New Channel Assignment Method for Access Points in Wireless LANs

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Abstract
Wireless LANs topology communicates using radio frequencies. The number of these frequencies is limited and not enough to assign a special frequency for each Access Point, this means that the communication topology should use a "re-use" mechanism, which allows the system to assign the same frequency that assigned previously for another access point. In this paper, we suggest a method to assign frequency channels to access points in a Wireless LANs system. The goal of this paper is to reach the assignment that prevents interference between access points especially neighbor ones. We used Genetic Algorithm to work on this issue, it is considered as an Expert System and one of the main multi point search technique used in computing to solve optimization and search problems.
Keywords: *Wireless LANs, Mobile Communications, Channel Assignment, Optimization, Genetic Algorithm, Soft Computing Techniques.*

1. Introduction

The most important issues on the design and deployment of wireless infrastructure mode are continuous coverage for the geographical area and an optimal channel assignment for access points (APs) while satisfying both the user's traffic demand and quality of services [1].

To satisfy all aims above, designers should have a mechanism that helps using the available narrow frequency spectrum efficiently [2].

When thinking about efficiently frequency use, designer should understand one more fact: All users of mobile and wireless system will use one shared medium: air, this means that users will be close to each other, and they will be able to "hear" or may be interfere each other [3].

WLAN communicates use radio frequencies (RF) or electromagnetic wave to carry a signal over part or the entire communication path similar way in AM/FM radios and FDMA [2].

FDMA, is based on dividing the available frequency range into smaller ranges (sub-frequencies), then use each sub-frequency as a standalone frequency. Each sub-frequency is called Channel [2].
The Federal Communications Commission (FCC) regulates the use of WLAN devices. To organize WLAN standards IEEE 802.11 appeared. IEEE 802.11 is a group of standards developed by the Institute of Electrical and Electronics Engineers Inc. to represent all WLAN computer communication [3]. Overviews of these standards are mention below.

IEEE 802.11 (legacy mode) - The original WLAN standard was released in 1997. It specified two rates 1 or 2 Mbps that operates in the 2.4 GHz frequency hopping spread spectrum (FHSS) and in the 2.4 GHz direct sequence spread spectrum (DSSS) [4].

IEEE 802.11a- It operates in the 5 GHz unlicensed frequency band Orthogonal Frequency Division Multiplexing (OFDM) with a maximum data rate of 54 Mbps. It offers 12 non interference channels, 8 channels for indoor use and 4 for outdoor [4], [5].

IEEE 802.11b- It operates in the 2.4 GHz unlicensed frequency band direct sequence spread spectrum with a maximum data rate of 11 Mbps. It divides band into 11 channels (North America) and 13 channels (Europe), but only 3 of them (channels 1, 6, 11) do not have band overlap [4], [6].

IEEE 802.11g- It operates in the 2.4 GHz unlicensed frequency band Orthogonal Frequency Division Multiplexing with a maximum data rate of 54 Mbps [4], [7].

The feature to use the same amount of information that sent formerly using a narrow band carrier signal spread it out over a higher frequency range is called Spread Spectrum Technology. This feature reduces the chance that will be damaged or jammed [3].

(FHSS)The process of splitting the spectrum into 79 nonoverlapping channels across the 2.402 to 2.480 GHz frequency range called Frequency Hopping Spread Spectrum. FHSS WLANs support 1 Mbps and 2 Mbps data rate. FHSS device changes or hopes frequencies within the RF frequency band [8].

(DSSS) is another WLAN physical method for the original 802.11. DSSS use 22 MHz channels. This model is well known, because it is easy to implement and it has a high data rates. These days most of wireless LAN uses DSSS model in the markets, because it allows sending a large data at a higher data rate than FHSS systems such as in IEEE 802.11b [8].

DSSS uses channels, with a band of frequencies 22 MHz wide, while in the FHSS, it uses 1 MHz carrier frequencies. For more details see the following example; there are two channels: channel 1, operate from 2.401 GHz to 2.423 GHz (2.412 GHz ± 11 MHz); channel 2 operates from 2.406 to 2.429 GHz (2.417 ± 11 MHz)" [3] as shown in figure (1).

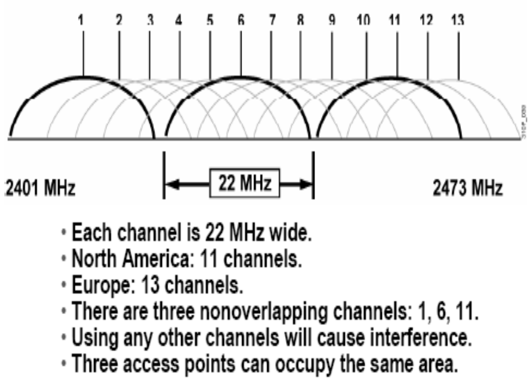

Fig. 1 DSSS channel allocation [4]

WLAN standard IEEE 802.11b and IEEE 802.11g uses three nonoverlapping channels 1, 6, 11 and using any other channels will cause interference, this means that the system should use a "re-use" mechanism. This re-use mechanism allows the system to assign the same channel which assigned previously for another AP if the distance is far enough to prevent interference.

In this paper, a new channel assignment mechanism is introduced. It uses genetic algorithm to specify a channel for each AP that prevents interference between APs especially neighbor ones.

The next section presents a channel assignment related works and section 3 explains genetic algorithm. Section 4 explains simulation method and the parameters used in the simulation; section 5 explains the result of simulation. Finally, section 6 draws the conclusions.

2. Related Work

The work [9] titled "Study on efficient channel assignment method using the genetic algorithm for mobile communication systems" presents a group channel assignment method for the optimization and its simulation results. This method utilizes the genetic algorithm (GA). Prior to the optimization calculation, whole channel cells are divided into subgroups and then, each subgroup is optimized. Using this result, the whole cells are further optimized. This process enables an efficient calculation to optimize the channel assignment. The results of simulation shows that the proposed method gives a shorter computation time compared with the method called as the individual assignment. See figure (2).

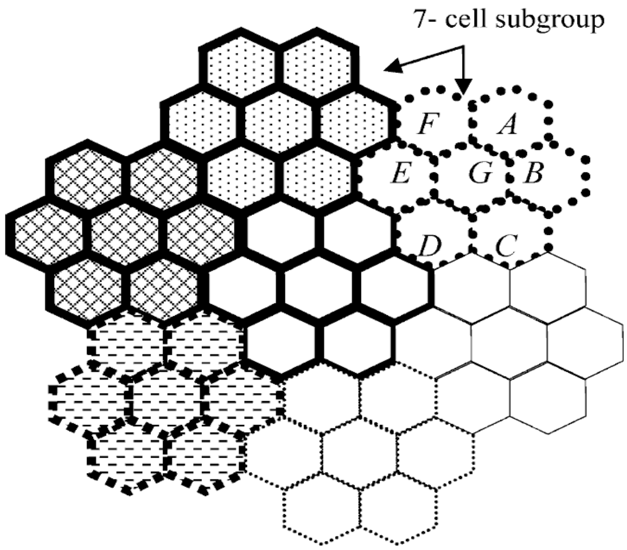

Fig. 2 Frequency Reuse - Channel Pattern [9]

In the study of [10] authors highlights the potential of using genetic algorithms to solve cellular resource allocation problems. Authors consider that cellular resource allocation deals with how and when to allocate radio frequency channels to mobile hosts. The objective of study is to gauge how well a GA-based channel borrower performs when compared to a greedy borrowing heuristic.

In the study of [11] authors stated an optimal access points allocation schema using GA which provided a solutions that allows a wireless user to choose an optimal AP according to its capacity not only to AP's power of signal.

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3. Genetic Algorithm

3.1 How GA works

The basic concepts of Genetic algorithms were created by John Holland in the 1960s. After that Holland and his students from the University of Michigan developed these concepts [12], [13].

Genetic Algorithm is a multi point search technique used in computing to solve optimization and search problems by finding approximate. It tries to solve optimization problems by mimicking the behavior of nature. Nature always takes a decision of re-producing or eliminating individuals in each generation according to their fitness with their life conditions [13].

The operation of GA usually starts from a population of randomly generated "individuals" or "phenotypes", this step called "Initialize chromosomes" and this group of individuals will be called the first generation; each individual represents a possible solution for a given problem. The individuals in this first generation will be represented by a string of bits "genes" which forms a chromosome [13], [14].

Each individual is evaluated and assigned a fitness value according to how good a solution to the problem it is "Evaluate Fitness". The algorithm knows the fittest individuals by running a function called: Fitness function. This function returns the ratio of fitness for each individual in the generation [14], [15].

The highly fit individuals are stochastically selected from the current population, and modified (crossover and possibly mutated) to form a new population (second generation). The new population is then used in the next iteration of the algorithm. The algorithm continues until the maximum number of generations has been produced, or a satisfactory fitness level has been reached for the population [14], [15].

The cycle described in Figure (3) will be repeated more and more, and at the end of the day, genetic algorithm will find the fittest individual, which will be hopefully the best solution for the problem. See figure-3 which describes the complete cycle of genetic algorithm.

The selection, crossover and mutation are the most important part of genetic algorithm. The performance is influenced mainly by these operators [15].

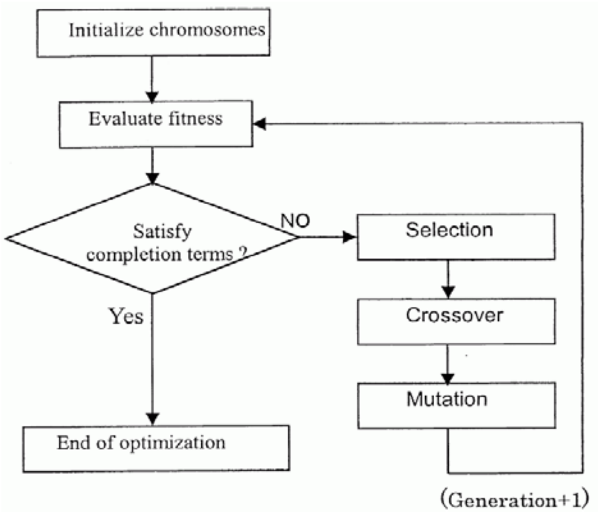

Fig. 3 Complete Cycle of Genetic Algorithm [13]

3.2 Crossover

It is the process of generating a child from two parents by taking a part from one of the parents and replaces it with the corresponding part from the second parent and vice versa [13].

3.3 Mutation

It is a change done on some of the children resulted from the crossover process by flipping the value of one of the bits randomly. The benefit of such operation is to restore the lost genetic values when the population converges too fast [14].

4. Simulation Method

4.1 Environment Circumstances

As we know WLAN standard IEEE 802.11b and IEEE 802.11g uses three nonoverlapping channels 1, 6, 11, so Simulation done supposed that there are three channels (i.e. sub-frequencies): Channel 1, 6 and 11. The goal is to find the best assignment that minimizes the interference. In other words, we have to find an assignment that guarantees that no neighbor APs use the same channel.

4.2 Representation and Encoding of the Chromosome

We used a chromosome which contains number of genes just like the number of APs in the network; each gene was represented by two bit, these two bits represent the channel number that used by the AP. so gene **"00"** represent channel **1**, gene **"01"** represent channel **6**, gene **"10"** represent channel **11**, gene **"11"** represent channel **16** which replaced by channel 1 or 6 or 11 according to the optimal solution. For example, if the chromosome is : **00 10 01 00 11 10 11 01 00**, then this means that the Network consists of **9 APs**, where ***AP#1*** uses channel 1 (which represented 00 in binary), ***AP#2*** uses channel 11 (which represented 10 in binary), ***AP#3*** uses channel 6 (which represented by 01 in binary) and so on. See Figure (4) below.

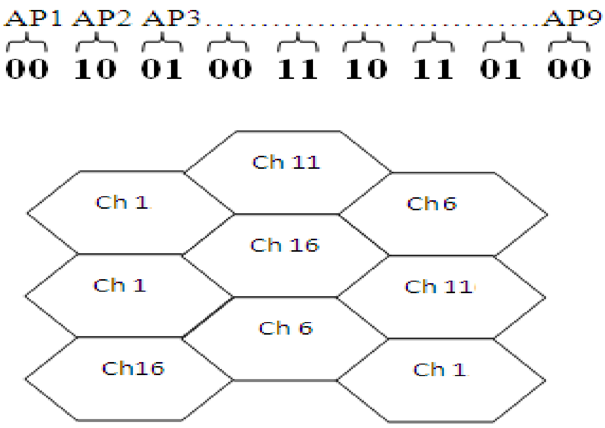

Fig. 4 Chromosome representation

4.3 Fitness Function

The fitness value has a value equals to 0 at the start of GA process. This value will be incremented by 1 for each two neighbor APs that use the same frequency channel. Chromosome with the minimum fitness value means that it is the optimal solution for the APs Allocation Channel Assignment problem.

- Fitness of each individual in a chromosome is calculated by using this Fitness Function:

    1. Fitness value is 0 by default.

    2. - The function starts checking the “gene” one by one.

    3. - Fitness value will be increased by 1 for each two neighbor APs “genes” use the same frequency channel.

4.4 Selection

Selection is the process of choosing structures for the next generation from the structures in the current generation [14]. In the simulation the Selection algorithm used is the "Roulette Wheel Selection", which allocate to each individual a portion of the wheel proportional to the individual's fitness.

4.5 Simulation Parameters

Table 1 below shows the parameters that used in the simulations.

Table 1: Simulation Parameters

Total APs Number	16 , 36, 64
Crossover Rate	20% , 40% , 60%
Mutation Rate	0.1% , 0.7% , 2%
Selection Method	Roulette Wheel Selection
Population Size	100

5. Simulation Results

After running the experiments using the parameters defined previously, we started drawing the relation between the generations and the fitness value. Here are the results in details:

5.1 Results by Crossover rate

Figures (5), (6) and (7) show the relation between the fitness value and generations when crossover rate value was 20%, 40% and 60%. Mutation rate was 0.1% for each experiment. Number of APs in experiments represented in Figure (5) was 16 APs; in Figure (6) was 36 APs; while it was 64 APs in experiment represented in Figure (7).

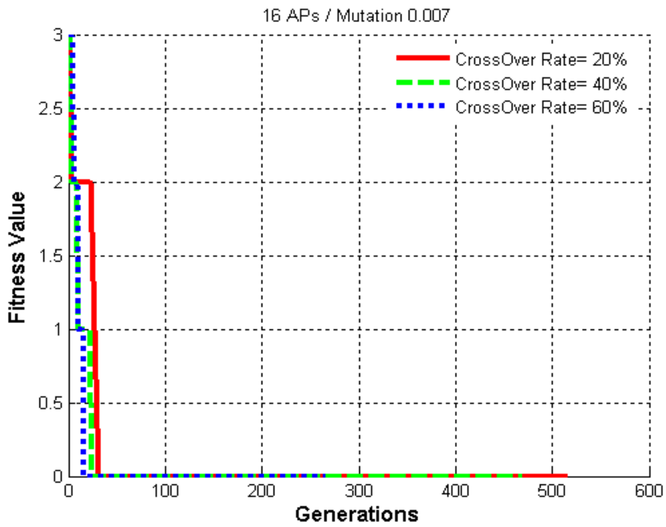

Fig. 5 Change by the Crossover rate in 16 APs

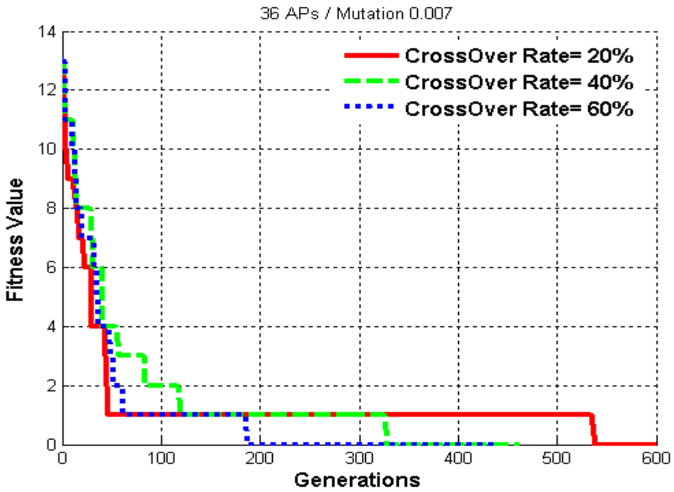

Fig.6 Change by the Crossover rate in 36 APs

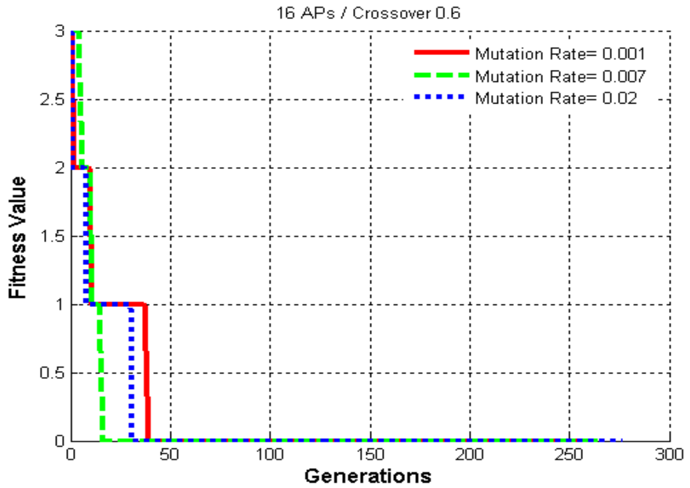

Fig.8 Change by the Mutation rate in 16 APs

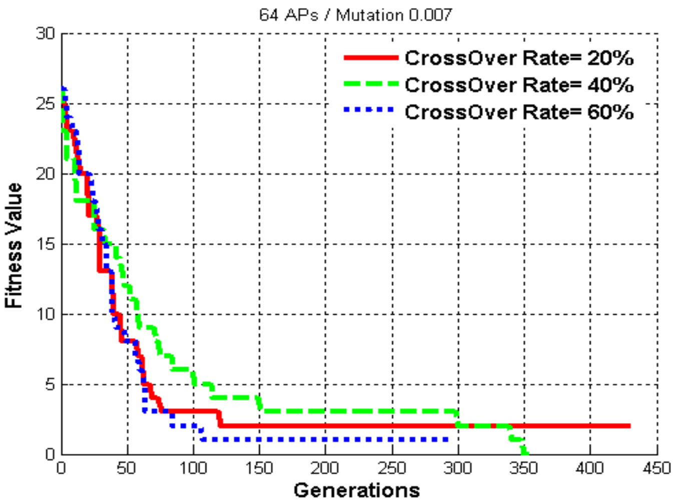

Fig. 7 Change by the Crossover rate in 64 APs

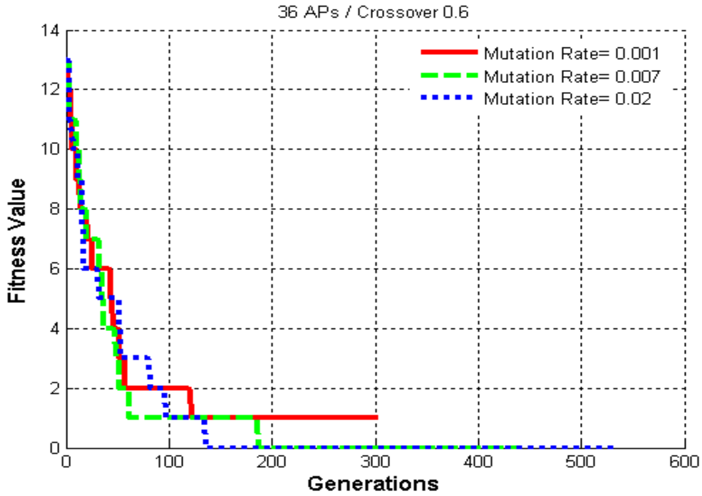

Fig. 9 Change by the Mutation rate in 36 APs

5.2 Results by Mutation rate

Figures (8), (9) and (10) show the relation between the fitness value and generations when mutation rate value was 0.1%, 0.7% and 2%. Crossover rate was 60%. Number of APs in experiments represented in Figure (8) was 16 APs, in Figure (9) was 36 APs, while it was 64 APs in experiment represented in Figure (10).

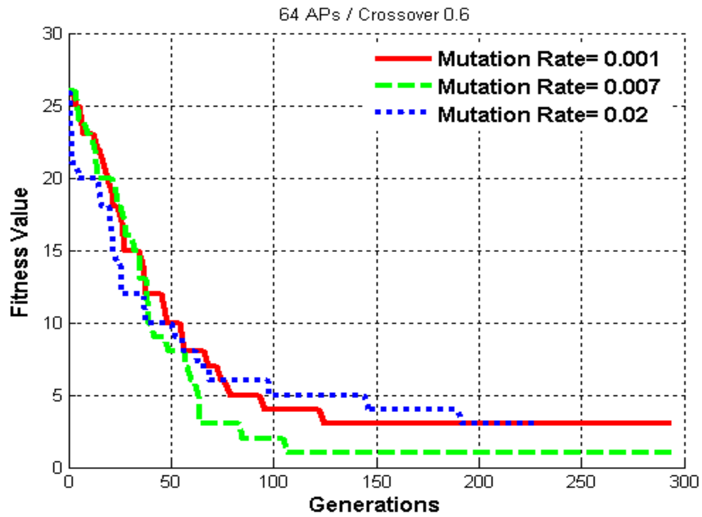

Fig. 10 Change by the Mutation rate in 64 APs

6. Conclusions

This paper introduced a frequency assignment method using genetic algorithm. This method differs from the method traditionally used in mobile systems (channel pattern).

This method worked well for small WLAN systems that maximum contain number of APs around 49 and introduces a multi and rapid solutions, but the performance of this method was decrease when using it with bigger WLAN systems.

From our point of view, this happened because the tool we used will face a tremendously large number of solutions that can be generated when the chromosome is long. This made the job of the tool morel hard.

From the above figures we could note that the optimal Crossover Rate was between 40% and 60%, and the optimal Mutation Rate was around 0.7%.

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