies used in this project.

- In unit testing, tested to each distinct piece of software. It ensures that the software's many components all function as intended.
- In integration testing, the integrated distinct components are examined to see whether or not the intended purpose was accomplished. It helps us find any problems that might appear after the units are combined.
- The entire piece of software is evaluated during system testing to make sure it meets all the requirements.

4.2 Output Screens and Results

1. Dataset

   The image shown below is the average of the original bandwidth dataset. The linear graph shown is the average value of the 10 nodes in the original bandwidth dataset.

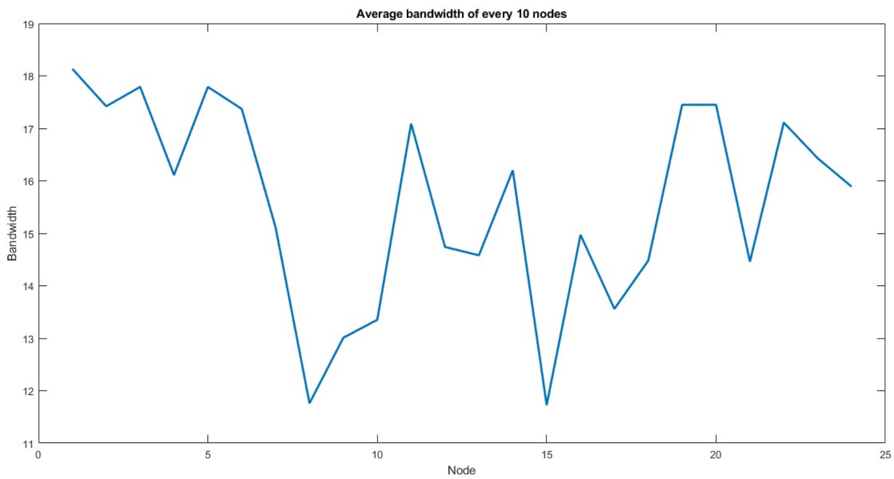

Figure 4.1: Original Dataset

2. Whale Optimization Algorithm

   The image shown below is the optimized bandwidth value of the nodes in the bandwidth dataset. The linear graph shown is the optimal bandwidth value of every 10 nodes using Whale Optimization Algorithm.

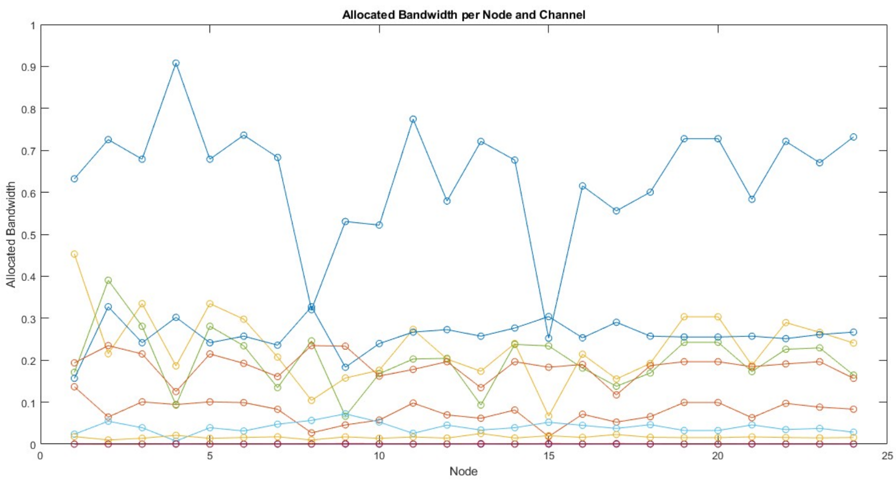

Figure 4.2: Linear Graph

3. Whale Optimization Algorithm

   The image shown below is the optimized bandwidth value of the nodes in the bandwidth dataset. The bar graph shown is the optimal bandwidth value of every 10 nodes using Whale Optimization Algorithm.

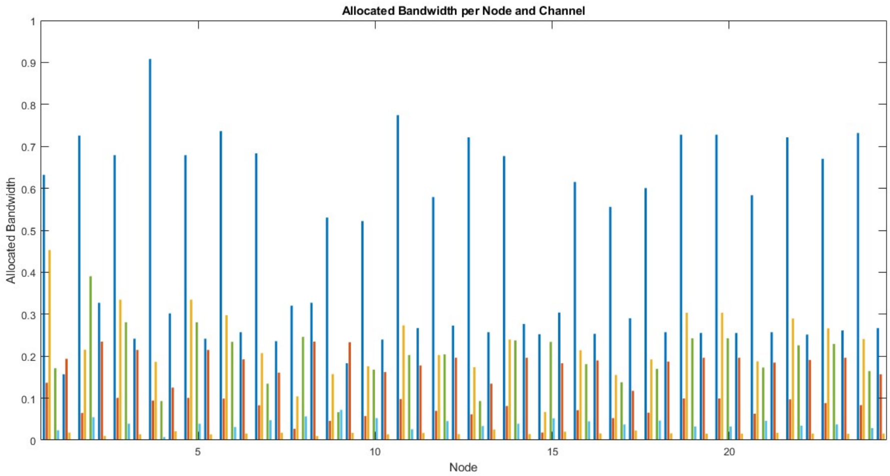

Figure 4.3: Bar Graph

4. Particle Swarm Optimization

   The image shown below is the optimized bandwidth value of the nodes in the bandwidth dataset. The bar graph shown is the optimal bandwidth value of every 10 nodes using Particle Swarm Optimization Algorithm.

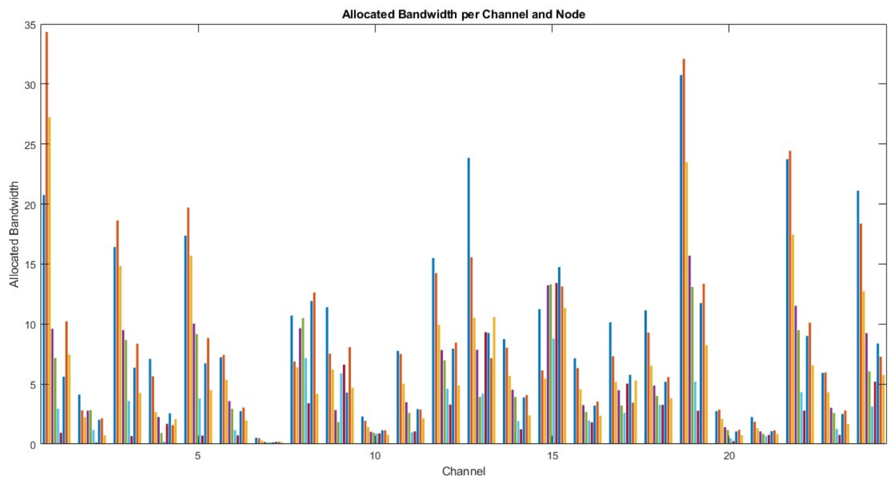

Figure 4.4: Bar Graph

5. Particle Swarm Optimization

   The image shown below is the optimized bandwidth value of the nodes in the bandwidth dataset. The linear graph shown is the optimal bandwidth value of every 10 nodes using Particle Swarm Optimization Algorithm.

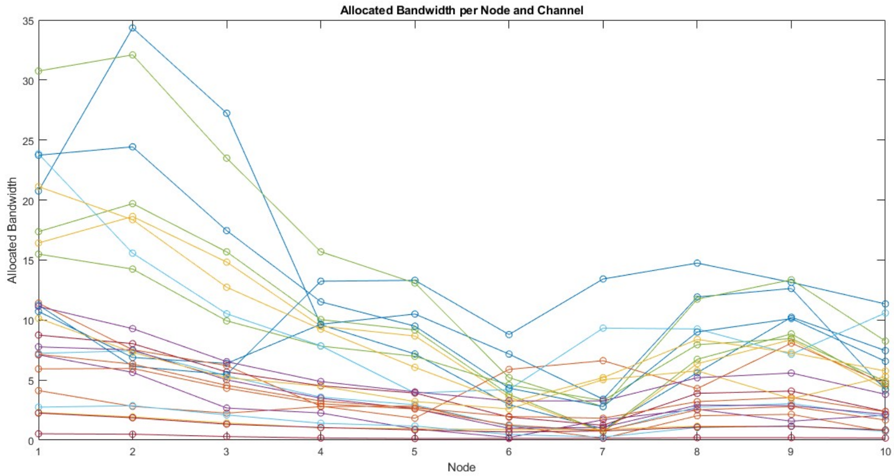

Figure 4.5: Linear Graph

6. Linear comparison

   The image shown below is the comparison of the optimized bandwidth value of the nodes in the bandwidth dataset. The linear graph shown is the comparison of every node in the bandwidth dataset using Whale Optimization Algorithm and Particle Swarm Optimization Algorithm.

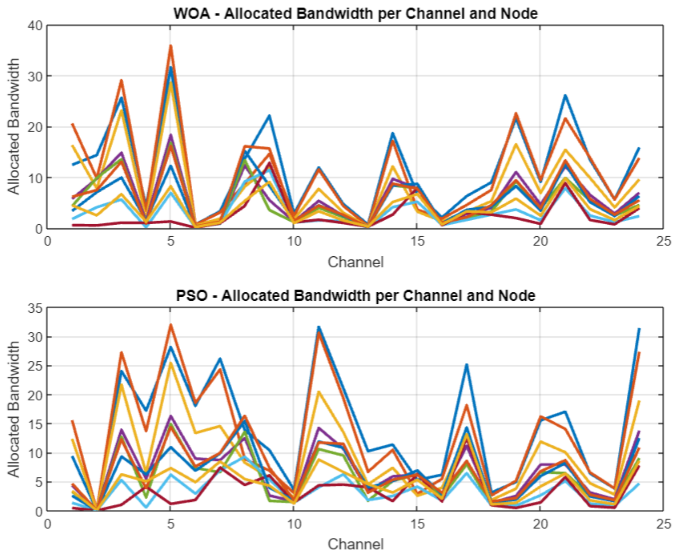

Figure 4.6: WOA and PSO

7. Bar comparison

   The image shown below is the comparison of the optimized bandwidth value of the nodes in the bandwidth dataset. The bar graph shown is the comparison of every node in the bandwidth dataset using Whale Optimization Algorithm and Particle Swarm Optimization Algorithm.

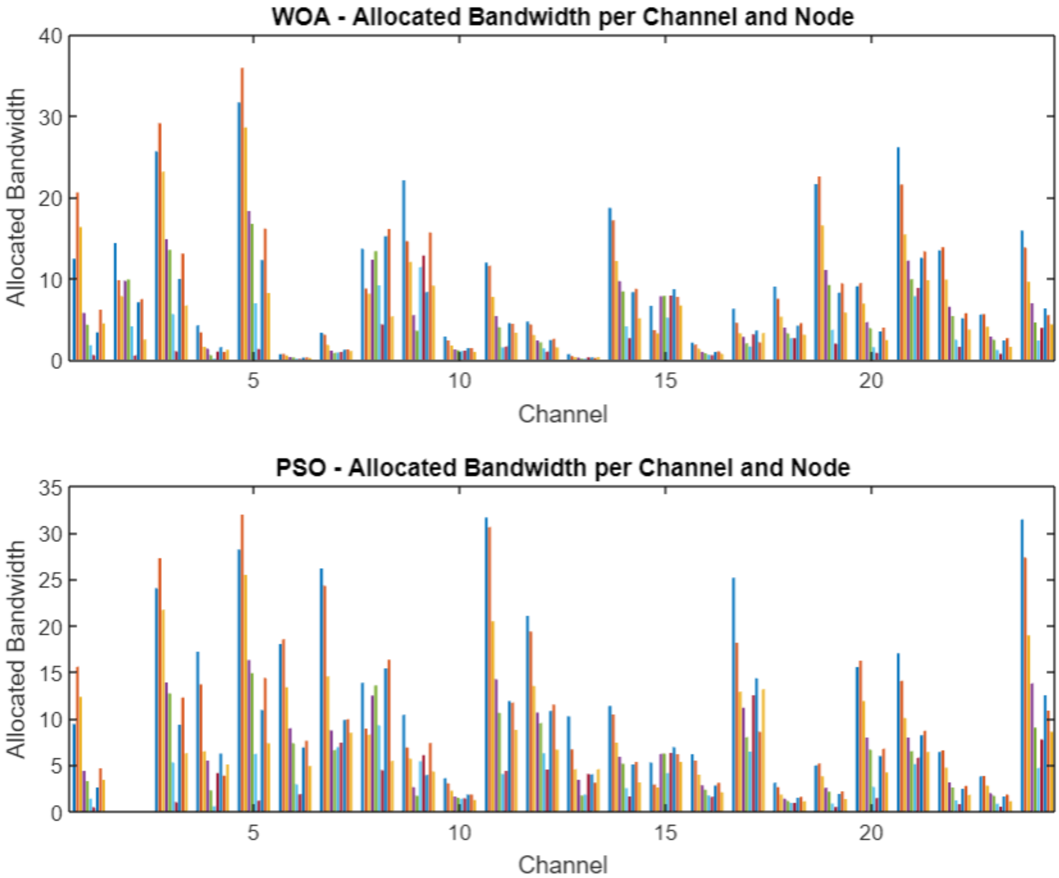

Figure 4.7: WOA and PSO

Chapter 5

CONCLUSION

The utilization of optimization algorithms, namely Whale Optimization Algorithm (WOA) and Particle Swarm Optimization (PSO), in the context of bandwidth optimization for wireless networks using MATLAB, holds significant potential for achieving enhanced network performance. Both WOA and PSO offer efficient approaches to address the challenge of optimizing bandwidth allocation in wireless networks.

MATLAB provides a robust and flexible environment for implementing and evaluating these optimization algorithms. With its extensive set of built-in functions and libraries, researchers can easily simulate and analyze the performance of WOA and PSO in optimizing bandwidth allocation for wireless networks. MATLAB's visualizations and data analysis capabilities enable researchers to gain insights into the optimization process and assess the effectiveness of the proposed approach.

5.1 Future Enhancement

The bandwidth optimization of wireless networks using WOA and PSO in MATLAB can further advance and adapt to the evolving needs of wireless communication systems, leading to improved network performance, reliability, and efficiency through

1. Hybridization with other optimization techniques: Combining WOA and PSO with other optimization techniques such as genetic algorithms or ant colony optimization can potentially enhance the search capabilities and convergence speed of the algorithms.

2. Dynamic optimization: Introducing dynamic optimization into the bandwidth allocation process can handle real-time variations in network conditions. By continuously adapting the bandwidth allocation based on changing network parameters such as traffic load, channel conditions, or user demands, the network can achieve optimal performance under varying circumstances.

3. Multi-objective optimization: Bandwidth optimization often involves multiple conflicting objectives, such as maximizing throughput while minimizing latency or power consumption. Extending the WOA and PSO algorithms to handle multi-objective optimization can enable the exploration of trade-offs between different performance metrics and provide a set of Pareto-optimal solutions.

4. Incorporating machine learning: Integrating machine learning techniques into the optimization process can enhance the intelligence and adaptability of the algorithms. Machine learning models can learn from historical network data, user behavior patterns, or real-time feedback to make more informed decisions on bandwidth allocation and optimize the network performance accordingly.

REFERENCES

[1] lalibo, T.J., Orike, S.U.N.N.Y. and Elechi, P.R.O.M.I.S.E., 2020. Bandwidth Optimization of Wireless Networks Using Artificial Intelligence Technique. Iconic Research and Engineering Journals, 3(9), pp.125-130.

[2] S. Ahmad, R. M. Nadeem, B. Ehsan, M. Ullah and A. B. Siddique, “Wireless networks throughput enhancement using artificial intelligence,” Indian Journal of Science and Technology, vol. 10, no. 26, pp. 1 – 5, 2017.

[3] J. Chang and H. Chen, ”Dynamic-grouping bandwidth reservation scheme for multimedia wireless networks,” IEEE Journal on Selected Areas in Communications, vol. 21, no. 10, pp. 1566-1574, 2003.

[4] B.I. Bakare and T.J. Alalibo, “Gigabit Fidelity (GIFI) as future wireless technology in Nigeria,” International Journal of Engineering Science Invention, vol. 7, no. 12, ver.3, pp. 1-6, 2018.

[5] C. Jiang, H. Zhang, Y. Ren, Z. Han, K. C. Chen, and L. Hanzo, “Machine learning paradigms for next-generation wireless networks,” IEEE Wireless Communications, vol. 24, no. 2, pp. 98- 105, 2017.

[6] S. Mirjalili and A. Lewis, ”The Whale Optimization Algorithm,” Advances in Engineering Software, vol. 95, pp. 51-67, 2016.

[7] Pham, Q.V., Mirjalili, S., Kumar, N., Alazab, M. and Hwang, W.J., 2020. Whale optimization algorithm with applications to resource allocation in wireless networks. IEEE Transactions on Vehicular Technology, 69(4), pp.4285-4297.

[8] Z. Afzal, P. A. Shah, K. M. Awan, and Zahoor-ur-Rehman, "Optimum bandwidth allocation in wireless networks using differential evolution," Journal of Ambient Intelligence and Humanized Computing, vol. 10, no. 4, pp. 1401 – 1412, 2019.

[9] Y. Shen, Y. Shi, J. Zhang, and K. B. Letaief. (2018) "LORA: Learning to Optimize for Resource Allocation in wireless networks with few training samples," [online] arXiv preprint arXiv: 1812.07998. Available: https://arxiv.org/abs/1812.07998.

[10] P. Akilandeswari, P. Gopikannan, and C. Balasubramanian, "A bandwidth allocation using genetic algorithm to providing solution for optimization problem in wireless mesh network," International Journal of Innovation and Scientific Research, vol. 25, no. 2, pp. 445 – 456, 2016.

[11] S. Orike and T. J. Alalibo, "Comparative analysis of computer network protocols in wireless communication technology," International Journal of Electronics Communication and Computer Engineering, vol. 10, no. 3, pp. 76 – 85, 2019.

[12] F. Farid, S. Shahrestani, and C. Ruan, "Quality of service concerns in wireless and cellular networks," Communications of the IBIMA, vol. 2013, pp. 1 – 15, 2013.

[13] M. L. Umashankar, and M. V. Ramakrishna, "Optimization techniques in wireless sensor networks: A survey," International Journal of Scientific Research Engineering Technology, vol 6, no. 7, pp. 704 – 708, 2017.

[14] L. Wang, W. Wu, J. Qi, and Z. Jia, "Wireless sensor network coverage optimization based on whale group algorithm," Computer Science and Information Systems, vol. 15, no. 3, pp. 569-583, 2018.

APPENDIX

Screenshots

WOA - Allocated bandwidth:

Columns 1 through 15

12.4273	14.3365	25.6238	4.2092	31.6436	0.6720	3.2952	13.6414	22.0827	2.8228	11.9225	4.7049	0.6759	18.6857	6.6193
20.5592	9.7672	29.0670	3.3438	35.8957	0.6914	3.0598	8.7630	14.5746	2.3752	11.5306	4.3257	0.4413	17.1627	3.6156
16.3056	7.7970	23.1415	1.5834	28.5781	0.4977	1.8318	8.1306	12.0130	1.7441	7.7088	3.0160	0.2982	12.1252	3.2151
5.7549	9.6834	14.8138	1.3375	18.2939	0.3331	1.0950	12.2863	5.4765	1.2622	5.3570	2.3783	0.2227	9.6650	7.7874
4.2953	9.8511	13.5326	0.5507	16.7118	0.2731	0.8289	13.3703	3.5332	1.1589	3.9851	2.1198	0.1113	8.3764	7.8319
1.7640	4.0913	5.6052	0.1279	6.9220	0.1085	0.8698	9.1244	11.3946	1.0786	1.5026	1.3960	0.1193	4.1003	5.1730
0.5671	0.5072	1.0410	1.0031	1.2855	0.0678	0.9312	4.3363	12.8079	1.1016	1.6332	0.9996	0.2644	2.6359	7.8986
3.3570	7.0425	9.9292	1.5244	12.2619	0.2556	1.2382	15.1772	8.3031	1.4114	4.4750	2.4128	0.2624	8.3178	8.6773
6.1302	7.4617	13.0521	0.9343	16.1184	0.2828	1.2485	16.0806	15.6345	1.4114	4.4097	2.5679	0.2028	8.7278	7.7317
4.4621	2.4900	6.6462	1.2293	8.2075	0.1820	1.0643	5.3301	9.0981	0.9524	3.2991	1.4821	0.3002	5.0961	6.6749

Columns 16 through 24

2.0873	6.2840	8.9814	21.5993	9.0311	26.1298	13.4258	5.5678	15.8659
1.8497	4.5331	7.4898	22.5439	9.4260	21.5690	13.8206	5.6030	13.7964
1.3315	3.2140	5.2682	16.4986	6.8984	15.3929	9.8719	4.0525	9.5655
0.9501	2.7822	3.9353	11.0201	4.6077	12.1623	6.5154	2.8368	6.9442
0.7845	1.9907	3.2371	9.1939	3.8441	9.8818	5.3703	2.4315	4.5528
0.5758	1.6070	2.6341	3.6524	1.5271	7.7914	2.4482	1.1805	2.3454
0.5326	3.1180	2.6341	1.9521	0.8162	8.8366	1.5795	0.7224	3.9090
0.9357	3.5737	4.1892	8.2493	3.4492	12.5423	5.0939	2.3610	6.3004
1.0364	2.1346	4.5065	9.3828	3.9231	13.3025	5.7257	2.6253	5.4726
0.6910	3.2859	3.0784	5.7934	2.4223	9.7868	3.7118	1.5681	4.3229

Figure A.1: Optimized WOA bandwidth value

PSO - Allocated bandwidth:

Columns 1 through 15

9.3943	0.0137	24.0007	17.1833	28.1599	18.0097	26.1419	13.8362	10.3962	3.5558	31.6312	21.0275	10.2084	11.3470	5.2587
15.5416	0.0094	27.2258	13.6503	31.9439	18.5287	24.2746	8.8882	6.8615	2.9921	30.5913	19.3330	6.6655	10.4222	2.8724
12.3261	0.0075	21.6756	6.4638	25.4320	13.3386	14.5323	8.2467	5.6555	2.1971	20.4520	13.4792	4.5037	7.3631	2.5542
4.3504	0.0093	13.8754	5.4601	16.2800	8.9270	8.6869	12.4618	2.5783	1.5900	14.2124	10.6293	3.3628	5.8691	6.1867
3.2470	0.0094	12.6754	2.2483	14.8720	7.3181	6.5761	13.5613	1.6634	1.4599	10.5726	9.4739	1.6814	5.0866	6.2220
1.3335	0.0039	5.2502	0.5219	6.1600	2.9065	6.9008	9.2547	5.3644	1.3587	3.9864	6.2389	1.8015	2.4899	4.1097
0.4287	0.0005	0.9750	4.0951	1.1440	1.8165	7.3879	4.3983	6.0298	1.3876	4.3330	4.4674	3.9933	1.6007	6.2750
2.5377	0.0068	9.3003	6.2229	10.9120	6.8510	9.8235	15.3939	3.9090	1.7779	11.8725	10.7833	3.9633	5.0510	6.8937
4.6341	0.0072	12.2254	3.8141	14.3440	7.5776	9.9047	16.3102	7.3605	1.7779	11.6992	11.4766	3.0625	5.3000	6.1425
3.3731	0.0024	6.2252	5.0185	7.3040	4.8787	8.4433	5.4062	4.2832	1.1997	8.7527	6.6241	4.5337	3.0946	5.3029

Columns 16 through 24

6.1468	25.1372	3.0852	4.9194	15.5175	17.0091	6.3795	3.7748	31.4217
5.4474	18.1333	2.5728	5.1345	16.1961	14.0403	6.5671	3.7987	27.3232
3.9213	12.8564	1.8097	3.7577	11.8530	10.0199	4.6908	2.7475	18.9441
2.7979	11.1294	1.3518	2.5099	7.9171	7.9170	3.0959	1.9233	13.7527
2.3104	7.9633	1.1120	2.0940	6.6051	6.4325	2.5518	1.6485	9.0167
1.6957	6.4282	0.9049	0.8319	2.6239	5.0718	1.1633	0.8004	4.6449
1.5685	12.4726	0.9049	0.4446	1.4025	5.7522	0.7505	0.4898	7.7416
2.7555	14.2956	1.4390	1.8788	5.9265	8.1644	2.4204	1.6007	12.4776
3.0522	8.5390	1.5481	2.1370	6.7408	8.6592	2.7207	1.7799	10.8382
2.0348	13.1443	1.0575	1.3195	4.1621	6.3707	1.7637	1.0632	8.5613

Figure A.2: Optimized PSO bandwidth value