OPTIMIZATION OF THE FIXED CHANNEL MODEL IN CHANNEL ASSIGNMENT PROBLEM USING SIMULATED ANNEALING

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"Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang tiap-tiap satunya telah saya jelaskan sumbernya."

Tandatangan : .....

Nama Penulis : NORHANI BT. ROMAN

Tarikh : 14/6/17

"Saya/kami akui bahawa saya telah membaca karya ini pada pandangan saya/kami karya ini adalah memadai dari skop dan kualiti untuk tujuan penganugerahan Ijazah Sarjana Muda Kejuruteraan Elektrik (Kuasa Industri)."

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PREFACE

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ABSTRACT

Recently, mobile communication technology is increasingly sophisticated and users have also increased. Because of it, the channel bandwidth is limited. To increase bandwidth in mobile communications is an expensive operation and it may lead to the wasting of bandwidth. Therefore, frequency reused is one of the techniques in mobile communications to improve utilization of bandwidth. In this study, channel assignment problems for fixed or static assignment of channels is studied and solved by using heuristic technique. An optimal solution is the assignment of channels to cells in network communication with the minimum interference. Simulated annealing (SA) is implemented to solve the channel assignment problem in fixed channel allocation in this study. Annealing is a process in which a solid material will heated to past its melting and then cooled to the frozen state. There have some crucial components of SA which are cooling schedule and neighbourhood structure. The algorithm is written into programming coding to maximize the reuse of the frequency with the minimum interference by using Matlab software. An analytical analysis is carried out to investigate the effects of different parameter values on the cost value that represents the interference level in calls.

ABSTRAK

Baru-baru ini, teknologi komunikasi mudah alih semakin canggih dan pengguna juga telah meningkat. Kerana itu, jalur lebar saluran adalah terhad. Untuk meningkatkan jalur lebar dalam komunikasi mudah alih adalah satu operasi mahal dan ia boleh membawa kepada pembaziran jalur lebar. Oleh itu, kekerapan digunakan semula adalah salah satu teknik dalam komunikasi mudah alih untuk meningkatkan penggunaan jalur lebar. Dalam kajian ini, masalah tugasan saluran untuk tugasan tetap atau statik saluran dikaji dan diselesaikan dengan menggunakan teknik heuristik. Satu penyelesaian yang optimum adalah tugasan saluran kepada sel-sel dalam komunikasi rangkaian dengan gangguan minimum. simulasi penyepuhlindapan (SA) dilaksanakan untuk menyelesaikan tugasan masalah saluran peruntukan saluran tetap dalam kajian ini. Penyepuhlindapan adalah satu proses di mana bahan pepejal akan dipanaskan ke masa lalu lebur dan kemudian disejukkan ke negeri ini beku. Ada mempunyai beberapa komponen penting SA yang penyejukan jadual dan kejiranan struktur. Algoritma yang ditulis ke dalam program pengekodan untuk memaksimumkan penggunaan semula frekuensi dengan gangguan minimum dengan menggunakan perisian Matlab. Analisis dijalankan untuk menyiasat kesan nilai-nilai parameter yang berbeza pada nilai kos yang mewakili tahap campur tangan dalam panggilan.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

SA	-	Simulated Annealing
CAP	-	Channel Assignment Problem
SCA	-	Static Channel Assignment
DCA	-	Dynamic Channel Assignment
HCA	-	Hybrid Channel Assignment
SIR	-	Signal-to-Interference
TS	-	Tabu Search
GA	-	Genetic Algorithm

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1 Research Background

Nowadays, people who communicate using mobile communication devices is increasing due to advances in technology. Mobile communications leads to an increase in the use of mobile phones causing limited radio spectrum. The radio signal is used as a medium of information will provide a communication system known as mobile communication. Therefore, what is important in designing mobile communication system is resource management. Resources are managed effectively is indispensable because the radio frequency spectrum is limited. Bandwidth allocation is limited; therefore, reused frequency or channel is one of the best ways that can improve bandwidth utilization. This is recognized as the channel assignment problem (CAP). Channel assignment was to reduce the overall interference while continuing to meet the demands and requirements of the channel. Furthermore, it is to reduce rejection of calls by passing off to call busy.

From one point to another point communications, which is a radio equipment communicates with another placed somewhere else in the world have a strong limitations. A very strong signal is require due to communicate through far distances. In addition, a different communication channels are use when many people use the communication equipment at the same time. The signal must not have too high a frequency when the long distance communication, otherwise it would be stopped through any obstacle, and this limits the amount of operating bands.

It is classified into two types: static channel assignment (SCA) and dynamic channel assignment (DCA). The combination of the two types yields Hybrid Channel Assignment (HCA). In the geographical area, static channel allocation has been split into several cells. In addition, a number of channels allocated to each cell with different patterns depending on the channel re-use demand and continuing need. Put all frequencies in pool, dynamic channel assignment can provide more flexibility and adaptability of traffic and it provides a channel for a new call [1].

According to interference and traffic constraints in the static channel assignment strategy every cell is permanently a set of nominal channels. Before the system is activate, deciding which channels should be assigned to which cells is needed in the assignment policy. In simplest form, a static channel assignment algorithm will allocate the same number of channels to every cell. Due to that, the set of channel is partitioned into a number of subsets of equal cardinality. For example, consider in the common hexagonal tiling as shown in Figure 1.1. As shown at right of figure, the partitioned three subsets which is numbered 1, 2 and 3 is the set of available channels. Meanwhile at the left of figure, indicate the possible assignment for a reuse distance equal to two.

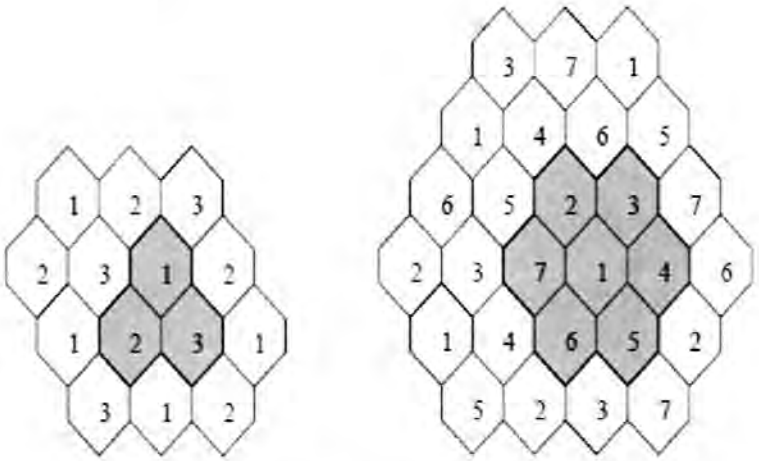

Figure 1.1: Reuse schemes for interference distance[2].

In communication network application, there have two endpoints of the connection where as a fixed antenna and mobile phone. A mobile phones can be pick up at a certain area was cover by each antenna. For a specific region (cell) have cover by each antenna and can assist several network units simultaneously. The frequencies assigned to each antenna must satisfy a number of requirements that depend on the availability, interference levels, technological requirements and size of the area with unacceptable interference[3].

Interference occurs when two users will be sent at a frequency near the radio spectrum. A radio interference susceptible to both external and internal sources when channels are allocated to cells in the communication network. The structure of the building is outside interference happens because the device does not participate in the network, while the channels are spectrally close in frequency domain and receive publications considered geographically close enough internal interference. Therefore, channel allocation is required to receive a call like that the ratio signal-to-interference (SIR) is maintained at an acceptable level. These interference can be classified into three categories with respect to the channel allocation problem are as follows:

- *Co-cell interference*: minimum interference between two channels allocated in the same cell.
- *Co-channel interference*: the same channel cannot be provided in other cells at the same time.
- *Adjacent channel interference:* interference between two adjacent cells allocated to the channel

In this study is aims to apply the approach of heuristic techniques to manage bandwidth allocation of property in the static channel assignments as accessibility is maximized and thus interference between channels is reduced. Channel assignment problem in a static channel complete with simulated annealing algorithm.

1.2 Problem Statement

Nowadays, mobile communication is common throughout the world. People using mobile phone either for calls or messages. Requirements channel are increased from time to time. Therefore, research are needed to provide an efficient channel to minimize disruption to services and maximizing the frequency reuse.

The formulation formed in the static channel assignment (SCA) regarding to the estimate traffic to meet the direct future demand. In a region, there is N is non-overlapping cells and M is the span of channels. While D is the demand vector that specify the channel demand in each of the cell. The minimal separation distance between the channel assigned in cells i and j is presented in compatibility matric C_{ij} which is $N \times N$ a matrix dimensions.

For the diagonal term, $C_{ii} = 5$ represent the co-cell interference constraints where any two channels allocated in cells i must be at least five frequencies apart. $C_{12} = 4$ means the channel assigned in cells one and two must be at least 4 frequencies

apart. Furthermore, off-diagonal terms of $C_{kj} = 1$ known as co-channel and $C_{ji} = 2$ known as adjacent channel. Meanwhile, $C_{ji} = 0$ is the same frequencies can be reused.

$X_{j,k}$ is set of binary variables are definite as follows:

$$X_{j,k} = \begin{cases} 1, if\ channel\ k\ is\ allocated\ to\ cell\ j \\ 0, otherwise \end{cases}$$

The way to measure penalty cost function by a cost tensor $P_{j,i,m}$ where m = $|k - l|$ which is the distance among channels k and l assigned at cells i and j, respectively. To obtain free-interference the cost decreasing must be far enough apart between two channels. Channel assignment problem in SCA formulated as zero and with the objective function of costs to be reduced. The cost function is shown below [4] and the penalty cost is known as cost value in the project:

$$F(X) = \sum_{j=1}^{N}\sum_{k=1}^{M} X_{j,k} \sum_{i=j}^{N}\sum_{l=k+1}^{M} P_{j,i,m}\ X_{i,l}$$

Formally the cost tensor can be generated from compatibility matrix as below:

$$P_{j,i,m} = \max\{(C_{j,i} - m), 0\}, \text{ for } m = 1,\ldots\ldots,M;$$

Cost tensor P is a three-dimensional matrix with diagonal elements are zero, while the first and second dimension is equal to the compatibility matrix [5].

1.3 Objective

There have several objectives as state below:

i. To optimize allocation of channels in mobile network with the minimum interference.

ii. To implement simulated annealing in channel assignment problem.

iii. To investigate the effect of different parameter values on the cost value.

1.4 Scope

In this project, the number of cells, available of channels and call demands are scoped to 21, 51 and 112, respectively. Matlab software is used to code the simulated annealing algorithm for simulation progress.

1.5 Significance of Study

Frequencies that are usable for communication purpose is a limited resource. Equal frequency can be reused in non-adjacent cells caused by mobile phones and base stations are the use of low power transmitters. To maximize the usage of available frequencies or channels need to be reused. Reuse the channels must be assigned in such a many interference between two channels being is minimized. Towards making more effective use of radio resources is accessed by using the frequency reuse.

1.6 Expected Project Outcome

Channel assignment problems have been going on since the demand in mobile phone use increases. Therefore, to solve the fixed channel model of channel assignment problem solution must be all constraints satisfied with the minimum interference. This solution will solve the development of simulation algorithms using MATLAB software.

CHAPTER 2

LITERATURE REVIEW

2.1 Literature Review on Related Works

Heuristic techniques have used to solve the channel assignment problem. In year 1978, an automated heuristic assignment technique in which channel requirements that proved themselves to be difficult, were solved by Box [1]. Besides that, heuristic techniques are capable to solve complex channel assignment problem, for fixed channel assignment and dynamic channel assignment problem. A heuristic is a one of technique that gives near optimal solutions at reasonable computational cost without being able to guarantee either probability a particular practical solution [1]. Anyway, it is useful in obtaining a satisfied solution for most of the problem where exact solution is unaccusable. Heuristic algorithm can be used to solve an optimization problem. The different methods in heuristic techniques have been suggested, containing local search algorithm, simulated annealing, tabu search, neural networks, genetic algorithm and cultural algorithm.

Simulated annealing is one of the method to solve the channel assignment problem in static channel allocation. Simulated annealing is a single solution based on meta-heuristic. SA is a common method for an approximate solution of an optimization problem that proposed by Kirkpatrick et al. [6]. Simulated annealing is a method can be used if want to maximize or minimize something. Simulated annealing (SA) is a stochastic computational technique established from principles of statistical mechanics to discovered near globally minimum cost solutions to large scale combinatorial optimization problem [7].

2.2 Review of Previous Simulated Annealing

In year 1953, Metropolis's algorithm to match the energy of the system changes the subject to the cooling process; system focused on the final frozen state until certain energy [8]. Annealing is a process in which the solid material is heated up past its melting point and then cooled back into a solid state. After melting the solid material, it is slowly to solid state at any given time melt temperature to reach thermal equilibrium budget. The Metropolis simulation can be used to find solutions for problems that can be implemented with the objective of focusing on the optimal solution [6]. Thus, annealing can be simulated using computer simulation.

A quite time-consuming procedure referred as traditionally simulated annealing which to upkeep must be taken to continue close to equilibrium so as not be fixed in highly local minima[9]. The results of optimality is transferred from finite-time thermodynamic to the context of simulated annealing and through the estimation that constant thermodynamic speed is also the optimal annealing schedule. Therefore, to keep the system near to equilibrium during the complete annealing process by a consequence of their schedule. SA is a random-search technique which is feats an analogy between the way in which a metal cools and freezes into a minimum energy crystalline structure (the annealing process) and the search for a minimum in a more general system[10]. Thus, an analogy of simulated annealing to statistical mechanism is to solve the combinatorial optimization problems.

According to the various method approaches to solving CAP, thus the tabu search (TS) and simulated annealing are presented and compared. Tabu Search meta-heuristics are created to solve hard of large combinatorial optimization problems [7]. TS can be illustrated as a type of neighborhood search with a set of significant and complementary components. In contrast to local search and tabu search, SA does not generate an entire neighborhood but creates it one at random and then evaluates it. With the comparison between two methods approaches are presented which SA is more efficient than the TS. Some small samples test for these methods is shown Figure 2.1. Besides that, SA also have a similar with TS which is allows for non-improving moves.

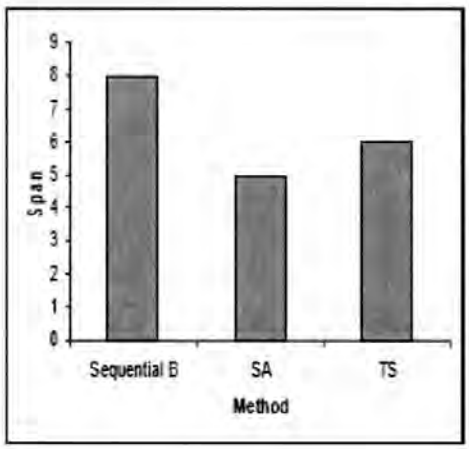

Figure 2.1: Comparison of Algorithm for 15 nodes [7].

The x-axis represent the algorithms used and the number of channels used by each algorithm is represented by y-axis. The simulated annealing and tabu search are tested on two instances having 15 nodes. Besides that, it is also compared to the sequential B algorithm. From the test, it shows that simulated annealing method performs better.

From the various trials conducted by researchers it has been shown that the simulated annealing and genetic algorithm (GA) became two very effective heuristic method for the channel assignment problems [11]. In communication network, to overcome the problem according to the procedures in accordance with the process of evolution by natural selection, known as genetic algorithms [12]. Meanwhile, to solve large scale combinational optimization problem by simulated annealing as an effective algorithm. Thus, to complete the channel assignment problem with new mechanisms and operators of genetic algorithms and simulated annealing recommended. The major idea is to use a traditional approach of genetic algorithm exploring the simultaneously in some areas in the search space and simulated annealing for an enhance search around a few of the selected area at the same time combine as a good mechanism [11]. But then, because of the importance assigned to frequency of radio cells have a certain distance within the frequency domain, this an approach which was considered the solution initialization.

There are plenty of optimization algorithm such as the uphill, genetic algorithms, local search, tabu search, gradient descent and more. But then, to avoid getting caught at local maxima which means the solution that are better than others nearby is strength of simulated annealing algorithms. For annealing simulation, it is known as iteration of improvements scheme (local search) based on the additional parameters: temperature, decrement function and more. And therefore, simulated annealing are an excess of general applicability for an all test conditions and abilities to achieve good quality solutions more consistent. In addition, the major advantages of simulated annealing over other methods are frugality and capability to jump out of local minima [6].

Simulated annealing is a firm and general technique in which can deal with highly nonlinear models, disordered and noisy data and many constraints. It is a method that consider a several practical issues which is the maximum temperature, the scheme for decreasing temperature and the strategy for proposing updates. Since the algorithm does not rely on any restrictive properties of the model, thus it is quite