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Optimizing WiFi Signal Quality Through Access Point Placement Using Genetic Algorithm Method

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ABSTRACT

The quality of WiFi signal is one of the critical factors that affects the performance of wireless networks in dense and complex environments. Proper placement of access points (APs) in an area can enhance network coverage and optimize signal quality. However, determining the optimal location for Access Points in a complex environment often presents a complicated and intricate challenge. PT. Globalriau Data Solusi is a company operating in the internet service provider sector. Within this company, there are still several areas with poor signal coverage, which can hinder the work processes of the staff in this office. Therefore, this research aims to optimize the WiFi signal quality by strategically placing Access Points using the Genetic Algorithm (GA) method. This will extend the signal coverage to areas that currently lack proper signal reception and improve the signal quality for overall enhancement. The Genetic Algorithm method proves effective in optimizing WiFi signal quality through the appropriate placement of APs. The results indicate the potential of applying this method in designing and managing efficient and reliable wireless networks in complex environments. This research demonstrates an increase in coverage area from an initial 60% to 80.5%, with signal quality reaching -65 dBm / -45 dBm.

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1. INTRODUCTION

The current era's advancement has progressed significantly, making society inseparable from the concept of the internet network. With the evolution of internet networks, it undeniably provides benefits in daily life such as ease of accessing information, reducing communication time, enabling limitless communication, cost savings, and more. WiFi is a telecommunications technology that operates on local networks without the need for cables, utilizing compatible components with devices to establish a connection. [1] However, WiFi signal quality is often influenced by various obstacles (interference) and the placement of Access Points, leading to disrupted connections, buffering, weak signals, overload, and areas with no WiFi coverage due to poor and unstable signal quality. As a result, network overload on WiFi usage is a common occurrence.

An Access Point is a network device containing a transceiver and antenna for transmission, which is used to receive signals from remote clients. Through Access Points, wireless clients can quickly and easily connect to a Local Area Network (LAN) wirelessly [2]. Access points can be utilized to achieve better coverage and location accuracy. Proper placement of access points offers good signal coverage and high location accuracy, yielding the desired result [3].

Genetic Algorithm is a search and optimization technique inspired by principles of genetics and natural selection (Darwin's evolutionary theory). This algorithm is used to find precise solutions for single-variable or multi-variable optimization problems [4]. Genetic Algorithms are largely applied to conventional optimization problems, incorporating biological-inspired operations like mutation, crossover, and selection [5].

Coverage Area refers to a targeted region to be reached. When this area is covered, devices within that area can access the WiFi network. Coverage area assessment is crucial as it determines the number of users and identifies which regions are covered or still out of reach for the network [2]. PT Globalriau Data Solusi is an Internet Service Provider company in Pekanbaru. Located at Jl. Rajawali Sakti, Kelurahan Simpang Baru, Kecamatan Tampan, Kota Pekanbaru, the company has been operating since 2012 [6].

Based on this background, this research aims to optimize WiFi signal quality by strategically placing access points using the genetic algorithm method. This optimization is necessary to cover areas with poor WiFi signal coverage and enhance signal quality received by users through the placement of access points using the genetic algorithm method. Given that signal quality significantly affects office staff's work processes, as poor signal quality can hinder service processes and disrupt technician's work quality, this study is significant. The distinction from prior research lies in the application of the genetic algorithm method. This study applies the genetic algorithm to compare access point positions based on selected conditions and combines these to design access point placements, covering uncovered areas and improving user signal quality. The study's outcome will reveal more optimal access point placements for better coverage and signal quality. Selecting the genetic algorithm as the research method for addressing optimization problems or coverage enhancement is based on prior research that yielded favorable outcomes in complex optimization issues [7]. Subsequent research by Jaloun, Guennoun, Elasri focused on optimizing LTE deployment using the genetic algorithm, comparing it with simulated annealing. While both algorithms yielded similar results, genetic algorithm's fitness value improved five times more than simulated annealing [8].

2. RESEARCH METHOD

2.1. Research Methodology

To ensure the successful progression of this research, particularly in the optimization of WiFi signal quality through the placement of access points using the genetic algorithm, the following research steps have been outlined, as depicted in Figure 1.

In this research, the steps taken adhere to the clearly depicted flowchart. Initial signal condition survey, problem identification, optimization calculations using the genetic algorithm method, and network quality testing through monitoring – all of these stages constitute a structured and comprehensive research process.

2.2. Computer Networks

A computer network is a collection of separate computers that can be interconnected or linked together to perform tasks. Computer networks can also be understood as a set of interconnections for a number of computers. Two computers can form a network when they can exchange data with each other.

2.3. Wireless Fidelity

WiFi stands for wireless fidelity, which is a modern technology that serves as a medium for data communication without the need for cables, enabling fast communication and data transfer capabilities [9].

2.3.1. Development of Internet and WiFi Networks

The development of the internet network has transformed the way people communicate and access information. The internet allows instant communication and broader information access through various online sources. WiFi has gained popularity due to its ease of access, multi-device connectivity, wide coverage, cost-effectiveness, and enhanced mobility. It offers the flexibility to connect wirelessly and improves connectivity in various locations.

2.3.2. Challenges in WiFi Networks

Challenges in WiFi networks involve several aspects that impact signal quality and efficient usage. Two main challenges that need attention are interference and inadequate coverage.

a. Interference

Interference occurs when WiFi signals overlap with other signals, such as signals from other electronic devices or nearby WiFi networks. Interference can disrupt the signal, causing instability or even disconnection. This can result in poor signal quality and slowed data transfer speeds.

b. Inadequate Coverage

Inadequate coverage means there are areas within the network that do not receive WiFi signals well or at all. This might happen due to improper placement of Access Points or physical obstacles like walls or electronic equipment blocking the signal. Poorly covered areas lead to weak connections, buffering, and other usage issues.

Both of these challenges directly impact WiFi network usage. Disruptions in connection and signal quality can interfere with online activities like video streaming, messaging, or accessing information. Inefficient usage can lead to long waiting times and a poor user experience. To address these challenges, optimizing coverage and handling interference become critical. By understanding the causes of disruptions, improving Access Point placement, and adopting solutions to reduce interference, signal quality can be enhanced, leading to smoother WiFi network usage.

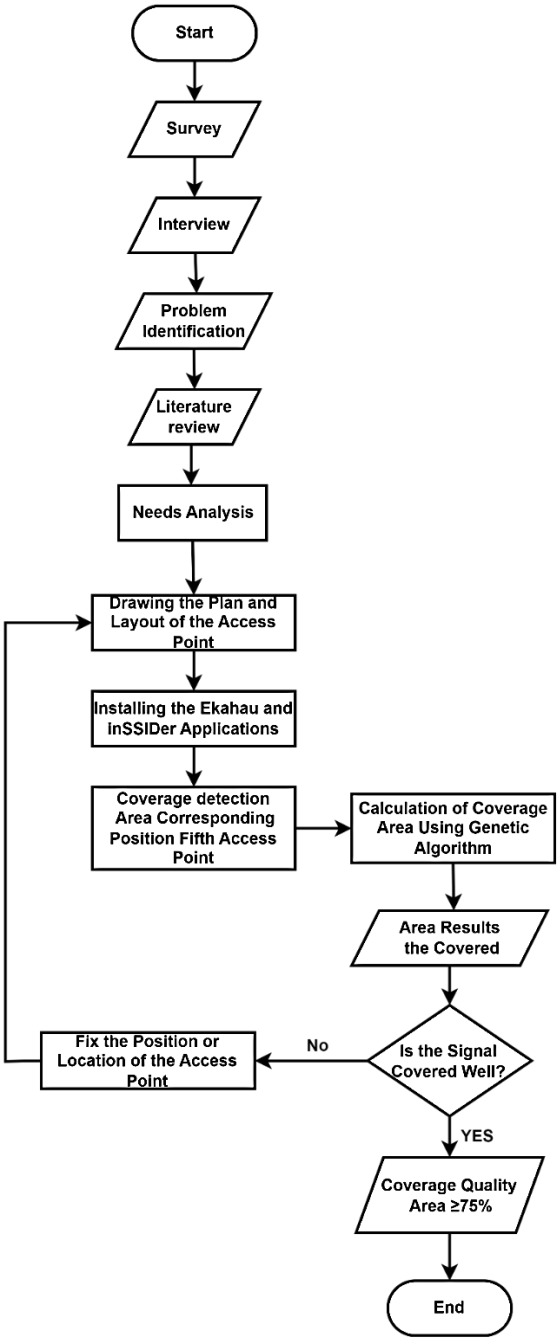

Figure 1. Research Flowchart

2.4. The inSSIDer Application

The inSSIDer application is an open-source application serving as a WiFi scanner that can identify BSSID, RSSI (signal strength), security, and settings present on the access point. The displayed results provide information about the signal conditions of the established wireless network and are easily comprehensible [10]. The inSSIDer interface can be seen in Figure 2.

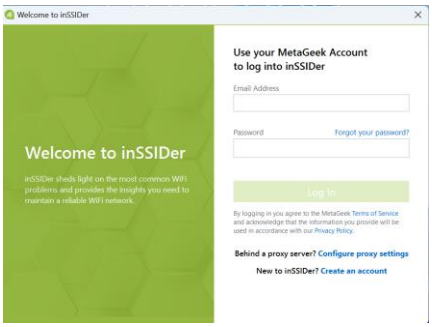

Figure 2. inSSIDer Interface

2.5. Ekahau Site Survey Application

The Ekahau Site Survey application is a network design application for WiFi that features building layouts consisting of walls and various wall material types required. Each wall type has a predetermined obstruction value. This application also offers a wide range of diverse access point options, making it easier for designers to conduct their planning. The Ekahau Site Survey application functions to diagnose WiFi networks for optimization and increased speed, resulting in more accurate and reliable data transmission [11]. The Ekahau interface can be observed in Figure 3.

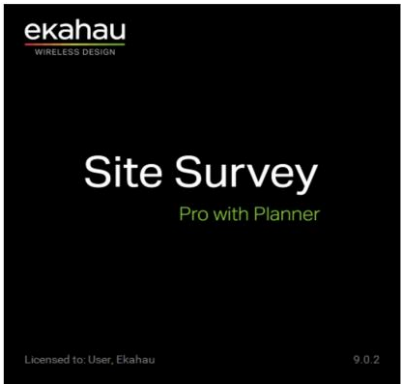

Figure 3. Ekahau Site Survey Interface

2.6. Genetic Algorithm

The Genetic Algorithm, also known as Genethic Algorithm (GA), was introduced by John Holland to solve optimization problems. Genetic Algorithm is a search method that simulates the biological evolution process [8]. It falls under the category of evolutionary algorithms, which are adaptive methods commonly used to solve optimization problems. This algorithm is based on the genetic process present in living organisms, which involves gradual development within a population following the principles of natural selection – the strong survive. By mimicking this theory of evolution, genetic algorithms can be used to find solutions to real-world problems. Some advantages of genetic algorithms include:

1. The formation process operates on the code of the given data (referred to as chromosomes).
2. The search process is conducted from multiple starting points with specific criteria within a formed population.
3. The search process is guided by the intended goal.

The main parts of the Genetic Algorithm are as follows:

1. Understanding Individuals

An individual represents a possible solution, akin to a chromosome comprising a set of genes. These genes can be binary, float, or combinatorial. In genetic algorithms, individuals symbolize points in the search space encompassing various potential solutions for the problem at hand. These individuals are then evaluated

based on how well they fulfill certain criteria set by the algorithm, often referred to as the objective function or fitness function. Individuals are a key component in genetic algorithms, enabling the algorithm to perform heuristic searches in the solution space to achieve better results. These individuals represent the variations of solutions that the algorithm must explore to attain optimal outcomes.

2. Fitness Value

The fitness value is a measure indicating the quality of a solution (individual). It serves as a reference point for achieving optimal values in genetic algorithms. The goal of genetic algorithms is to find individuals with the highest fitness value.

$$\text{Fx(i)} = \frac{Area\ tercoverAbs(sqrt[(Crx(i) - Crx(i) + (Cry(i) - Cry(i))] \leq \text{S(i)}}{100} \quad (1)$$

$$\text{S(i)} = \frac{Th\ x\ Smax}{Pmin} \quad (2)$$

Where:

Fx(i)	= Fitness Function
S(i)	= Threshold Distance
Cr_X(i)	= Chromosome Gen X at position i
Cr_Y(i)	= Chromosome Gen Y at position i
Th	= Power threshold level = (-60 dBm)
Smax	= Maximum measurement distance (m)
Pmin	= Minimum measurement power (dBm)

3. Selection

Selection is used to choose individuals for crossover and mutation. It aims to identify suitable parent candidates. Good parents will produce good offspring. The higher the individual's fitness value, the greater the likelihood of being selected.

4. Crossover

Crossover is a genetic algorithm operator that involves two parents to create a new chromosome. This crossover generates new points in the search space that are ready to be tested. This operation is not always applied to all individuals. Individuals are randomly selected for crossover, with a crossover probability (Pc) between 0.6 and 0.95. If crossover is not performed, parental values will be passed down to their offspring.

5. Mutation

The next operator in the genetic algorithm is mutation. This operator is used to replace genes that are lost from the population because selection allows the re-emergence of genes not present in the initial population.

3. RESULTS AND ANALYSIS

3.1. General Overview

Based on the introductory overview and literature review provided in the previous chapters, the upcoming research aims to address issues and optimize the placement of access points using the genetic algorithm method, employing the inSSIDer and Ekahau Site Survey applications. The data collection methodology applied in this study involves both primary and secondary data. Primary data is obtained through direct analysis of the WiFi network at PT Globalriau Data Solusi using the inSSIDer application along with Ekahau Map Survey. Secondary data consists of theories gathered from journals, theses, and previous research, which serve as the foundation for the development of this study.

3.2. Research Map

As seen in Figure 5, the research site encompasses the scope of PT Globalriau Data Solusi, which is the focal point for optimizing the placement of access points. This optimization aims to provide good signal quality for the staff and employees, ensuring effective wireless connectivity.

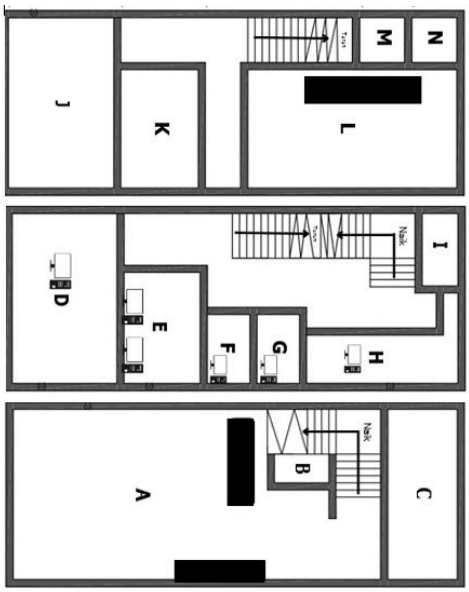

Figure 4. PT Global Riau Data Solusi Map

3.3. Optimization Results

To determine a more optimal position for Access Points in order to effectively cover areas that are not well-covered, the genetic algorithm method is utilized. Genetic algorithms are suitable for optimization problems related to positioning, distance, and decision-making due to their efficiency and rapidity.

The results of this research involve a systematic series of steps taken to enhance WiFi signal quality at the PT. Globalriau Data Solusi office. The research commences with field surveys to assess the initial signal conditions. Subsequently, interviews with office staff are conducted to gather information about the number of access points, their types, user count, bandwidth, and existing access point positions. Identification of network problems at PT Globalriau Data Solusi is accomplished through interaction with office personnel, in order to comprehend the issues affecting the current network. Literature review is conducted to obtain reliable references, including previous research and journals related to the research topic.

The analysis of hardware and software requirements follows. In this research, hardware such as MikroTik devices, switches, UTP cables, and client PCs are required. Meanwhile, software tools like Ekahau Site Survey and inSSIDer are used to analyze WiFi signal quality. With these applications, data related to WiFi signal quality is identified, including areas covered by the office WiFi. If suboptimal access point positions are identified, the genetic algorithm method is applied to recalculates and redesigns the access point placements. The output of this algorithm yields improved position recommendations that encompass poorly covered areas and enhance signal quality for users.

After monitoring the WiFi signal conditions using the Ekahau Site Survey application, it is evident that the previous placement of access points had suboptimal locations, resulting in poor signal coverage and quality. The areas that can be reached and the coverage area graph can be seen in Figure 5 and Figure 6.

Figure 5. Coverage Area Display Before Research

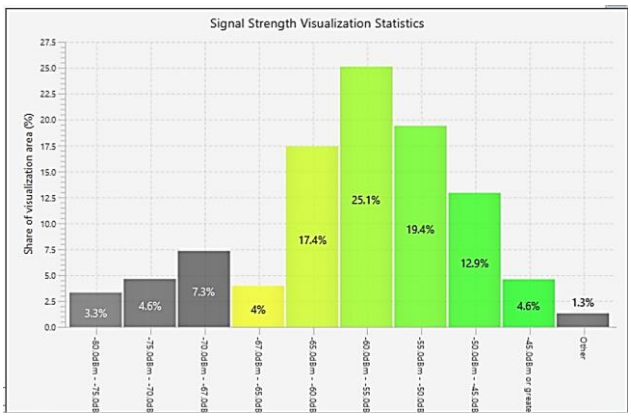

Figure 6. Coverage Area Graph Before Research

From the above Figure 4, the results prior to optimization are displayed. In this image, Figure 4 depicts the initial positions of the existing access points at the location. Several access points are still positioned irregularly and closely to each other, resulting in suboptimal coverage area and a decrease in signal strength due to signal interference between these access points.

Figure 7. Coverage Area Display After Research

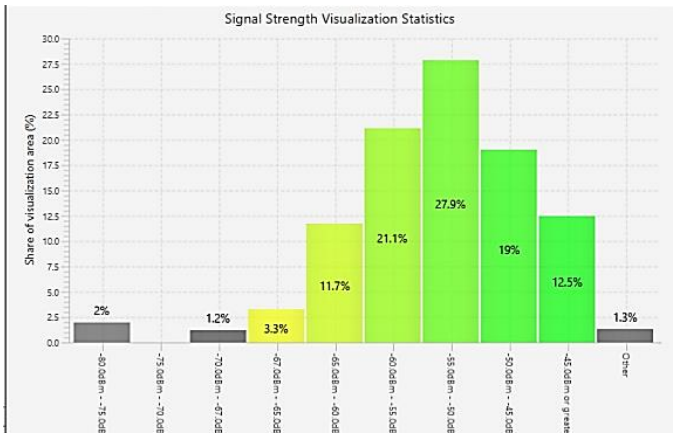

Figure 8. Coverage Area Graph After Research

However, after optimization using the genetic algorithm, the positions of the access points become more organized and there is no longer overlapping placement. This leads to improved coverage area and the elimination of interference among access points, resulting in enhanced signal quality.

In Figure 8, it can be observed that the signal strength graph has increased from the initial condition of the previous 5 access points. The signal strength in the covered area before optimization was 62%. However, after optimization using the genetic algorithm, the coverage area's signal strength has increased to 80.5%. This

result signifies an enhancement in coverage area from the initial 62% to 80.5%. The signal strength obtained ranges from -65 dBm to -45 dBm. This signal strength range has become the standard, ensuring that each access point position now possesses good signal strength.

4. CONCLUSION

From the research on the optimization of Signal Quality Enhancement through Access Point Placement using Genetic Algorithm, the desired outcomes have been achieved. Initially, the study involved 5 access points with a coverage area percentage and signal strength of 62%. After optimization using the genetic algorithm, the results show that there are still 5 access points, but the coverage area and signal strength have improved to 80.5%. The signal strength ranges from -65 dBm to -45 dBm.

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