A Spectrum Assignment Method based on Genetic Algorithm in WiMAX/WiFi Integrated Network

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ABSTRACT

Recently, the lack of spectrum resources becomes an important problem for advanced wireless networks. To overcome this problem, dynamic spectrum access receives much attention. In this paper, we propose a spectrum assignment method based on a genetic algorithm in which a WiFi system temporarily uses a spectrum band of WiMAX system in WiMAX/WiFi integrated networks.

Categories and Subject Descriptors

C.2.1 [**Network Architecture and Design**]: Wireless Communication.

General Terms

Algorithms

Keywords

WiMAX, WiFi, spectrum sharing, genetic algorithm

1. INTRODUCTION

With advances in wireless communication technologies, people can use multimedia services not only via wired networks but also via wireless networks such as Cellular, WiFi, and WiMAX. As a technology to utilize the scarce spectrum resources efficiently, dynamic spectrum access (DSA) [1, 2] attracts much attention. By using DSA, a wireless system can scan for the availability of the radio frequency spectrum that is assigened to another wireless system.

In this paper, we propose a spectrum assignment method to improve throughput by using DSA in WiMAX/WiFi integrated network[3]. Specifically, in the proposed method, WiMAX and WiFi systems share the spectra and WiFi access points (APs) that support much more users can use an extra spectrum.

2. PROPOSED METHOD

Simply speaking, we should assign an extra spectrum to APs supporting much more users. Note here that, however, a couple of adjacent APs cannot use the same spectrum because of radio interference. This must be considered as a *constraint*.

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To maximize the total throughput in the network, we find a better spectrum assignment pattern based on Genetic Algorithm (GA) which can detect multiple solution in parallel. We use the total number of users getting access to an AP which has an extra spectrum as a *fitness value*.

We assume n cells in an access area of a WiMAX BS as shown in Fig. 1, where each number is treated as a cell ID. We define an *individual* as a set of cell ID and a digit where '1' means that the cell is an assignment target.

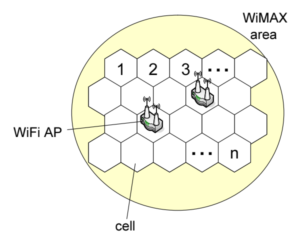


Figure 1: Cell ID

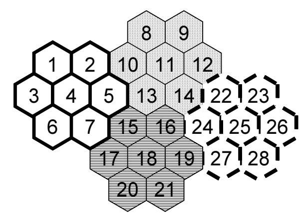


Figure 2: Cluster

In the following paragraphs, we explain the procedures of the proposed method in detail.

Initialization.

First, the proposed method randomly selects a cell i which has an AP whose all adjacent cells have the element '0' (i.e., without assignment of extra spectrum) and assigns an extra spectrum to the AP. This operation is repeated until there are no APs which can be assigned an extra spectrum, and we define the pattern after above iteration as individual. In the same manner, the proposed method makes l individuals.

Crossover by Cluster.

We introduce a *cluster* as a set of adjacent seven cells such as 1-7, 8-14, 15-21, and 22-28 in Fig. 2. A crossover is made by this cluster. The cluster which has the same ID for each individual consists of the same cells, so that any cells without AP are never target of spectrum assignment.

First, the proposed method randomly selects two individuals α and β as parents from l individuals, and also randomly selects k clusters in each individual. After that, the proposed method exchanges the elements between α and β, and repeats this process for m pairs of parents.

Fig. 3 shows the execution example of a crossover. The value shown in each cell represents the element of the spectrum assignment list. Suppose to make a crossover by the thick boxed clusters in α and β. The element of the list corresponding to cell ID of cluster between α and β is exchanged, and new spectrum assignment lists, α' and β' as children, are generated. Then these children are added to the initial group as new individuals. Because α and β are belonging to the initial group, as a result, the number of individuals increases by two.

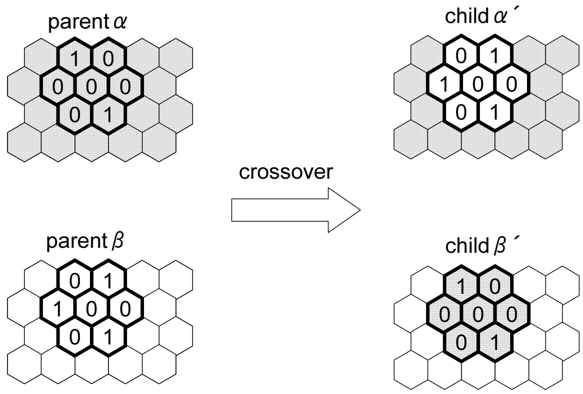


Figure 3: Example of Crossover by Cluster

However, a child generated by a crossover may cause interference. Therefore, in such a case, to satisfy the constraint, the proposed method excludes the AP which causes interference and has the lowest impact on the fitness value from assignment candidates.

The proposed method repeats above process for m pairs of parents.

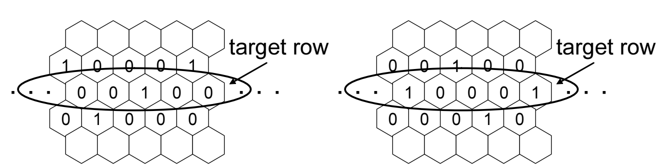
Selection.

After crossover, the number of individuals is $l + 2m$. To maintain the number of individuals, $2m$ individuals are discarded by roulette selection, that is, an individual with the higher fitness value is discarded with the lower probability.

Mutation.

If two or more individuals are identical, any new assignment patterns are never generated after crossover from these parents. To overcome this situation, mutation process is invoked to generate a different assignment pattern.

We explain the mutation process with Fig. 4. A row is selected as a target of mutation and the digit of some randomly selected cells are inverted. After that, as shown in Fig. 4(b), in the cells of adjacent rows of the target row, the elements are changed to consider the constraint.



(a) Before Operation (b) After Operation

Figure 4: Mutation

Spectrum Assignment.

After repeating the above operation in a certain period of time, the proposed method assigns spectrum based on the individual which has the maximum fitness value at the time. Note here that the proposed method does not stop after a certain number of iteration but continues to seek for better individuals.

3. PERFORMANCE EVALUATION

We set one WiMAX BS including $8 \times 8 = 64$ cells where randomly selected 32 cells had AP. The throughput of WiMAX BS and WiFi AP were decided according to the evaluation in WiMAX Forum and preliminary experiments using ns-2, respectively. As a parameter setting of the proposed method, k, l, m, the number of clusters of each individual, the interval time of spectrum assignment, were set to 3, 5, 1, 13, 300[s] respectively.

Users were supposed to get a file whose size followed an exponential distribution with mean 10[MBytes]. When a new user arrived at a cell with AP, he/she used WiFi. Otherwise, he/she uses WiMAX. Handover was not considered. Generally speaking, because APs are set up in places where much more people gather, we set the arrival rate in a cell with AP to λ and that without AP to 0.1λ.

We used two comparison methods. One is a greedy method which assigns extra spectra to APs in descending order of the number of connected users. The other is the method that does not share any spectra. As a performance measure, we observed the average throughput over 10 experiments, where an experiment ran 10^5[s].

Fig. 5 shows the average throughput as a function of λ for each method. This result shows that the proposed method achieves higher throughput than that of other methods, since the proposed method can use spectrum resources more efficiently.

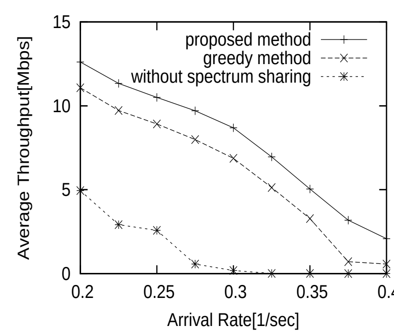


Figure 5: Simulation Result

As a future work, we are evaluating the impact on the performance by changing the parameters of GA and try to enhance the proposed method to take handoff users into account.

4. REFERENCES

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