El Cezeri
Journal of Science and Engineering
ISSN: 2148-3736

Research Article

Optimizing Access Point Allocation Based on Genetic Algorithm with Channel Conflict Detection

Ramazan Kocağolu[1a], M. Hanefi Calp[1b], M. Ali Akcayol[1c]
[1]Computer Engineering, Faculty of Engineering, Ostim Technical University, Ankara, Türkiye
[2]Management Information Systems, Ankara Hacı Bayram Veli University, Ankara, Türkiye
[3]Computer Engineering, Faculty of Engineering, Gazi University, Ankara, Türkiye

ramazan.kocaoglu@ostimteknik.edu.tr

DOI : 10.31202/ecjse.1529228
Received: 07.08.2024 Accepted: 28.03.2025
How to cite this article:
Ramazan Kocağolu, M. Hanefi Calp, M. Ali Akcayol, " Optimizing Access Point Allocation Based on Genetic Algorithm with Channel Conflict Detection ", El-Cezeri Journal of Science and Engineering, Vol: 12, Iss: 2, (2025), pp.(153-166).
ORCID: [a]0000-0002-6554-3335; [b] 0000-0001-7991-438X. [c] 0000-0002-6615-1237.

Abstract : In recent years, high-bandwidth and cost-effective wireless network technologies have emerged as a competition factor in the process of forming its own infrastructure. On the other hand, today's challenges of designing an effective layout have become an important problem for public institutions and private companies with increasing requests. There are some methods to solve this problem. In this study, a new approach based on a genetic algorithm is proposed to solve the mentioned problem. A simulation is developed to test the success of the algorithm. The most effective layout design of the access points is constituted by the distance between the access points and the communication channels used in the developed simulation. The experimental results obtained showed that the proposed algorithm successfully achieved the challenge of designing an access point layout in terms of total coverage area and average bandwidth per user. We have obtained experimental results that the maximum coverage area is 1181.1 m, 1183.6 m and 1148 m, and bandwidth usage is 11, 54 and 248 mbps for 802.11b, 802.11g and 802.11n standards, respectively.

Keywords : Access Point Allocation, Genetic Algorithms, Optimization, Channel Conflict

1 Introduction

Wireless network technologies such as IEEE 802.16 (WiMAX) and IEEE 802.11 (Wifi) are used commonly in almost every field of life such as home, office, airport, and other open public spaces. These technologies are more popular than cabled technologies in open public spaces [1]–[7]. Effective usage of wireless networks depends on the quality of a given network service. One of the most important factors that affect the service quality is a layout of access points to an area in which network service will be given. While mentioned layouts are relatively easy in case of less access points, the most effective layouts are considerable difficult where there is a need of many access points like corporations and institutions. For this reason, today's complex and difficult conditions cause new solution methods that give fast and easy solutions for the problems.

In literature, genetic algorithms have been used in many studies to solve problems in wired and wireless network technologies. Lee et al. studied access point allocation optimization for smart home systems by using a genetic algorithm [1], [8]. They have revealed the impact of access point allocation on overall wireless system performance regardless of channel conflict challenge. However, the issue is quite a component which impacts on the quality of wireless services. Yoshino and Ohtomo [9] conducted a study about effective channel assignment methods for mobile communication systems by using genetic algorithms whereas we focus on wireless network systems and their issues. Therefore, their study cannot directly adapt to wireless infrastructure because of different technologies.

Funabiki et al. [10] studied the subject that allocates an optimal access point for a wireless infrastructure mesh network. Turgut et al. [11] studied clustering algorithm optimization on mobile Ad Hoc networks by using a genetic algorithm approach. Singh and Bhukya suggested a solution based on a hybrid genetic algorithm that can be a candidate to solve the problem of the minimum energy usage on wireless ad-hoc networks. The suggested hybrid approach was compared with the known intuitional approaches to solve this problem [12]. These studies attempt to solve issues about the allocation of access points for mesh networks, mobile ad-hoc networks, and energy efficiency problems for ad-hoc networks, respectively. Our study differs from them in terms of using wireless technology. Agustin-Blas et al. suggested a hybrid genetic algorithm application to solve the problem regarding the determination of access points places needed to be distributed for constituting wireless networks. The

Table 1: The Comparison of the related studies

Related Studies	Network Type	Optimization Problem	Optimization Algorithm
T. Scully and K.N. Brown [2]	Wireless	Load Balancing	GA
W. Yan et al. [3]	Wireless	Bandwidth	GA
J. H. Lee et al. [8]	Wireless	Location	GA
J. Yoshino and I. Ohtomo [9]	GSM	Channel Assignment	Hybrid
Funabiki et al. [10]	Mesh	Location	GA
Turgut et al. [11]	Ad Hoc	Clustering	Hybrid
Singh and Bhukya [12]	Ad Hoc	Energy Consumption	Hybrid
Agustin-Blas et al. [13]	Wireless	Load Balancing	Hybrid
El-Alfy [14]	MPLS	Minimum Cost	GA
Calvo et al. [15]	Ethernet	Dividing	GA
Zhang and Zhang [16]	Ethernet	Dividing	GA
Sanz et al. [17]	Ethernet	Switch Layout	Hybrid
Singh et al. [18]	WSN	Sink Location	GA
Quyang et al. [19]	Wireless	AP Location	Hybrid
Hanh et al. [20]	WSN	Coverage	Hybrid
V. Bertolini et al. [22]	Wireless Charging	Energy Consumption	Hybrid
Y. E. M. Hamouda [23]	WSN	Sink Location	Hybrid
L. V. Quan [24]	WSN	Sink Location	GA
D. J. Bahadur et al. [26]	WSN	Energy Consumption	Hybrid
X. Gong et al. [27]	WSN	Energy Consumption	GA

proposed algorithm aimed to determine a cost-effective network topology for this problem. Performance and effectiveness of the algorithm were tested by constituting a topology determined by two different 1000 and 2000 users randomly [13]. They focus on the load balancing problem while we consider the channel conflict issue.

El-Alfy suggested a design method based on a genetic algorithm to find the topological structure of networks based on MPLS which supplies the minimum cost. With this technology, designing an ISP backbone with the most effective and minimum cost emerged as a problem. An approach based on a genetic algorithm was suggested to solve this problem [14]. Calvo et al. suggested a new genetic algorithm to solve the problem of dividing traditional ethernet networks into parts. The performance of the suggested genetic algorithm was tested in various simulations. When it is compared with previous genetic algorithm approaches, it can be said that the suggested approach can produce faster and more productive solutions [15]. Zhang and Zhang analyzed the problem of dividing the network into parts in industrial key ethernet technology. The genetic algorithm was suggested to solve the problem of dividing networks into parts [16]. Sanz et al. suggested a model based on hybrid genetic algorithm that supplies switches to place into the optimum points in a network to achieve the most efficient performance. They tested the approach that suggested a switch layout problem on network architecture in Madrid, Spain. Obtained experimental results showed that the hybrid genetic algorithm method obtained the best performance in solving the switch layout problem [17]. These studies are related to some challenges of wired technology such as MPLS, switches, and ISP infrastructure whereas our study attempts to cope with challenges such as efficiency access point allocation and channel conflict for traditional wireless networks.

Singh et al. suggested a Genetic Algorithm (GA) based sink mobility technique for WSN. The GA process determines the optimal sink locations on the trajectory for each cluster. In addition, a network energy consumption model is proposed that implements the fitness evaluation operator of the GA process. Obtained experimental results showed that GA based sink mobility provides increase in network lifetime than other protocols [18]. Ouyang et al. suggested a model adaptive genetic algorithm (IAGA) to handle the localization problem of wireless networks and a modified evaluation function to reduce the error of distance measurement in a topological structure [19]. Hanh et al. proposed a novel and efficient metaheuristic in the form of a genetic algorithm. The proposed genetic algorithm includes a heuristic population initialization procedure and the proposed exact integral area calculation for the fitness function. Obtained experimental results showed that the algorithm delivers the best performance in terms of solution quality and stability on a majority of the tested instances [20].

In this study, a genetic algorithm, which makes access point layout optimization regarding problem of crossing channels between access points, is proposed. The rest of the paper is prepared as follows. In section 2, the problem is defined, and limits in the real world are mentioned that need to be taken into consideration in the solution of the problem. In section 3, the design of the developed algorithm is mentioned in detail. Tests and obtained experimental results are presented in section 4. Section 5 concludes the paper with some further discussions.

2 Problem Definition

Some challenges should be solved to use wireless networks in a more effective way after these networks have become widespread. While the institutional wireless network is taken into consideration, there are some problems that affect the overall performance of the network. The design, which is made by regarding these problems, is important because of achieving real-like results. Developed methods and algorithms need to solve these problems within the existing limits. The problems and limits considered by GA design in this article are as below:

- Each access point serving from 2.4 GHz frequency uses a wireless channel between 1 and 13 to give service. Channel

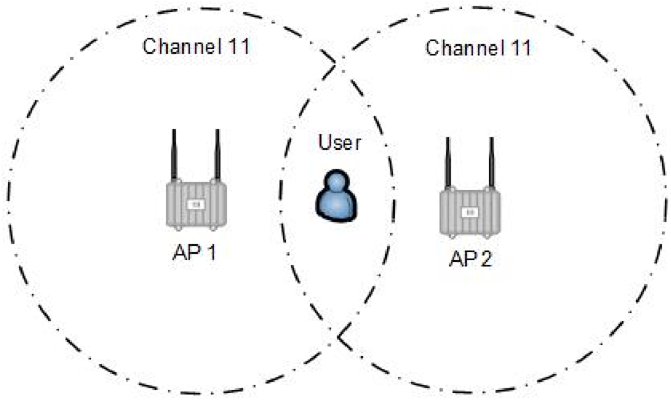

Figure 1: Channel conflict problem

conflict means that access points, which have the same SSID and the same channel, are neighbors that they enter into each other's coverage area. The users of wireless service expose to channel conflict have a serious lack of many services. A channel conflict, which can occur with two access points, as shown in Figure 1. The wireless user is at the junction point of coverage areas of two access points that use the same channel. In this situation, critical problems in the user's connection can be encountered. As a conclusion, the neighbor access points should not use the same channel. In other words, access points which use the same channel should not be near to each other. Suggested GA design determines the place of access points by regarding this problem. This means that it appoints different channels to neighbor access points.

- One of the most important elements that affect the efficiency and coverage area of wireless communication in a building is walls. The proposed algorithm places access points regarding this situation.
- Making optimization considering 802.11 b/g/n wireless network standards is an acceptable solution that is similar to the real world's problem. Accordingly, the designing of access point allocation is made based on network standards determined by the user while specifying the most suitable place for them.
- It makes layouts to the specific places such as corners and edges of the walls while locating the places of access points. It means that access point cannot be placed any desired area in order to approximate the real environment.
- The proposed algorithm determines optimal places of access points considering the 3D environment.

3 A Genetic Algorithm for Access Point Layout with Channel Conflict Detection

A genetic algorithm is an algorithm that can successfully solve critical problems like the deployment of devices on communication networks in urban planning. It is a technique that codes feasible solutions to solve an existing problem inspiring an evolutionary process. The most important point should be taken into consideration in GA design is that coding the problem and defining the fitness function that impact on directly solution of the problem. While the coding of the problem draws limits of search space GA works on, the fitness function determines the suitability of achieved solutions [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26], [27].

Nowadays, there are different wireless network standards to be used for wireless communication. Although there are some distinctions that separate these standards, the most remarkable difference is the distance of coverage area technology provides. In this paper, a genetic algorithm has been designed to place access points to the most efficient places inside buildings so that it can achieve overall coverage area at the top level, and prevent channel conflict by considering 802,11b, 802,11g, and 802,11n wireless network standards.

3.1 Problem Encoding

GA is a selection algorithm based on natural selection and the evolution mind. Generally, there are four fundamental steps in the GA optimization procedure. These are selection, crossing, mutation, and evaluation. GA optimization procedure practices repeated selection strategy applies crossing and mutation, and then evaluates the suitability of chromosomes. The structure of a chromosome in the proposed GA is seen in Figure 2. Each access point is represented as a chromosome and a set of chromosomes is represented as a population. In other words, population is expressed as a candidate solution that contains a set of access points. An access point consists of some units such as X, Y, and Z coordinates, channel, and cost calculated according to the position of other access points in the population. Each unit is called a gene in the chromosome as shown in Figure 2.

Figure 3 shows structure of population in the proposed algorithm and possible layout in the real world.

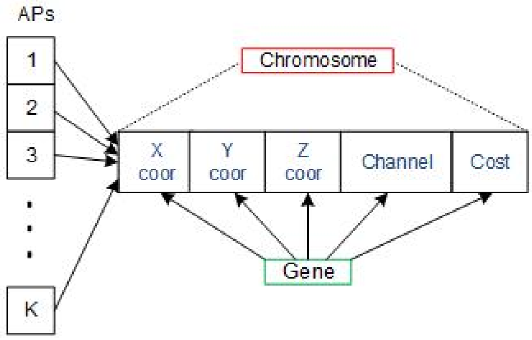

Figure 2: Structure of the AP encoding in GA

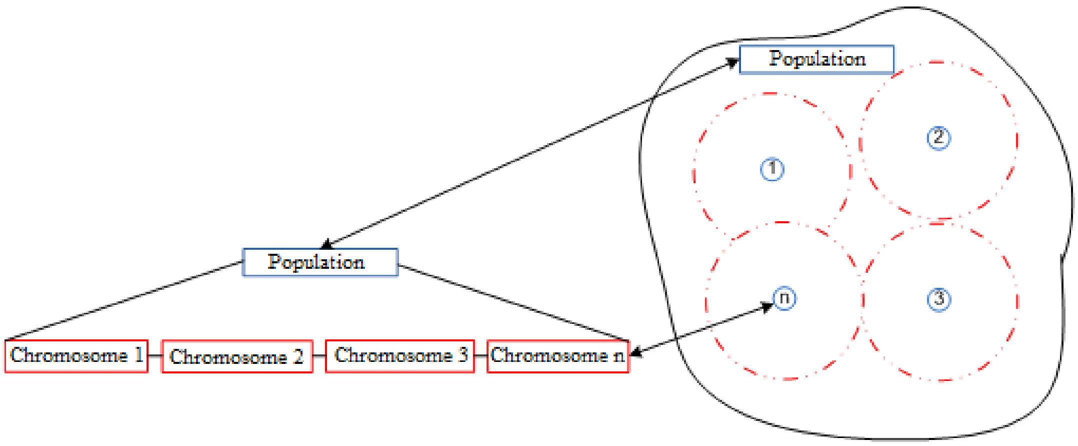

Figure 3: Population and its Allocation in a Reel Network Environment

Consequently, each population is a candidate solution that represents the allocation of access point in real environment as shown in Figure 3. The most important challenge is to discover the optimal allocation of access points by considering used channel of them. The population can include inefficient layout the distance between access points is either too close or too far.

3.2 Initialization of the Algorithm

Each chromosome in the population is randomly generated at the beginning of algorithm as following.

- Firstly, all coordinates where access points can be placed are discovered. Specific points where access points will be placed are randomly selected between these coordinates. These selected coordinates are transferred to genes that constitute the x, y, and z coordinates of chromosomes.
- Each access point serving from 2.4 GHz frequency selects randomly a wireless channel between 1 and 13 to serve network services for wireless users. Channel conflict is not taken into consideration at this state and is not make any operation to detect it. Besides, each access point serving from the 5 GHz frequency wireless standard selects randomly an available wireless channel.
- While generating the initial population, a 0 value is appointed to cost the gene of all chromosomes.

The process of generating the initial population continues to reach a determined iteration number. All state of the proposed optimization procedure is shown in Figure 4.

3.3 Selection Operator

In this section, a rank-based wheel selection mechanism, as described in [9] is used. Therefore, the individuals are sorted in a list based on their efficiency. The position of the individuals within the list is sorted by comparing cost which is a gene defined in our study. Efficiency of fitness function, the most important section of genetic algorithm, impacts directly on efficiency of the algorithm. The fitness function considers the distance between access points and channel conflict. It gives a point that implies the possibility of passing the next generation to individuals according to the distance between two access points and the used channel. The point is the saved cost gene in each chromosome. The total of these points is used to determine whether the individuals in the population pass to the next generation or not.

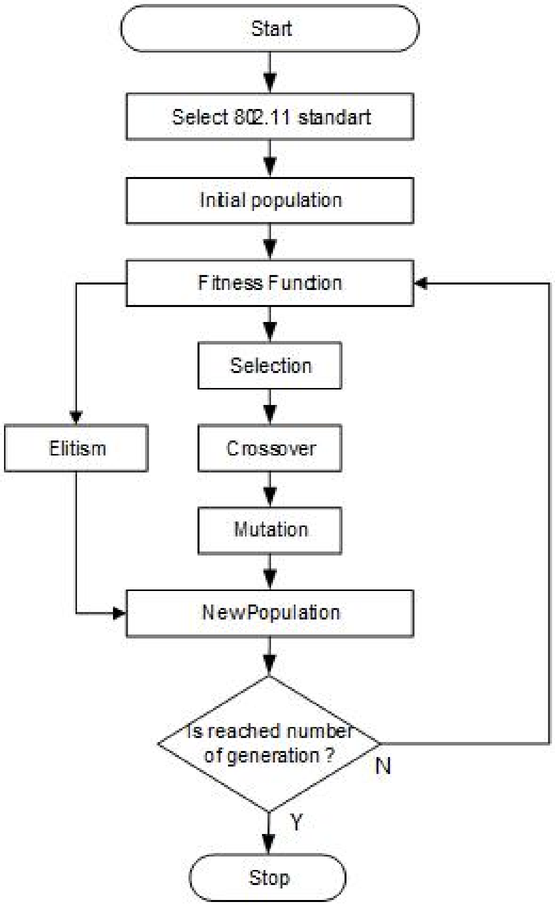

Figure 4: The General Flow Diagram of the Algorithm

We suggest that the coverage areas of neighbor access points should overlap at the rate of % 25 because a wireless user to pass between access points without interrupt of any services. Figure 5 shows the optimum layout of access points in space. Consequently, if the radius of the access point's coverage area is r, the distance between two access points (1) is calculated as below:

$$D_S = 2r - \frac{r}{4} = \frac{7r}{4} \quad (1)$$

$$W = Number\ of\ Wall \times \beta \quad (2)$$

$$D_W = D_S - W = \frac{7r}{4} - W \quad (3)$$

The optimum distance (3) between two access points can be found by subtracting the loss of (2) because of the existing walls in (1) distance. (2) is calculated by multiplying the number of walls the in-coverage area and the β constant. β represents the loss of signal noise because of the existing wall in the area. It is assumed 1,5 meters. (3) distance between each neighbor area is the optimal location where the access point can be placed. Let AP_1 and AP_2 be neighbor access points. We denote that AP_{1C} and AP_{2C} are channels used by AP_1 and AP_2, respectively. α is the fitness function of the proposed GA. Let χ be the distance between AP_1 and AP_2. The fitness value is calculated as below.

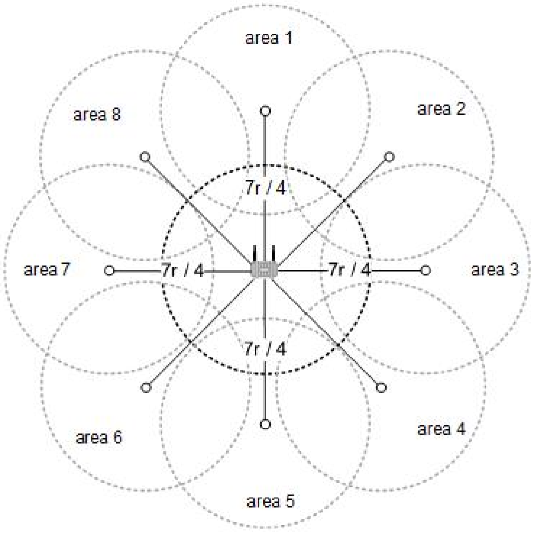

Figure 5: Optimal Allocation Between Neighbor Access Points

Algorithm 1 Fitness function

```
if AP_1C == AP_2C then
α ← −500
else
  if χ < 20 then
  α ← −100
  end if
  if 20 - (2) ≤ χ ≤ 30 - (2) then
  α ← 0
  else if 30 - (2) < χ ≤ 40 - (2) then
  α ← −20
  else if 40 - (2) < χ ≤ 50 - (2) then
  α ← −50
  else if 50 - (2) < χ ≤ 55 - (2) then
  α ← −70
  else if 55 - (2) < χ ≤ 59 - (2) then
  α ← −90
  else if 59 - (2) < χ ≤ 62 - (2) then
  α ← −100
  else if 62 - (2) < χ ≤ 66 - (2) then
  α ← −90
  else if 66 - (2) < χ ≤ 70 - (2) then
  α ← −70
  else if 70 - (2) < χ ≤ 80 - (2) then
  α ← −50
  else if 80 - (2) < χ ≤ 90 - (2) then
  α ← −20
  else if 90 - (2) < χ ≤ 100 - (2) then
  α ← −10
  else
  α ← −100
  end if
end if=0
```

The fitness value is equal to 0 at the start of the process. A chromosome with the maximum fitness value means that it is the optimal solution for the problem. Initially, this value will be decremented by 500 for each neighbor APs that uses the same channel in order to prevent channel conflict. Additionally, fitness value will be increase or decrease by distance between

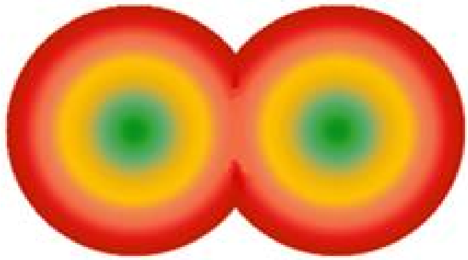

Figure 6: Position of Neighbor Access Points With Each Other

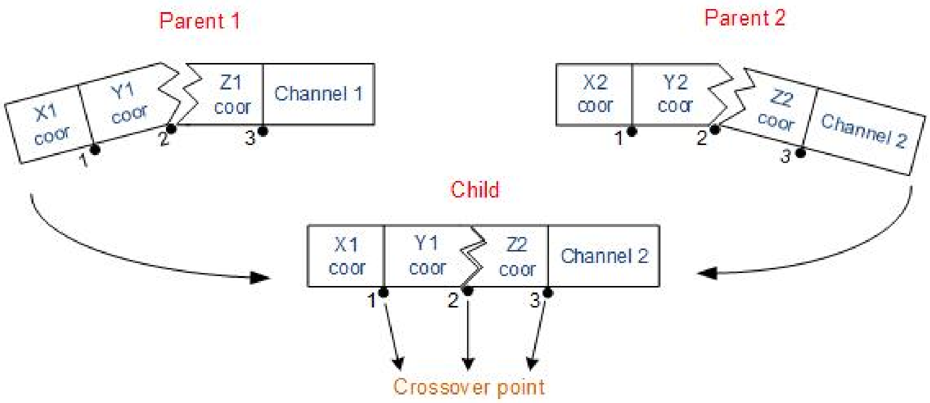

Figure 7: Example of Crossover Process in GA

neighbor access points. While the fitness value is 100 for the optimum distance between neighbor APs, it is decremented far or near this distance. The fitness function catches the best value by considering the distance according to 802.11 standards and then sends it to the next population. Figure 6 shows the position of two access points is how to influence each other. The optimum position of neighbor access points is the green field. Consequently, being far from or too near each other of access points are unsuited solution. In addition, access points can be placed only at the edge, or corners of walls. Other places apart from these points are not accepted as solutions.

After arraying of individuals in each population according to the cost gene in chromosome, % 30 of individuals which have the best location of access point pass directly to the next generation by elitism. As a result of tests, when the rate of elitism is % 30, the best result is achieved. Therefore, the rate of elitism is selected as % 30. Other individuals are transferred to the next generation after selecting randomly from the population and applying crossing and mutation.

3.4 Crossover and Mutation Operators

The crossover and mutation operators implemented in the proposed algorithm are based on those used in [9], [12]. The process for performing the crossover is the following: We consider a special crossover operator in which two parents produce one child. Two individuals are selected; one will be named father, and the other mother. Only one offspring individual will be generated from these two individuals. The parents are randomly chosen among the individuals in the population that have not been discarded. The two parents are coupled and a crossover point is randomly selected. Figure 7 shows the process of producing a new individual from the two parents. There are three crossover points in each individual. These points are used for the crossover operator. For example, point 2 is randomly selected by a proposed genetic algorithm in order to produce a new child. After this operation, population diversity is ensured by producing new individuals.

After the crossover operator, a mutation operator is applied so as to generate more diversity in the population. A swap-type operator is used. Two parents are coupled at random, and two genes of each parent are swapped to generate two mutated individuals. The mutation is used to avoid that the algorithm remains stuck in the local minimums of the fitness function. Figure 8 shows an example of the process of mutation for coordinate genes. If the channel gene is selected for mutation, the swap-type operator is not used. See Figure 9 as an example. A number is randomly produced between 1 and 13. This number is swapped to the existing channel number. Therefore, a new individual with a different channel number is produced after the mutation operator.

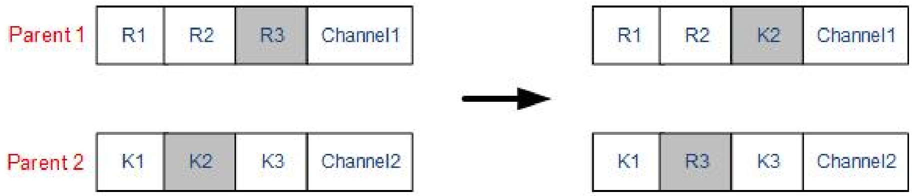

Figure 8: Example of Crossover Process for Coordination in GA

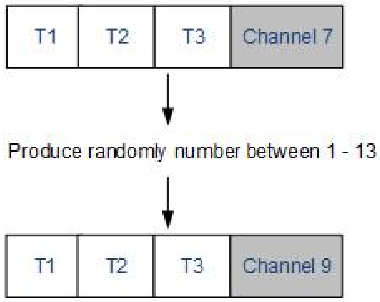

Figure 9: Example of Crossover Process for Channel in GA

4 Simulation

In this section, we have simulated the proposed GA optimization model in Visual Studio with the parameter lists in Table 2. The simulation has been performed on an Intel Core 2 Duo CPU 2.53 GHz with 4 GB RAM. The proposed GA attempts to discover optimal places of access points on the used building in the simulation taking into consideration the wireless standards and channel conflict.

4.1 Assumptions and Parameters

In Turkey, city hospitals have begun to be built in various cities of Turkey within the scope of public-private partnerships. Kayseri City Hospital is one of these hospitals and was opened in 2018. It has a bed capacity of 1583 and a closed area of 300,000 m^2. It consists of 4 blocks that are architecturally similar to each other, a central hospital connecting these blocks, and 1 physical therapy rehabilitation center. It will serve approximately 5,000 wireless network users daily. Determining where access points will be positioned in such large structures is a very difficult process. Access points must use appropriate channels so as not to cause channel conflict. In addition, the number of access points must be at an optimal level. Using too many access points increases both the cost and the possibility of channel conflict. The building architecture of Kayseri City Hospital is shown in Figure 10.

One of the buildings with the same architecture is a cardiovascular hospital. Therefore, the developed algorithm was applied

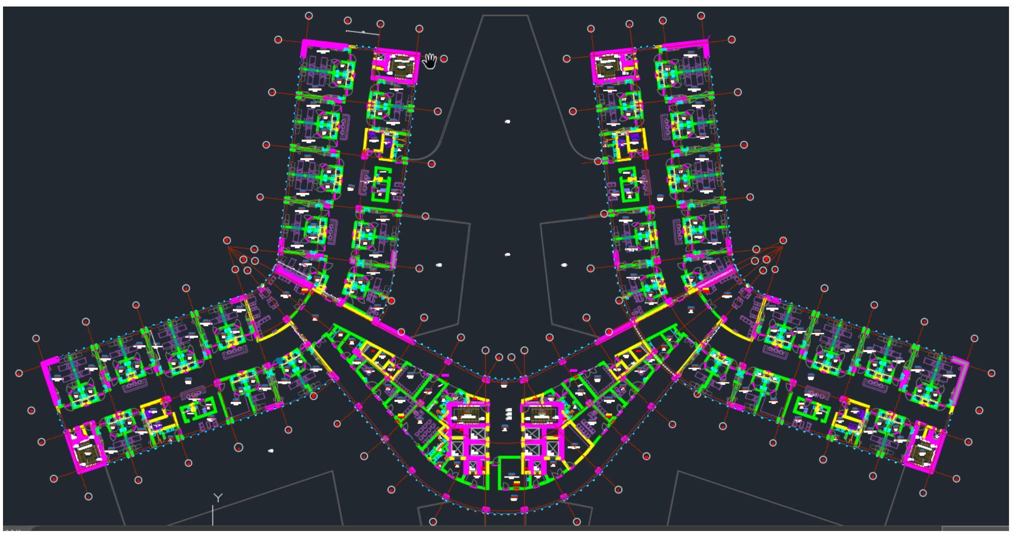

Figure 10: Kayseri City Hospital Building Plan

Table 2: Simulation Parameters

Parameters	Values
The signalling range of access point with 802.11.b	35(m)
The signalling range of access point with 802.11.g	35(m)
The signalling range of access point with 802.11.n	70(m)
The number of access points with 802.11b	55
The number of access points with 802.11g	55
The number of access points with 802.11n	33
The number of wireless users	800

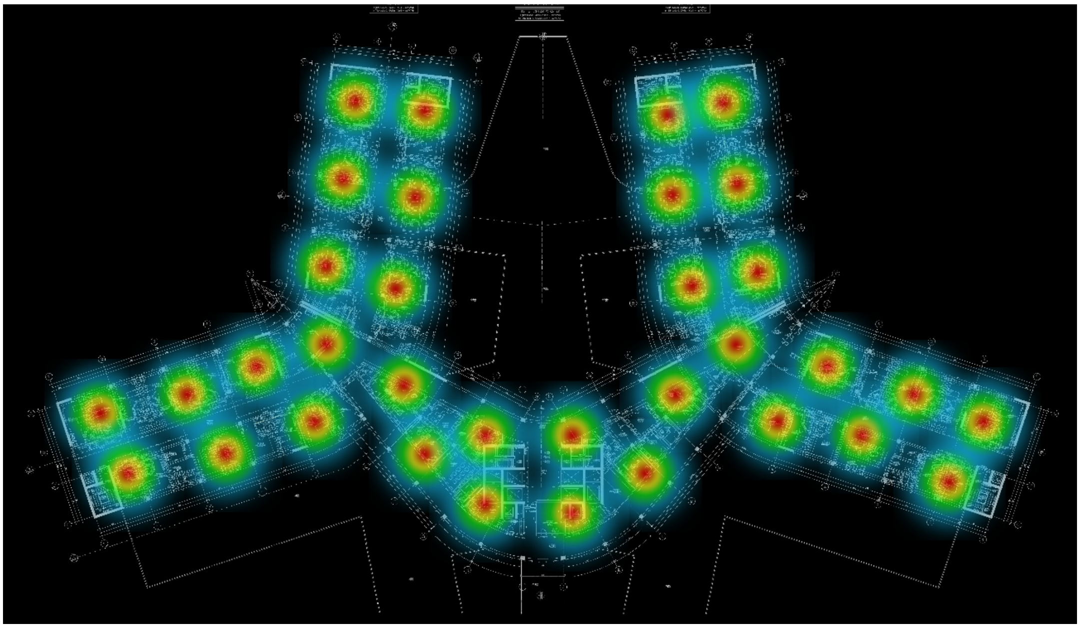

Figure 11: Kayseri City Hospital Used in the Simulation

in the cardiovascular hospital. In addition, it was tested in a physical therapy rehabilitation center.

4.2 Simulation Results

In this section, we present the impact of the proposed GA scheme on the maximum coverage area and average bandwidth per user.

4.2.1 Maximum Coverage Area

Firstly, we examine the maximum coverage area. 802.11 standards have different signaling range. For example, in the building, 802.11b, 802.11g, and 802.11n wireless standards cover the area about 35, 35, and 70 meter diameter area, respectively [15]. We employ 25, 25 and 50 access points for 802.11b, 802.11g and 802.11n standards, respectively. Therefore, we can simply calculate maximum coverage area for space environment as multiplying number of access point and signaling range of wireless standard. Thus, maximum coverage area is 1750 m for all wireless standards in the simulation. However, it is expected the maximum coverage area is considerably shorter than 1750 m in simulation because existing walls in the building causes signal noise. We have obtained experimental results that maximum coverage area is 1181.1 m, 1183.6 m and 1148 m and average coverage area of each access point is 23.62 m, 23.67 m and 45.92 m for 802.11b, 802.11g and 802.11n standards, respectively. X, Y, Z coordinates, channels, and coverage area of each access point are detail shown in Table 3. Figure 12, 13 and 14 depict that proposed GA allocates access points on building shown figure 11 according to 802.11b, 802.11g and 802.11n, respectively.

We calculate the fitness function as mentioned in section 3.3. When the optimal distance between access points is obtained, the fitness function achieves 100 award points. Obviously, the optimal layout for 50 access points should have 5000 points according to proposed algorithm. Similarly, it should have 2500 points for 25 access points. Figure 15 shows that the algorithm reached a maximum point after 5000 iterations according to 802.11b and 802.11g standards, and after 3000 iterations according to 802.11n standards. The population size is determined as p_s= 200, the rate of crossing was p_c=0,7, and the rate of mutation was p_m= 0,1, and the rate of elitism was p_e= %30 in the simulation. 802.11b and 802.11g standards have the same signaling range of access points. The curve of the two technologies in the graphic overlaps because the fitness function makes optimization by considering the distance between access points.

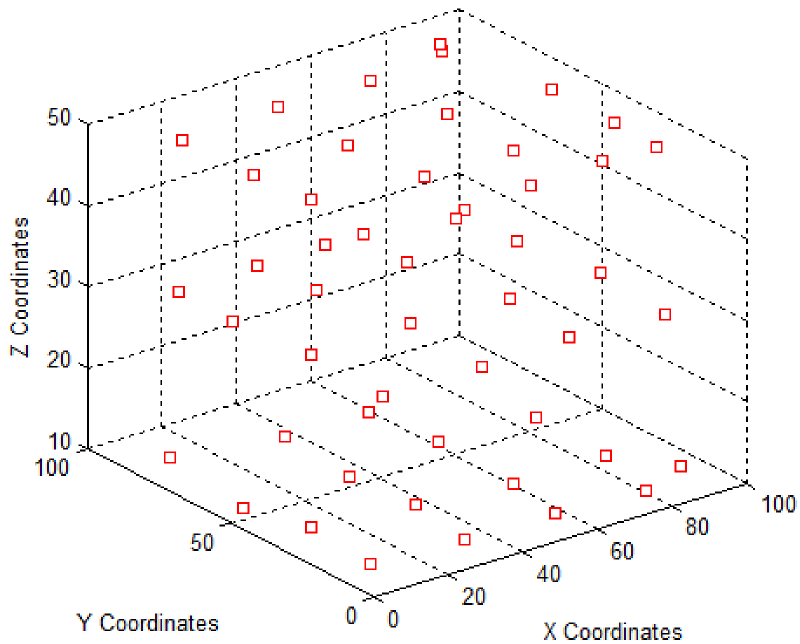

Figure 12: Access Point Allocation According to 802.11b Standard

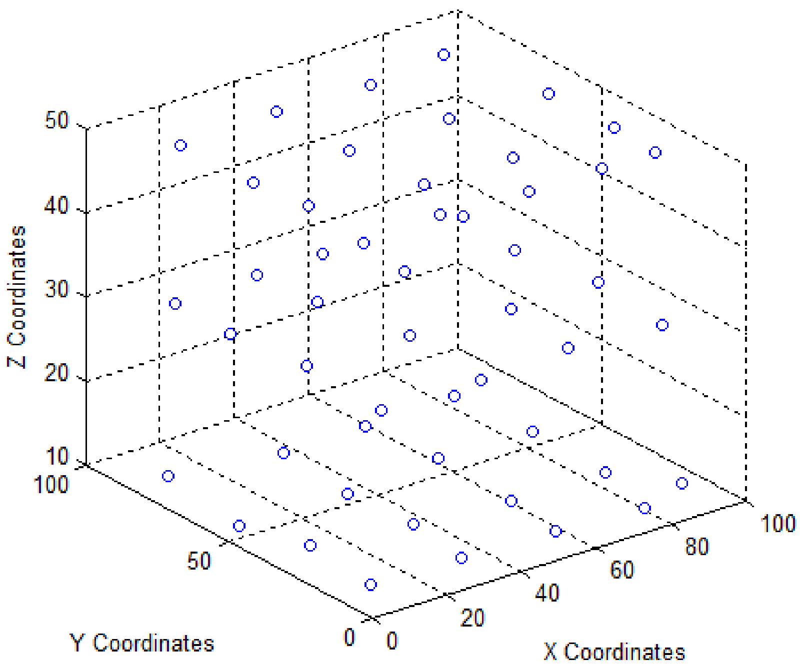

Figure 13: Access Point Allocation According to 802.11g Standard

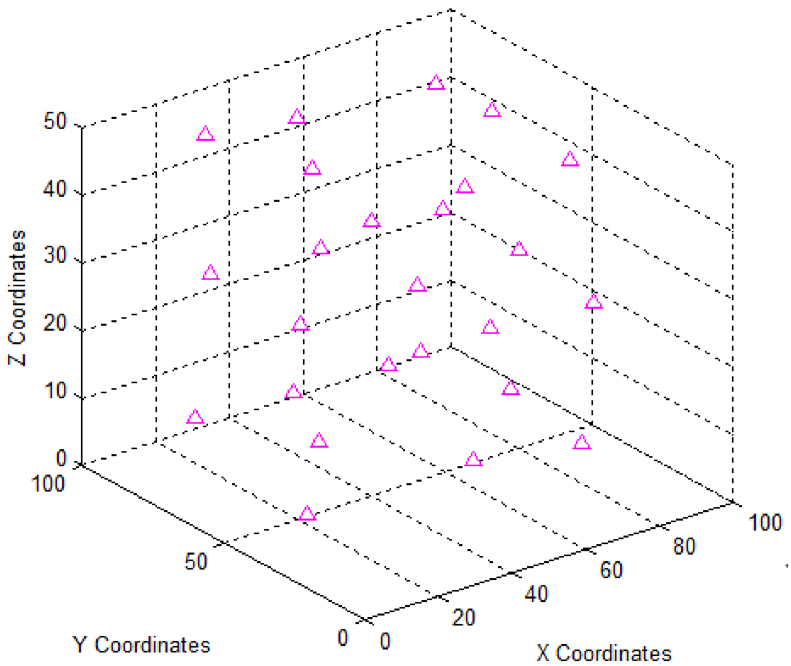

Figure 14: Access Point Allocation According to 802.11n Standard

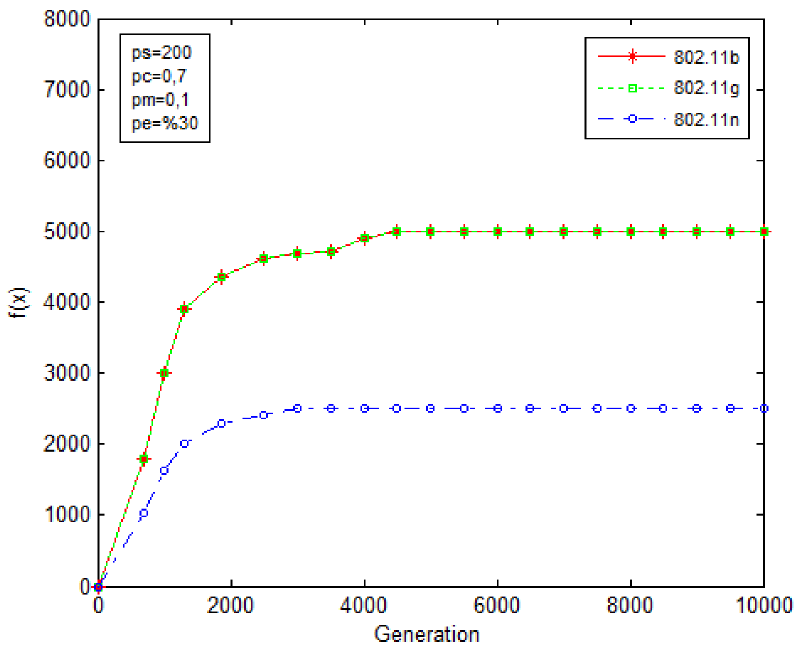

Figure 15: The Curve of Fitness Function According to Number of Generations

Table 3: Coordinate, Channels and Coverage Area of Access Points in the Building

AP	802.11b					802.11g					802.11n				
	X	Y	Z	Ch	Cvr	X	Y	Z	Ch	Cvr	X	Y	Z	Ch	Cvr
1	10,3	14,4	10	10	20,8	10,5	14,1	10	11	20.8	24,1	23,5	10	13	43,8
2	34,2	12,9	10	2	21,3	34,1	13,3	10	4	21,3	47,3	23,3	10	4	45
3	58,4	12,5	10	6	21,5	58,7	12,3	10	6	21,5	71,1	16,3	10	7	47,5
4	80,7	10,1	10	12	21,3	80,9	10,1	10	9	21,3	26,9	51,5	10	9	43,8
5	94,3	15,6	10	1	22,5	94,7	15,3	10	10	21,3	75,9	47,5	10	1	45
6	12,5	38,1	10	5	26,5	12,7	38,3	10	8	26,5	13,1	77,3	10	5	46,3
7	37,3	33,9	10	13	23,8	37,1	33,7	10	3	23,8	37,9	74,7	10	12	47,5
8	60,9	30,2	10	9	21,3	60,7	30,7	10	12	21,3	78,7	74,7	10	3	50
9	85,1	29,8	10	4	25	85,5	29,7	10	5	25	20,7	18,7	30	10	42,5
10	7,3	55,2	10	3	20	7,1	55,5	10	2	21,3	49,5	20,3	30	2	43,8
11	35,6	54,4	10	10	26,3	35,3	54,7	10	7	26,3	75,1	16,9	30	8	47,5
12	61,8	57,7	10	1	22,5	61,9	57,3	10	1	22,5	18,1	46,3	30	4	41,3
13	86,3	55,4	10	12	25,8	86,1	55,9	10	4	25,8	50,3	47,3	30	11	43,8
14	10,9	85,5	10	8	26,8	10,7	85,3	10	9	26,8	78,9	48,1	30	5	45
15	37,5	79,6	10	11	25	37,3	79,5	10	11	26,3	18,9	79,3	30	7	46,3
16	59,7	79,1	10	3	25	59,3	79,3	10	3	25	45,5	75,1	30	13	47,5
17	84,4	80,9	10	7	26,3	84	80,7	10	6	26,3	78,7	74,9	30	1	48,8
18	14,4	15,4	30	9	21,3	14,5	15,3	30	1	21,3	20,5	24,3	50	9	43,8
19	40,9	15,2	30	3	23,8	40,7	15,1	30	8	23,8	47,1	26,3	50	3	45
20	65,1	16,6	30	5	23,8	65,5	16,5	30	4	23,8	73,5	23,3	50	12	50
21	88,6	13,7	30	13	25	88,3	13,9	30	7	25	26,7	53,3	50	4	43,8
22	15,9	42,5	30	6	23,8	15,7	42,9	30	2	22,5	75,7	53,9	50	6	45
23	42,9	42,8	30	8	23,8	42,9	42,7	30	6	23,8	19,1	81,5	50	2	47,5
24	67,7	40,3	30	10	25	67,9	40,1	30	13	25	40,3	76,5	50	8	47,5
25	91,5	39,8	30	2	23,3	91,1	39,9	30	11	23,3	74,5	71,9	50	10	50
26	13,4	66,6	30	12	20	13,1	66,5	30	1	20	-	-	-	-	-
27	37,4	68,5	30	1	23,8	37,5	68,1	30	5	22,5	-	-	-	-	-
28	61,9	68,8	30	11	21,3	61,7	68,9	30	9	21,3	-	-	-	-	-
29	87,5	63,7	30	5	25	87,5	63,9	30	4	25	-	-	-	-	-
30	13,7	85,8	30	7	26,3	13,3	85,7	30	12	26,3	-	-	-	-	-
31	35,5	86,7	30	4	23,8	35,7	86,9	30	3	23,8	-	-	-	-	-
32	53,9	86,9	30	13	23,8	53,9	87,1	30	8	25	-	-	-	-	-
33	85,4	87,9	30	2	26,3	85,5	87,7	30	5	26,3	-	-	-	-	-
34	10,7	17,5	50	11	20,8	10,9	17,3	50	10	20,8	-	-	-	-	-
35	36,1	15,2	50	4	21,3	36,1	15,1	50	2	21,3	-	-	-	-	-
36	55,1	16,6	50	6	20,3	55,1	16,7	50	6	20,3	-	-	-	-	-
37	74,9	17,3	50	9	21,3	74,7	17,1	50	12	21,3	-	-	-	-	-
38	88,4	16,4	50	10	22,5	88,5	16,5	50	1	23,8	-	-	-	-	-
39	13,6	39,6	50	8	26,5	13,3	39,5	50	5	26,5	-	-	-	-	-
40	39,9	33,8	50	3	23,8	39,7	33,7	50	13	23,8	-	-	-	-	-
41	63,2	33,4	50	12	21,3	63,1	33,1	50	9	21,3	-	-	-	-	-
42	89,9	32,7	50	5	23,8	89,7	32,5	50	4	23,8	-	-	-	-	-
43	11,6	56,7	50	2	21,3	11,3	56,1	50	3	22,5	-	-	-	-	-
44	37,2	57,3	50	7	26,3	37,7	57,1	50	10	26,3	-	-	-	-	-
45	64,1	57,6	50	1	22,5	64,7	57,3	50	1	22,5	-	-	-	-	-
46	89,8	54,8	50	4	25,8	89,5	54,9	50	12	25,8	-	-	-	-	-
47	10,7	80,9	50	9	28	10,9	80,7	50	8	28	-	-	-	-	-
48	37,8	82,6	50	11	23,8	37,9	82,9	50	11	23,8	-	-	-	-	-
49	61,8	81,4	50	3	25	61,9	81,3	50	3	25	-	-	-	-	-
50	83,5	84,7	50	6	25	83,9	84,3	50	7	25	-	-	-	-	-

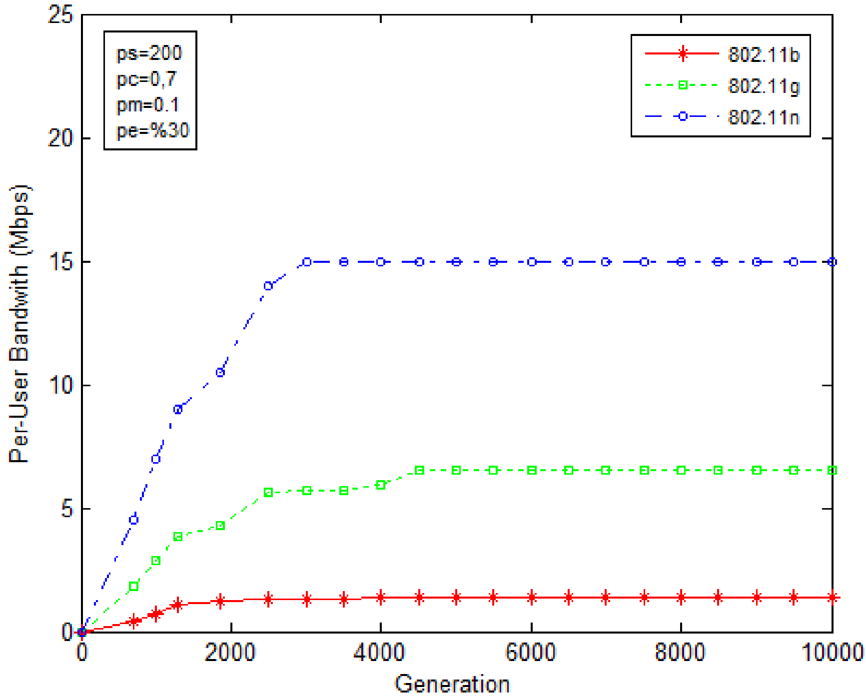

Figure 16: Average Bandwidth Per User with Generation Number

4.2.2 Average bandwidth per user

We investigate the sharing of bandwidth to wireless users. They are randomly located in the simulation to show how to effect on amount of bandwidth. 802.11b, 802.11g, and 802.11n network standards have 11, 54 and 248 mbps bandwidth respectively [15]. The bandwidth per user changes according to the number of users because wireless network architecture is the sharing network. In addition, the distance between a user and the access point affects directly on the amount of bandwidth. In other words, if the distance between the user and the access point increases, the bandwidth per user decreases. Consequently, the position of access points is a milestone for service quality. The bandwidth per user according to the optimal access point is calculated according to network standards. Figure 16 show the amount of average bandwidth per user according to generation number.

The bandwidth per user reached the top level after 5000 generations for 802.11b and 802.11g, and 3000 generations for 802.11n as in Figure 2. As it is seen from these two graphics, there is a parallel between the layout of access points and the average bandwidth per user. Optimal allocation of access points provides the best service quality because of average bandwidth apart from the maximum coverage area. Finally, the experimental results obtained show that the proposed algorithm successfully discovered the optimal layout of the access point on the building in simulation.

5 Conclusion and Future Work

In this paper, we have presented an optimal access point layout based on GA with channel conflict detection. The proposed algorithm optimizes parameters such as coverage area and channel conflict to provide service quality for wireless users in building environments. We have implemented the proposed GA method and then simulated it to demonstrate the impact of the proposed algorithm on overall system performance in terms of maximum coverage area and average bandwidth per user. Based on simulation results, the proposed GA method provides an acceptable solution and stable performance. In the future, we would like to improve the GA code implemented for real-world conditions such as the types of materials used for walls in the building due to the effect on signal quality. We also consider conducting field tests to validate the simulation results and explore the adaptability of the algorithm to different wireless standards and environments. The finding of optimal AP location will also be evaluated with other optimization algorithms in the future.

Acknowledgments

The authors greatly thank Kayseri City Hospital for their support in conducting the simulation.

Authors' Contributions

Ramazan KOCAOĞLU: Conceptualization, Methodology, Writing, and Visualization. M. Hanefi CALP: Conceptualization, Methodology, Writing, and Visualization. M. Ali AKCAYOL: Validation, Formal analysis, and review & editing. All authors have read and approved the final manuscript.

Competing Interests

The authors declare that they have no conflict of interest.

References

[1] J. Lee, B. Han, H. J. Lim, Y. D. Kim, N. Saxena, and T. M. Chung, ''Optimizing access point allocation using genetic algorithmic approach for smart home environments,'' *The Computer Journal*, vol. 52, pp. 938–949, 2009.
[2] T. Scully and K. Brown, ''Wireless lan load-balancing with genetic algorithms,'' *Knowledge-Based Systems*, vol. 22, pp. 529–534, 2009.
[3] W. Yan, S. Xin-xin, and S. Yan-ming, ''Study on application of genetic algorithms in the optimization of wireless network,'' *Procedia Engineering*, vol. 16, pp. 348–355, 2011.
[4] D. Pandey, R. Dhara, S. Bhunia, and S. Kundu, ''Design and analysis of a compact millimeter-wave pentaband antenna for 5g fr-2 band wireless technologies,'' *International Journal of Electronics and Communications*, vol. 184, 2024.
[5] E. Oughton, G. Geraci, P. M., V. Shah, B. D., and S. Blue, ''Reviewing wireless broadband technologies in the peak smartphone era: 6g versus wi-fi 7 and 8,'' *Telecommunications Policy*, vol. 48, no. 6, 2024.
[6] K. Guan, X. Guo, D. He, P. Svoboda, M. Berbineau, S. Wang, B. Ai, Z. Zhong, and M. Rupp, ''Key technologies for wireless network digital twin towards smart railways,'' *High-speed Railway*, vol. 2, no. 1, pp. 1–10, 2024.
[7] H. J. Madi, ''A review of new developments in reliability and connectivity of wireless sensor technology over recent years.'' in *Comprehensive Materials Processing (Second Edition)*. Elsevier, 2024, p. 5700.
[8] J. H. Lee, B. J. Han, H. K. Bang, and C. T-M., ''An optimal access points allocation scheme based on genetic algorithm,'' *In Proceedings of IEEE Future Generation Communication and Networking*, vol. 2, pp. 55–29, 2007.
[9] J. Yoshino and I. Ohtomo, ''Study on efficient channel assignment method using the genetic algorithm for mobile communication systems,'' *Soft Computing*, vol. 9, no. 2, pp. 143–148, 2005.
[10] N. Funabiki, T. Nakanishi, Y. Nomura, T. Farag, S. Tajima, and T. Higashino, ''An optimal access-point allocation for wireless infrastructure mesh networks,'' *In Proceedings of IEEE International Conference on Computer Theory and Applications*, vol. 9, no. 2, pp. 143–148, 2006.
[11] D. Turgut, S. K. Das, R. Elmasri, and B. Turgut, ''Optimizing clustering algorithm in mobile ad hoc networks using genetic algorithmic approach,'' *In Proceedings of IEEE Global Telecommunications Conference*, vol. 1, pp. 62–66, 2002.
[12] A. Singh and W. N. Bhukya, ''A hybrid genetic algorithm for the minimum energy broadcast problem in wireless ad hoc networks,'' *Applied Soft Computing*, vol. 11, no. 1, pp. 667–674, 2011.
[13] L. E. Agustin-Blas, S. Salcedo-Sanz, P. Vidales, G. Urueta, and J. A. Portilla-Figueras, ''Near optimal citywide wİfi network deployment using a hybrid grouping genetic algorithm,'' *Expert Systems with Applications*, vol. 38, no. 8, pp. 9543–9556, 2011.
[14] E.-S. M. El-Alfy, ''Applications of genetic algorithms to optimal multilevel design of mpls-based networks,'' *Expert Systems with Applications*, vol. 30, no. 9, pp. 2010–2020, 2007.
[15] L. Calvo-Carro, S. Sanz-Salcedo, J. A. Figueras-Portilla, and E. G. Ortiz-Garcia, ''A genetic algorithm with switch-device encoding for optimal partition of switched industrial ethernet networks,'' *Journal of Network and Computer Applications*, vol. 33, pp. 375–382, 2010.
[16] Q. Zhang and W. Zhang, ''Network partition for switched industrial ethernet using genetic algorithm,'' *Engineering Applications of Artificial Intelligence*, vol. 20, pp. 79–88, 2007.
[17] S. S. Sanz, J. A. P. Figueras, E. G. O. Garcia, A. M. P. Bellido, C. Thraves, A. F. Anta, and X. Yao, ''Optimal switch location in mobile communication networks using hybrid genetic algorithms,'' *Applied Soft Computing*, vol. 8, pp. 1486–1497, 2008.
[18] M. K. Singh, S. I. Amin, and A. Choudhary, ''Genetic algorithm based sink mobility for energy efficient data routing in wireless sensor networks,'' *International Journal of Electronics and Communications*, vol. 131, 2021.
[19] A. Ouyang, Y. Lu, Y. Liu, M. Wu, and X. Peng, ''An improved adaptive genetic algorithm based on dv-hop for locating nodes in wireless sensor networks,'' *Neurocomputing*, vol. 458, pp. 500–510, 2021.
[20] N. T. Hanh, H. T. T. Binh, N. X. Hoai, and M. S. Palaniswami, ''An efficient genetic algorithm for maximizing area coverage in wireless sensor networks,'' *Information Sciences*, vol. 488, pp. 58–75, 2019.
[21] M. H. Calp, ''A hybrid anfis-ga approach for estimation of regional rainfall amount,'' *Gazi University Journal of Science*, vol. 31, no. 1, pp. 145–162, 2019.
[22] V. Bertolini, F. Corti, M. Intravaia, A. Reatti, and Cardelli, ''Optimizing power transfer in selective wireless charging systems: A genetic algorithm-based approach,'' *Journal of Magnetism and Magnetic Materials*, vol. 587, 2023.
[23] Y. E. M. Hamouda, ''Optimally sensors nodes selection for adaptive heterogeneous precision agriculture using wireless sensor networks based on genetic algorithm and extended kalman filter,'' *Physical Communication*, vol. 63, 2024.
[24] L. V. Quan, N. T. Hanh, H. T. T. Binh, V. D. Toan, D. T. Ngoc, and B. T. Lam, ''Optimally sensors nodes selection for adaptive heterogeneous precision agriculture using wireless sensor networks based on genetic algorithm and extended kalman filter,'' *Expert Systems with Applications*, vol. 217, 2023.
[25] M. H. Calp and A. M. A., ''Optimization of project scheduling activities in dynamic cpm and pert networks using genetic algorithms,'' *Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, vol. 22, no. 2, pp. 615–627, 2018.
[26] D. J. Bahadur and L. Lakshmanan, ''A novel method for optimizing energy consumption in wireless sensor network using genetic algorithm,'' *Microprocessors and Microsystems*, vol. 96, 2023.
[27] X. Gong, D. Plets, E. Tanghe, T. D. Pessemier, L. Martens, and W. Joseph, ''An efficient genetic algorithm for large-scale transmit power control of dense and robust wireless networks in harsh industrial environments,'' *Microprocessors and Microsystems*, vol. 65, pp. 243–259, 2018.