Multidisciplinary

Using the bird flock algorithm as a technique to access wireless networks

Israa Falih Muslm
Department of Quality Assurance and Academic Performance, University of Babylon, Iraq
Correspondence Author: Israa Falih Muslm
Received 1 March 2025; Accepted 2 Apr 2025; Published 14 Apr 2025

Abstract
Wired and wireless networks are an effective means of exchanging data, as they reduce the time of transfer and exchange compared to traditional methods, in addition to reducing the effort and cost required for that. Wireless networks have the greatest advantage of the two types because they provide an additional feature, which is roaming, and these networks suffer from many problems, including interference and the presence of obstacles in front of them, which makes them need more follow-up to obtain better services. This project aims to identify shortcomings in the places where wireless network access devices are placed, and then propose a modern method based on artificial intelligence techniques inspired by nature to reduce the problem of the signal not being distributed optimally inside buildings. Through the results obtained, it became clear that the Particle Swarm Optimization (PSO) method is one of the important methods used to find the optimal place to place an access point for wireless local networks, as this method is characterized by ease of use, speed of implementation, and improving the quality of service inside buildings.

Keywords: Wireless networks, Bird flock algorithm, Node-RED programming, Windows 10

Introduction

The wireless networking industry is one of the fastest developing industries in the world of networks, especially for users with limited range, such as use in homes and offices [1]. A recent study expected the number of wireless access points in public places to grow from 124 million devices in 2017 to about 549 million devices by 2022 [2]. The local wireless network built according to the specifications of the standard (IEEE 802.11) is one of the most popular technologies spread in homes, universities, and cafes. To obtain the best services from the Internet, access points must be placed in the optimal place within the building.

With the spread of the term "Internet of Things" in the world during the past few years, which refers to an advanced concept of the Internet, so that all things in our lives have the ability to connect to the Internet or to each other to send and receive data to perform specific functions through the network [3, 4]. Network designers and global companies specializing in information technology solutions are working to develop applications to support the spread of these technologies, amid expectations that the number of connected devices will reach about 60 billion devices in the world by 2022, which raises the question of what the Internet of Things and artificial intelligence will do to human life in the future.

In 1895, Charles Darwin presented his famous theory of evolution, which states that, in the presence of limited resources, individuals compete with each other for survival. Individuals with the best traits have a greater chance of surviving, reproducing, and passing on their traits to the next generation. Over time, these good traits become more common in subsequent generations. This process is called “survival of the fittest.” Darwin’s theory also suggests that random changes can occur that lead to a combination of new traits. An organism’s chance of survival increases if the new changes are beneficial to it. This is called natural selection.

Evolutionary algorithms are a branch of artificial intelligence that simulates the natural distribution of some living organisms. These algorithms work on biological techniques such as reproduction, reassortment, and selection mechanisms, and use concepts of biological evolution such as natural selection and survival of the fittest to solve different problems to obtain the best results (or close to the best).

There are many evolutionary algorithms, including: Ant Colony Algorithm (ACO) [5] and Bird Swarm Algorithm (Bird Swarm Algorithm)(PSO) [6, 7], Genetic algorithm. These algorithms have proven their ability to provide the optimal solution in many fields, especially in systems that contain a large search space [5]. The difference lies in the information and its use to guide the search. In traditional algorithms, the search is sequential and is represented by moving from one point to the next, while in evolutionary algorithms, the search process is carried out in parallel, through which different areas in the search space are explored. One of the most important features of evolutionary algorithms is the ability to add prior knowledge in the problem area and the ability to use traditional search algorithms alongside them. In this research, the method of four-element examples was chosen because of its advantages over other evolutionary methods [7]. It provided a solution inspired by its working mechanism that is compatible with the research problem. This project aims to study the shortcomings of wireless access devices placement inside buildings, and then propose an Optimization method based on swarm intelligence to reduce the problem of signal inadequacy inside buildings [8].

The practical side

The practical part will be presented, which includes the data acquisition system, in which the Node-RED programming tool was used, in addition to the study case and discussion of the results.

Data acquisition system

As an introduction to what Node-RED is, it can be said that it is a powerful programming tool specialized in building Internet of Things applications and services. Node-RED was created as an open source project by the IBM group, which initially created Node-RED as a tool for the group while they were working on IOT projects.

The initial version of Node-RED was released as an open source project in late 2013 and the community of users and developers grew during 2014. It has seen significant adoption by experimental makers and a number of large and small companies who have used it to meet their needs. Node-RED is based on the Node.js platform and consists of a web browser-based flow editor for creating programs, which can be easily imported and exported in JSON format for sharing with others. Although Node-RED was specifically designed for the IoT environment, its applications have expanded and evolved and it has become used in many fields. Figure 1 shows a block diagram of how the signal is captured [9].

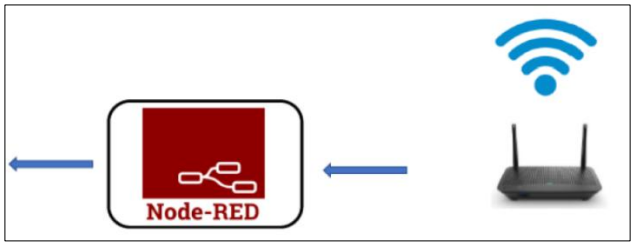

Fig 1: A block diagram showing how the signal is captured

Node-RED uses a visual programming approach that allows developers to link predefined JavaScript code blocks, known as nodes, together to perform a specific task. Building a program in Node-RED requires linking together a set of nodes, typically a combination of input nodes, processing nodes, and output nodes. These nodes are connected together to form flows. Data is generated in the node itself or receives data from a previous node in the flow. Each node processes the data according to its behavior and then passes it to the next node in the flow or transmits the data in some other way if it has no output. Figure 1 shows the basic screen of the Node-RED programming tool [11].

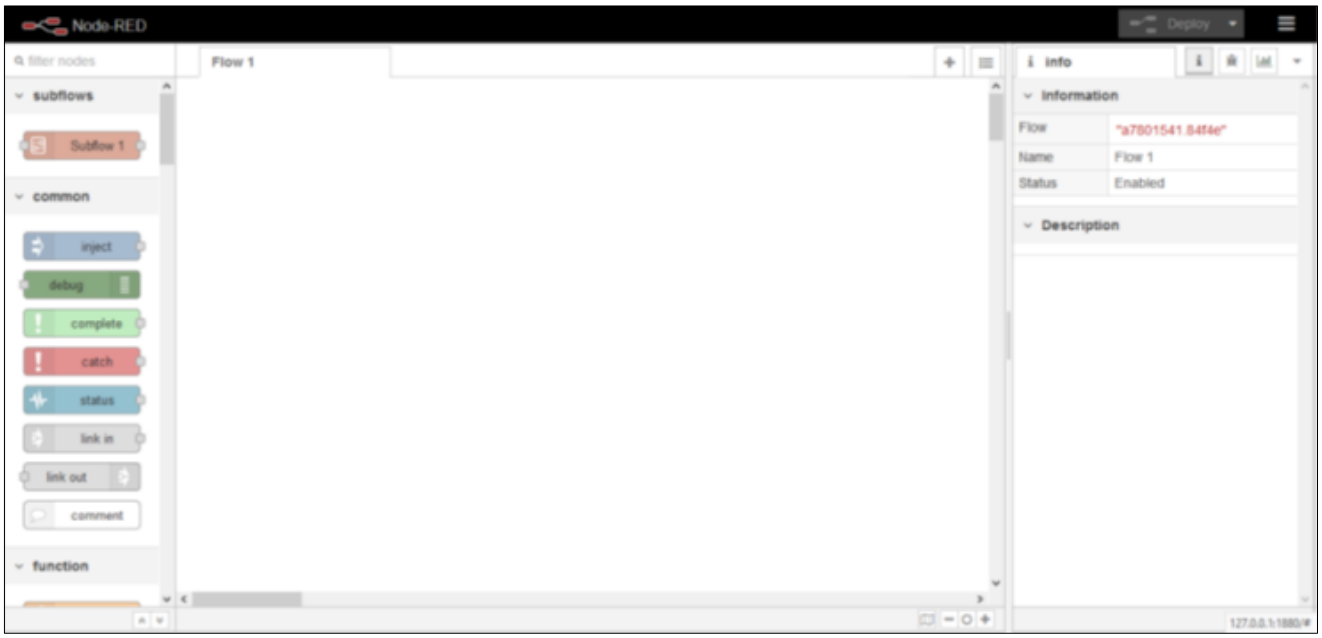

Fig 2: The main screen of the tool Node-RED

In this research, this tool was used to acquire or collect data, and Figure (3) shows the interface that was designed through this tool, where the Dashboard node was used, which consists of several sub-nodes, including a node called Table, which shows the table listed in the interface, which shows the network name SSID and the physical address MAC, as well as the signal level Single Level and Channel [14]. Another node was used called the control button, through which several buttons are controlled, which are the search, delete, stop, and store buttons, each of which has a function corresponding to the name of the button. For example, when the search button is clicked, it performs a search or scan for nearby Wi-Fi signals, which then appear in the table. Also, the Chart node was used, from which a graph was obtained describing the signal strength at different times. As for the instantaneous value of the signal strength, it was obtained using the Gauge node [15].

ssid	mac	signal_level	channel
Galaxy A21s4F64	b6:1a:1d:a1:4f:64	-50	11
LNET-HOTSPOT	e4:8d:8c:83:ae:ef	-50	11
Mi 9T	e2:f6:8f:42:d0:c3	-98	10
Tariq elgaddari	3c:57:6c:1f:2a:43	-68	11
hacker	a4:9b:4f:cb:a2:6b	-60	1
Sohib??s iPhone	86:73:8f:6c:09:fc	-74	6
LTT4G-QEN3	5c:03:39:b9:15:1b	-50	9
LNETHOTSPOT	54:78:1a:70:43:f0	-71	3
LAPTOP-8BHHPA...	26:41:8c:94:72:ee	-50	3

Fig 3: Data acquisition interface using the tool Node-RED

One of the most important principles that must be understood to understand the mechanism of radio wave propagation inside buildings is the basic influences on signal transmission, which include: absorption, reflection, refraction and interference. Where radio waves are diminished or weakened when they pass through a material, which leads to the transfer of energy to the material through which they are transmitted. The Node-RED tool was used to measure the signal strength by taking different positions for the location of the AP relative to the location of the device. First, the AP was placed directly next to the device without any separators as shown in Figure 4 and the reading representing the signal strength was recorded on the data acquisition interface using Node-RED. Then, a separator in the form of a wooden wall was placed between the device and the AP as shown in Figure 5 and the reading obtained from the interface was recorded. By comparing the results obtained from the two cases for the location of the AP relative to the device, the rate of loss or decline in signal strength was obtained [16], which was found to differ depending on the separator between the device and the AP. Thus, the signal strength measurement was carried out by taking several other separators and comparing them with the case in which the AP is next to the device without any separators.

Fig 4: AP location next to the device

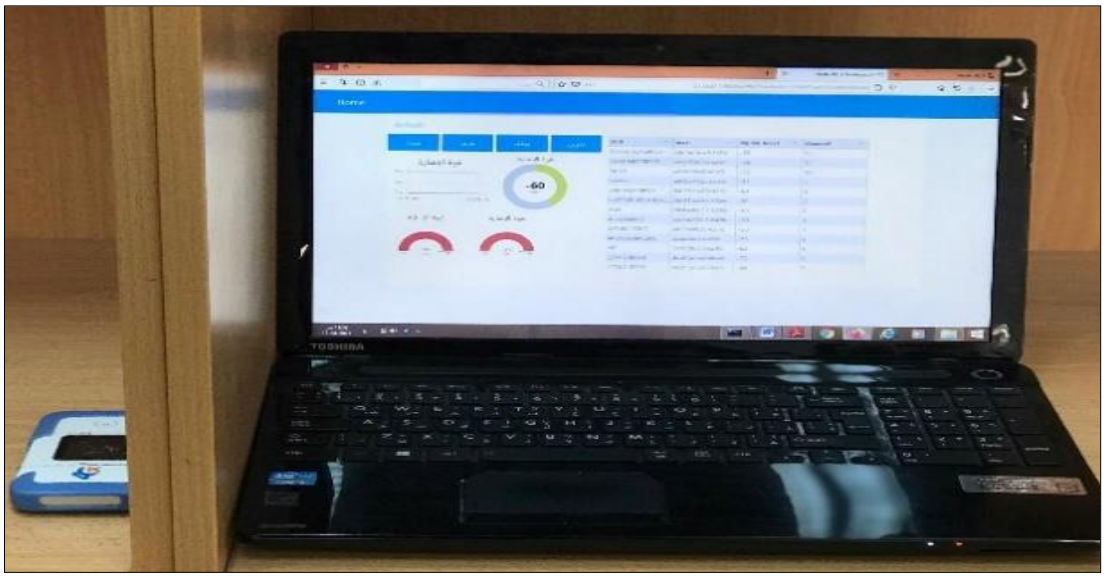

Fig 5: Wooden partition between AP and device

Case study

Before the age of wireless networks, setting up a computer network in a business or home required running cables through many walls and ceilings, in order to provide network access to all network-enabled devices in the building.

With the creation of wireless networks or what is known as "Access Point", network users have become able to add devices and access the network while reducing the number of extended wires. However, despite all this savings that accompanied the use of the AP access point, whether on the material level by reducing the number of wires and cables used in the extension, or in terms of saving the user's effort and time [17], there are some issues that cannot be attributed to being among the advantages of these networks, most notably the issue of the limited Wi-Fi signal that it broadcasts, so that the location of the AP device is considered a fundamental pillar of the strength and weakness of the signal for the user. In detail, this issue was conducted on a house with a single AP access point randomly placed somewhere around the house, which is considered a problem because the network signal does not cover the entire house. First, the map of the house and the number of individuals in it were identified. The house consisted of three bedrooms, a living room, a guest lounge, in addition to a kitchen with a storage room next to it. The head of the family was a civil engineer working for a contracting company. The construction, the mother is an Arabic language teacher, the eldest son is a medical student, the next son is an engineering student, [18] as well as two sons in the primary stage of study. Also, the question was addressed for each individual about the average number of hours he uses the Internet. The main objective of conducting this study is to find a way to place the AP in the optimal place using the Birds Nest algorithm, taking into account the distance and the number of hours of use for each individual, noting that this method is nothing but a measurement of the algorithm's work and an explanation of it. Determining the exact location to place the AP in the optimal place is a geometric optimization problem that can be formulated as follows [19]:

- Maximizing the Internet speed according to the highest usage, which is equivalent to minimizing the total weighted distance by the average usage hours. This concept can be accepted by recognizing the existence of a direct relationship between distance and speed (the greater the distance, the slower the speed). In order to give priority to individuals with the highest usage, this protocol must be included in the objective function. Since this case study is defined by two criteria [20]:
- Average hours of use per month (in hours).
- Coordinates (- x, y) in meters.

The average values of internet usage hours per month were calculated for each room according to the individuals present in it, as well as the coordinates (x, y) for each room. Hence, the fitness function for the problem can be written as follows:

Minimize F(x, y) $=180\sqrt{(x-0.5)2+(y-1)2+120\sqrt{(x-1)2+(y-2)2+90\sqrt{x2+(y-0.5)2+30\sqrt{(x-2)2+(y-1)2+15\sqrt{(x-2.5)2+(y-1)2+60\sqrt{(x-1)2+y2}}}}}}+0\sqrt{(x-3)2+(y-4)2}$

Constraints: Yes, there is a large area in the house, but if the middle of the house is chosen to place the AP device, it only allows you to set the device within the coordinates of the middle of the house, meaning that we are limited to a specific area through [21].

In this study, the objective function was the sum of the distances between the AP and the consumers according to the average consumption of each individual. The Birds Flock algorithm method was used to solve this engineering problem using a computer with the following specifications: processor speed (2.5 GHz), memory size (4 GB), MATLAB program (R2018a) installed on Windows 10.

Results and Discussion

The first and most important step that any telecommunications/internet service provider must take before starting to install any equipment is to determine the goals it wants to achieve and the challenges it faces.

Choosing the optimal location in wireless networks (just like in any other communication system) affects the quality of the service provided, especially with the recent increase in demand for the Internet of Things. To ensure the quality of service, all aspects of the communication network must be known, not just those related to the equipment and specifications of the network. Just as in all communication systems, it is possible to build a wireless network easily, but building a wireless network with good performance requires a lot of time and experience. In this research, one of the artificial intelligence algorithms was used, which is inspired by the behavior of some groups in nature, such as fish and birds that swim or fly in search of food through cooperation between group members [22].

It is worth noting here that this case study is to illustrate the concept of examples in a simplified way, as the real environment in Wi-Fi networks requires many other considerations that accurately simulate the mechanism of signal propagation and its various models, some of which were explained in the third chapter of this project, and since studying these propagation models requires separate studies outside the scope of this project. To illustrate this concept, the following two experiments were conducted: Case 1: An experiment was conducted outside the home so that there were no barriers, where the computer was placed next to the access point and then moved away from it by a distance of half a meter, for example, each time, and the signal strength was recorded. Figure 6 shows the signal strength in the absence of barriers [23].

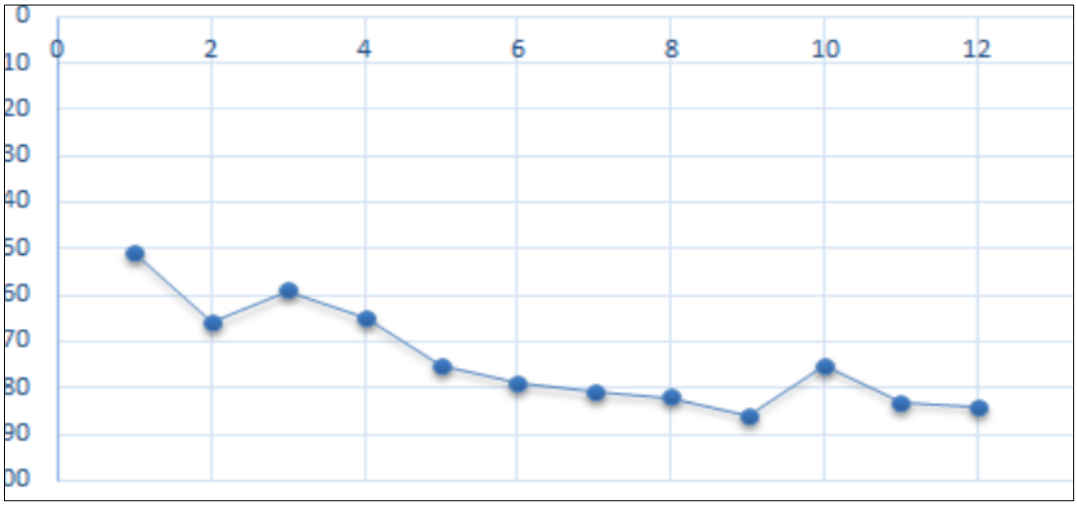

Fig (6): Signal strength in the absence of obstacles

Second case: The same previous experiment was conducted, but this time inside the house, where there are many obstacles that could cause signal reflections. Figure No. (6) shows the signal strength in the presence of obstacles.

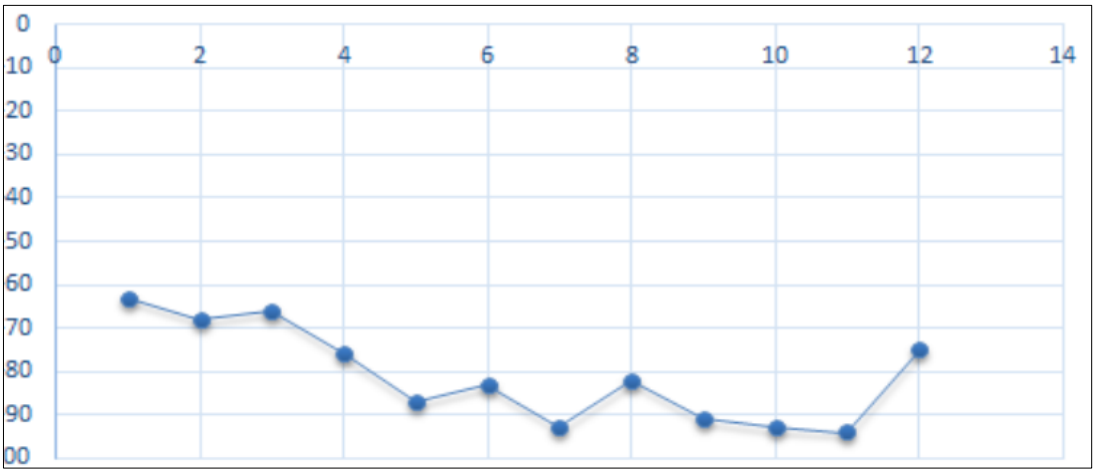

Fig (7): Signal strength in the presence of barriers

The four-element-separate-element-sampling algorithm (PSO) is one of the best algorithms in the field of examples because it can be used to work with other objective functions in the field of communications to reach the required results of the examples. To solve the aforementioned problem, there are many objective functions in previous research, some of which depend on theoretical models [24-26] or experimental models [27], and some of which depend on neural networks [28]. There are many objective functions that take into account barriers or obstacles affecting the spread of the signal, as mentioned in references [29].

Conclusions

The wireless network is one of the means of connecting to the Internet that provides the opportunity to exchange data without the need to use wires and connections. The research problem was to propose a method to find the optimal location for the access point in Wi-Fi networks inside buildings using a technology inspired by nature. From the above, the following conclusions can be summarized: Through the results, it became clear that the method of optimizing four elements (-PSO) is one of the important methods used to find the optimal location for placing the access point for wireless local networks, as this method is characterized by ease of use, speed of implementation, and accuracy in the results. The proposed model using the PSO algorithm has explained the concept of examples in a simplified way, as the real-world deployment environment of Wi-Fi networks, as mentioned in previous chapters, is governed by many considerations that can be included within other objective functions to work with the PSO algorithm to obtain optimal results in different communication fields.

Recommendations

From the results reached, the research recommends the following:

Using the optimization of four elements in finding the optimal solution to the problems of placing access devices inside buildings, due to the importance and accuracy of this method in analyzing the results and reducing the period of reaching the optimal state.

References

1. Li X, *et al*. A review of industrial wireless networks in the context of industry 4.0. Wireless Netw. 2017;23:23–41.
2. Cisco. Cisco Visual Networking Index: Forecast and Trends, 2017–2022.
3. Rouse M. Internet of Things (IoT), 2018.
4. Gubbi J, *et al*. Internet of Things (IoT): A vision, architectural elements, and future directions. Future Gener Comput Syst. 2013;29:1645–60.
5. Whitley D. A genetic algorithm tutorial. Stat Comput. 1994;4(2):65–85.
6. Eberhart R, Kennedy J. Particle swarm optimization. In: Proc IEEE Int Conf Neural Netw, 1995.
7. Zedadra O, *et al*. Swarm intelligence and IoT-based smart cities: A review. In: The Internet of Things for Smart Urban Ecosystems. Springer, 2019, p177–200.
8. Yang X-S. Nature-inspired metaheuristic algorithms. Leicestershire: Luniver Press, 2010.
9. Abdulshahed AM, *et al*. The application of ANFIS prediction models for thermal error compensation on CNC machine tools. Appl Soft Comput. 2015;27:158–68.
10. Abdulshahed A, *et al*. A particle swarm optimisation-based Grey prediction model for thermal error compensation on CNC machine tools. In: Laser Metrology and Machine Performance XI, LAMDAMAP 2015; Huddersfield, 2015, p369–78.
11. Kaur M, *et al*. Binary cuckoo search metaheuristic-based supercomputing framework for human behavior analysis in smart home. J Supercomput, 2019, 1–24.
12. Yang N, Xiong M, *et al*. A three dimensional indoor positioning algorithm based on the optimization model. In: 2017 13th Int Conf Natural Computation, Fuzzy Systems and Knowledge Discovery (ICNC-FSKD). IEEE, 2017.
13. Kouhbor S, Ugon J, *et al*. Optimal placement of access point in WLAN based on a new algorithm. In: Int Conf Mobile Business (ICMB'05). IEEE, 2005.
14. Vilović I, Burum N. Location optimization of WLAN access points based on a neural network model and evolutionary algorithms. Automatika. 2014;55(3):317–29.
15. Yigit T, Ersoy M. Testing and design of indoor WLAN using artificial intelligence techniques. Elektron Elektrotech. 2014;20(6):154–7.
16. Sadowski S, Spachos P. RSSI-based indoor localization with the Internet of Things. IEEE Access. 2018;6:30149–61.
17. Pahlavan K, Krishnamurthy P. Principles of wireless networks. Upper Saddle River (NJ): Prentice Hall PTR, 2001.
18. Iskander MF, Yun Z. Propagation prediction models for wireless communication systems. IEEE Trans Microw Theory Tech. 2002;50(3):662–73.
19. Friis HT. Introduction to radio and radio antennas. IEEE Spectr. 1971;8(4):55–61.
20. Rappaport TS. Wireless communications: principles and practice. Upper Saddle River (NJ): Prentice Hall PTR, 1996.
21. Crane RK. Propagation handbook for wireless communication system design. Boca Raton (FL): CRC Press, 2003.
22. Ren Z, Wang G, *et al*. Modelling and simulation of Rayleigh fading, path loss, and shadowing fading for wireless mobile networks. Simul Model Pract Theory. 2011;19(2):626–37.
23. Crow BP, Widjaja I, *et al*. IEEE 802.11 wireless local area networks. IEEE Commun Mag. 1997;35(9):116–26.
24. Hiertz GR, Denteneer D, *et al*. The IEEE 802.11 universe. IEEE Commun Mag. 2010;48(1):62–70.
25. López-Pérez D, Garcia-Rodriguez A, *et al*. IEEE 802.11be extremely high throughput: The next generation of Wi-Fi technology beyond 802.11ax. IEEE Commun Mag. 2019;57(9):113–9.
26. Nagy L, Farkas L. Indoor base station location optimization using genetic algorithms. In: 11th IEEE Int Symp Personal Indoor and Mobile Radio Communications (PIMRC), 2000, p843–6.
27. Arya L, Sharma S. Coverage and analysis of obstructed indoor WLAN using simulation software and optimization technique. In: Conf Adv Commun Control Syst 2013. Atlantis Press, 2013.
28. Mukti FS. Access Point Placement Model for Indoor Environment using Hybrid Empirical Propagation and Simulated Annealing Algorithm. Int J Comput Digit Syst, 2021, 10.
29. Kuhl CK, Mielcareck P, *et al*. Dynamic breast MR imaging: are signal intensity time course data useful for differential diagnosis of enhancing lesions? Radiology. 1999;211(1):101–10.