A Channel Allocation Scheme Including Migration Concept in Cellular Mobile Environment

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Abstract

The efficient management and sharing of the radio spectrum among numerous users become an important issue. The frequency channels are a scarce resource in a cellular mobile system. Thus, many schemes have been proposed to assign frequencies to the cells such that the available spectrum is efficiently used. In this paper, we propose a channel allocation mechanism including migration concept using genetic algorithm in cellular mobile computing environments. Our simulation results indicate that the proposed algorithm could reduce a search time for an available channel.

Keywords: *Resource balancing, Cellular System, Migration, Genetic Approach*

1. Introduction

The tremendous growth of the mobile users coupled with the bandwidth requirements of multimedia applications requires an efficient use of the scarce radio spectrum allocated to mobile communications. The efficient management and sharing of the radio spectrum among numerous users become an important issue. This limitation means that the frequency channels have to be reduced as much as possible in order to support the tremendous of simultaneous calls that may arise in any typical mobile communication environment. The concept of cellular architecture is generally conceived as a collection of geometric areas [1], called cells (typically hexagonal-shaped). This cellular mobile structure is shown in Figure 1.

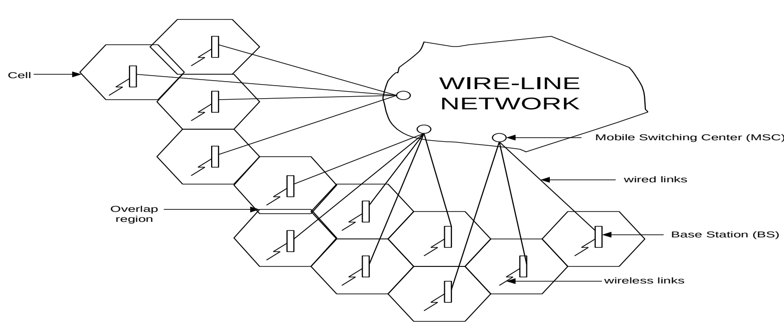

Figure 1. Cellular mobile structure

Each served by a Base Station (BS) located at its center. A number of cells (or BS) are again linked to a mobile switching center (MSC). A BS communicates with the mobile users through wireless links, and with the MSC's through wired links.

The frequency channels are a scarce resource in a cellular mobile system. Thus, many schemes have been proposed to assign frequencies to the cells such that the available spectrum is efficiently used, thus the frequency reuse is maximized. They can be classified into three – fixed [1, 2, 3], dynamic [3, 4, 5], flexible [3] – methods. This paper is based on the fixed method. A summary of the comparison results between the FA and dynamic assignment (DA) schemes is given in Table 1.

Table 1. Comparison between FA and DA

FA(Fixed Channel Assignment)	DA(Dynamic Channel Assignment)
○ Performs better under heavy traffic ○ Low flexibility in channel Reusability ○ Maximum channel reusability ○ Sensitive to time and spatial changes ○ Not stable grade of service per cell in an interference cell group ○ High forced call termination probability ○ Suitable for large cell environment ○ Low flexibility ○ Low computational effort ○ Low call set up delay ○ Complex. Labor intensive frequency planning ○ Low implementation complexity ○ Centralized control	○ Performs better under light/moderate traffic ○ Flexible allocation of channels ○ Not always maximum channel reusability ○ Insensitive to time and spatial changes ○ Stable grade of service per cell in an interference cell group ○ Low to moderate forced call termination probability ○ Suitable in micro-cellular environment ○ High flexibility ○ High computational effort ○ Moderate to high call set up delay ○ No frequency planning ○ Moderate to high implementation complexity ○ Centralized, decentralized. Distributed control depending on the scheme

In a fixed assignment (FA) scheme, a set of channels is permanently allocated to each cell, which can be reused in an another cell, sufficiently distant, so that co-channel interference is tolerable. The advantage of a FA scheme is its simplicity. But the disadvantage is that if the number of calls exceeds the number of channels assigned to a cell, the excess calls are blocked. This problem can be partially alleviated by a channel borrowing method [6]. In the channel borrowing method, a channel is borrowed from a suitable one of the neighboring cells in case of blocked calls provided that it does not interfere with the existing calls. The disadvantage of channel borrowing is that the BS's communicate with each other to decide a suitable cell to lend a channel until a suitable channel will be searched.

The above mentioned channel assignment techniques have not contain the concept "channel borrowing". So, these methods could not be adapted in mobile computing environments that the service requests change dynamically in accordance with the time and place. Therefore, the channel assignment techniques with load redistribution have been studied [7-9]. In [7], a subscriber moves from the current cell to the other cell through the hand-off process. Hand-off process means that the mobile host being operation moves a current cell to an another cell to model "channel borrowing".

Therefore, this scheme is generated many hand-offs and increase co-channel interference. The study in [8] includes a concept of “channel borrowing”. The channel borrowing mechanism is performed when a set of channels in a cell was used. A channel was borrowed from only a neighboring cell. A set of channels is composed of seven groups. Channels in one group were occupied for services of itself. Channels in other groups are used for channel borrowing when a cell was received a service request from neighboring cells. This scheme shows very low performance problem when neighboring cells are a hot (overloaded) because channels are borrowed from only neighboring cells. The study in [9] includes a “channel borrowing” concept too. This scheme used a selective channel borrowing by corresponding cell before a set of available channels is used. A selective channel borrowing was used to transfer a channel from a cold cell to a hot cell. The transferred channel was assigned in accordance with a priority of users. This scheme was needed much computation time because it might consider a priority of users and it searches a optimal lender.

We propose a genetic algorithm approach for load redistribution to improve above-mentioned problems. The purpose of using genetic algorithm in this paper is to decrease search time for an available channel and is to migrate from a searched channel to a hot cell. The genetic operators such as selection, crossover, and mutation are applied to a population of binary chromosomes. Each of these binary chromosomes stands for a list of cells to which the transfer request messages are sent off. The rest of this paper is organized as follows. We described the brief introduction to genetic algorithm in Section 2. In Section 3, we proposed a genetic algorithm approach for load redistribution in mobile computing system. Section 4 described simulation results. Lastly, we described the conclusions in Section 5.

2. Introduction to Genetic Algorithm

It turns out that there is no rigorous definition of “genetic algorithm” accepted by all evolutionary-computation community. However, it can be said that most methods called “GAs” have at least the following elements in common: populations of chromosomes, selection according to fitness, crossover to produce new offspring, and random mutation of new offspring. The chromosomes in a GA population typically take the form of bit string. The GA processes populations of chromosomes, successively replacing one such population with another. The GA most often requires a fitness function that assigns a score (fitness) to each chromosome in the current population. The fitness of a chromosome depends on how well that chromosome solves the problem at hand [15].

Given a clearly defined problem to be solved and a symbol string representation for candidate solutions, a simple GA works as follows [15]:

1. Start with a randomly generated population of n l-bit chromosomes (candidate solutions to a problem).
2. Calculate the fitness function of each chromosome in the population.
3. Repeat the following steps until n offspring have been created:

   3.a Select a pair of parent chromosomes from the current population.

   3.b With probability p_c(crossover probability), cross over the pair at a randomly chosen point to form two offspring.

   3.c Mutate the two offspring at each locus with probability p_m(mutation probability), and place the resulting chromosomes in the new population.

4. Replace the current population with the new population.
5. Go to step 2.

Each iteration of this process is called a *generation*. The entire set of generations is called a *run*. The procedure just described is the basis for most applications of GA. In this paper, we used a GA method to allocate a channel in cellular environments.

3. Proposed algorithm

In this section, we describe various factors to be needed for new proposed load redistribution mechanism in cellular mobile environments. That is, load measure, coding method, fitness function and algorithm.

3.1. Load measure

Load redistribution in cellular mobile computing environments means a channel borrowing from a cold cell to meet a service request of a hot cell. So, it needs a measure to decide a cell whether a cell received a service request is a hot or a cold. A load measure used in this paper uses the following equation.

$$\text{Degree\_of\_coldness}_\text{i} = \frac{\text{No\_of\_available\_channels}}{\text{No\_of\_total\_channels}} . \qquad (1)$$

A No_of_total_channels is the number of total channels in each cell. A No_of_available_channels is the number of available channels in each cell. Therefore, A $\text{Degree\_of\_coldness}_\text{i}$ means a load degree of each cell. The channel migration policy uses the threshold policy that makes decisions based on $\text{Degree\_of\_coldness}_\text{i}$. The migration policy is triggered when a service request arrives at a cell. This paper uses two thresholds(T_{low}, T_{up}) to decide whether the cell is a hot or a cold. A cell identifies as a suitable cold cell for a channel acquisition if the cell's $\text{Degree\_of\_coldness}_\text{i}$ will not cause to exceed T_{low}.

Table 2. 3-level scheme & two thresholds

Hot cell	$\text{Degree\_of\_coldness}_\text{i} > T_{up}$
Moderate cell	$T_{low} \leq \text{Degree\_of\_coldness}_\text{i} < T_{up}$
Cold cell	$\text{Degree\_of\_coldness}_\text{i} < T_{low}$
Lower threshold	T_{low}
Upper threshold	T_{up}

The BS in the cell performs a load redistribution based on genetic algorithm to borrow a channel from cold cell if the cell is hot. The algorithm is performed in its BS when a call enters a cell.

3.2. Representation method

Each cell in cellular mobile computing systems has its own population which genetic operators are applied to. There are many Representation methods. We use the binary representation method. Therefore, a chromosome in a population can be defined as a binary-coded vector which indicates a set of cells to which the request messages are sent off. If the request message is transferred to the cell c_i (where $0 \leq i \leq n$-1, n is the total number of cells in mobile system), then v_i is 1, otherwise v_i is 0.

3.3. Fit function

The fitness of a chromosome depends on how well that chromosome solves the problem at hand. Each chromosome involved in a population is evaluated by the following equation.

$$F = \frac{1}{\text{NMSG+DS+Degree\_of\_coldness}_i} . \qquad (2)$$

A *NMSG* means the number of messages communicated between BSs to find a cold cell. *DS* means a distance from the current cell to a searched cold cell. Degree_of_coldness$_i$ means a degree of load for a cell. Eventually, a chromosome with the highest fitness value in population is selected. Then the request messages are transferred to cells corresponding to bits set '1' in a selected chromosome.

3.4. Algorithm

A load redistribution approach using genetic algorithm in cellular mobile system consists of five modules. A Genetic_operation module consists of three sub-modules. These modules are executed at each BS in cellular mobile system.

```
{ Initialization()
   while (Check_load())
     if (Degree_of_coldness_i > T_up) {
        Chromosome_evaluation();
        Genetic_operation();
        Message_evaluation(); }
   Process a task in local processor;   }

Procedure Genetic_operation()
  { Mutation();
    Reproduction();
  Crossover();
```

In an Initialization(), a population of chromosomes is randomly generated without duplication. A Check_load() is used to observe its own cell's load by checking the Degree_of_coldness$_i$ whenever a call is arrived in a cell. If the observed load is a hot, the load redistribution activity performs the following modules. A Chromosome_evaluation() calculates fitness value of chromosomes in the population. A Genetic_operation() is executed on the population in such a way as follows. The following Genetic_operation() is applied to each chromosome, and new population of chromosome is generated:

Mutation()

Chromosome 1 is chosen. A copy version of the chromosome 1 is generated, and it is mutated. This new chromosome is evaluated by the fitness function. If the evaluated value of the new chromosome is higher than that of the original chromosome, it is replaced the original chromosome with the new chromosome. Next, the second chromosome is chosen. And above-mentioned mutation operation is done. This operation is applied to all chromosomes in the population.

Reproduction()

A reproduction operation is applied to the newly generated chromosomes. We use the "wheel of fortune" technique.

Crossover()

A crossover operation is applied to the newly generated chromosomes. These newly generated chromosomes are evaluated. We applied to the one-point crossover operator.
The Genetic_operation() selects a chromosome from the population at the probability proportional to its fitness value, and then sends off the request messages according to the contents of the selected chromosome. A Message_evaluation() is used whenever a cell receives a message from a different cell. When a cell c_i receives a message, it sends back an accept or reject message depending on its $\text{Degree\_of\_coldness}_i$.

Suppose that there are 25 cells in cellular mobile system, and the cell c_1 is a hot cell. Then the genetic algorithm is performed to decide a suitable cold cell. It is selected a chromosome by a proportional to its fitness value. Suppose a selected chromosome is <0, -, 0, 0, 0, 1, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0>. The hot cell c_1 sends a request message to the cells(c_5, c_6, c_{11}, c_{19}). After each cell receives a request message from the cell c_1, each cell checks its load. If the cell c_{11} is a cold cell, the cell c_{11} sends an accept message to the cell c_1. Then the cell c_1 borrows a channel from the cell c_{11}.

4. Simulation and analysis

We simulated several experiments to show the effectiveness on the proposed load redistribution approach in cellular mobile system. Our simulations have the following assumptions. Firstly, the load rating over systems is about 90 percent. Secondly, a number of channels in each cell are 25. And there are 50 cells in cellular mobile computing system. In genetic algorithm, the crossover probability(p_c) and mutation probability(p_m) are 0.7 and 0.1. A number of calls to be served are 5000. These values in p_c and p_m were known as the most suitable values in various applications [10-13]. The table 3 shows the detailed contents of parameters used in our experiments.

Table 3. Experimental parameters

Number of calls	5000
Number of cells	50
Crossover probability(p_c)	0.7
Mutation probability(p_m)	0.1
Number of channels	25

[Simulation 1] This simulation is to observe a search time for a suitable cell to lend a channel when the number of calls to be served is 5000.

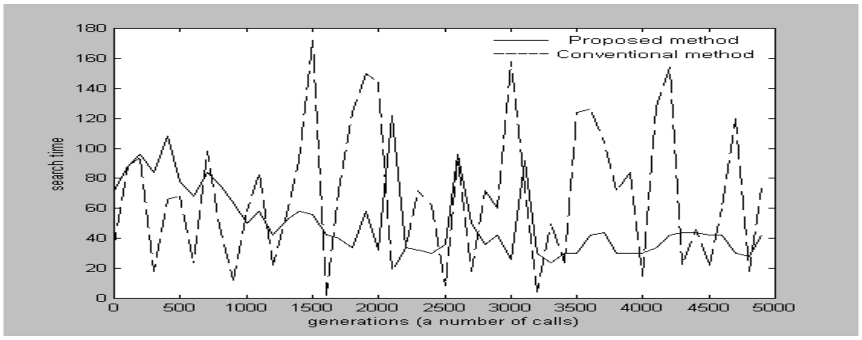

Figure 2. Result of simulation 1

From this simulation, we know the fact that the proposed algorithm has better performance than that of the conventional method. This enhanced performance results from the genetic_operation() process which generates better chromosomes in the current generation than that of the previous generation.

[Simulation 2] This simulation is to observe a convergence of the average fitness value for all chromosomes in the specific cell(c_2).

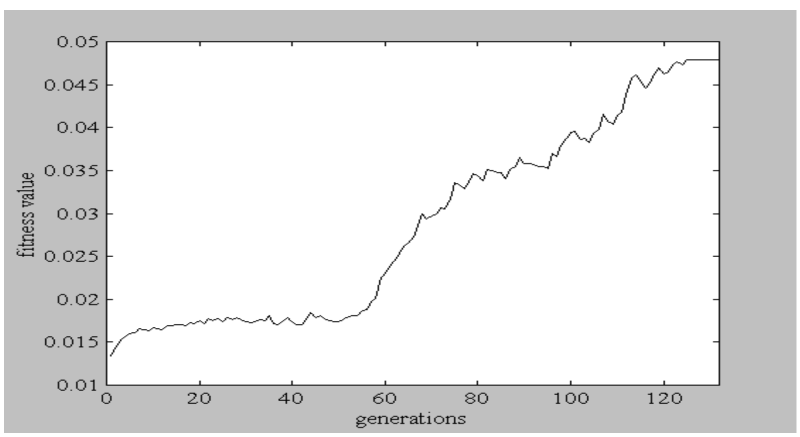

Figure 3. Result of simulation 2

Through this simulation, we know that the about 130 calls among 5000 calls adapted in the cell c_2. The fitness value is converged after about 100 generations are executed. From this simulation result, we know that the higher fitness function was made through more iteration until about 100 generations. The fitness of a chromosome depends on how well that chromosome solves the problem.

[Simulation 3] This simulation is to observe the convergence of the fitness value for the best chromosome in the cell c_2.

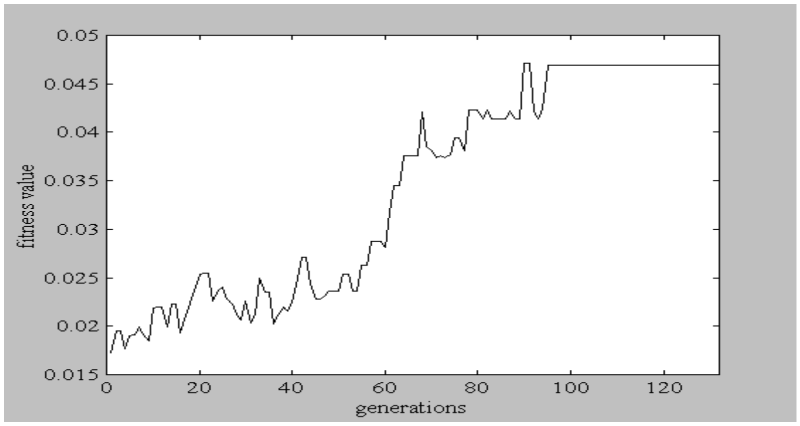

Figure 4. Result of simulation 3

5. Conclusions

The frequency channels are a scarce resource in a cellular mobile system. Thus, many schemes have been proposed to assign frequencies to the cells such that the available spectrum is efficiently used, thus the frequency reuse is maximized. We propose genetic-based channel allocation mechanism. The purpose of using genetic algorithm in this paper is to decrease search time for an available channel and is to migrate from a searched channel to a hot cell. The channel request messages are sent off to the cells in accordance with the contents of a chromosome. Through the simulations, we know the fact that the genetic algorithm approach can be improved a performance for channel allocation in cellular mobile computing environments.

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