OPTIMIZATION OF CHANNEL ASSIGNMENT IN MOBILE COMMUNICATION USING TABU SEARCH

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A Report Submitted in Partial Fulfilment of the Requirements for the Degree of Bachelor of Electrical Engineering (Power Industry)

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DECLARATION

I declare that this thesis entitle "Optimization of Channel Assignment in Mobile Communication using Tabu Search" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : …….

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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electrical Engineering (Power Industry).

Signature	:	……
Supervisor Name	:	DR. LOH SER LEE
Date	:	……

DEDICATION

This project is dedicate to my beloved family especially my father, Amat Ali bin Sapan, my mother, Asparala binti Tarmin, and my siblings. Thank you for all your support and encouragement to me.

ABSTRACT

Mobile communication is a process of exchanging information by connecting between two parties through a wireless network. It is being connected through existing channels in a particular coverage region. Practically, mobile communication system involves a large coverage area that serves a large geographical area. However, there has only limited channels to accommodate all the users. With the increasing number of mobile users recently and the existing channels are limited, it leads to channel assignment problem (CAP). In order to prevent the channel assignment problem from getting worse, an initiative is taken to reuse the existing channels in an efficient way with the minimum interference occur in the channels assignment. This helps to optimize the usage of the channel assignment in mobile communication. Basically the channel is reused in such a way the interference between the assigned channels is minimized. Tabu Search (TS) technique is implemented to solve the CAP by searching for the global optimum solution with the minimum interference cost value. Interference cost value represents the severeness of the interference occurred among the channels assigned. The optimization process is implemented by first determine the initial solution. Then, the chosen initial solution is used to generate the neighbourhood solutions. The reallocated channels are being analysed the value of the penalty cost based on the penalty cost function. The process keeps repeating until the termination criterion is satisfied. Among the available solutions, the solution with lowest penalty cost function is chosen as the final solution. The optimization of the channels assignment is a process of reducing total channels required as the solution is improved. An analytical analysis is carried out to investigate the effect of demand calls and the number of available channels on the cost value. The results are being compared by varying the demand required in the channel assignment with different number of channels used.

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RF	-	Radio Frequency
MIN	-	Mobile Identification Number
MSC	-	Mobile Switching Centre
BS	-	Base Station
CAP	-	Channel Assignment Problem
SCA	-	Static Channel Assignment
DCA	-	Dynamic Channel Assignment
HCA	-	Hybrid Channel Assignment
U.S	-	United States
AM	-	Amplitude Modulation
FM	-	Frequency Modulation
GA	-	Genetic Algorithms
NNs	-	Neural Networks
SA	-	Simulated Annealing
TS	-	Tabu Search
AI	-	Artificial Intelligence
FDMA		Frequency-Division Multiple Access
TDMA		Time-Division Multiple Access

CHAPTER 1

INTRODUCTION

1.1 Introduction

In globalization era nowadays, communication is one of the interesting parts for exchanging information among people. Mobile device is widely used for a communication network system. Communication process is propagating through a radio frequency medium. Radio Frequency (RF) is a form of electromagnetic wave frequencies which is in a range extending from around 3 kHz to 300 GHz; including the frequencies that are normally used for communications or radar signals.

Each mobile has its own Mobile Identification Number (MIN). In processing a call request, it involves two main components which are called Mobile Switching Centre (MSC) and Base Station (BS). Generally, wireless networks communication are organised in geographical cells. Each of the cells is consists of a few existing channels that is being controlled by a Base Station (BS) [3]. Meanwhile for the whole BS, it is controlled by MSC. Then, for a user that is making a call request to MSC, it is a process communication between the caller and the receiver.

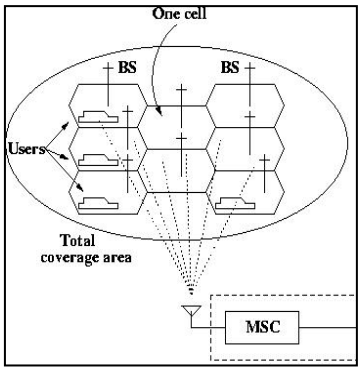

Figure 1.1: Each of base station is represented as one cell [1]

Then, the MIN of receiver will be sent to MSC. The MSC will process the MIN by sending the MIN to all BS which under control of it to find out the location of the call receiver. After that, the respective BS will send signal back to MSC to report that the mobile is within its area of cells. Next, the MSC will order the BS to access the unused voice channel pair to the pair of caller receiver to communicate [1].

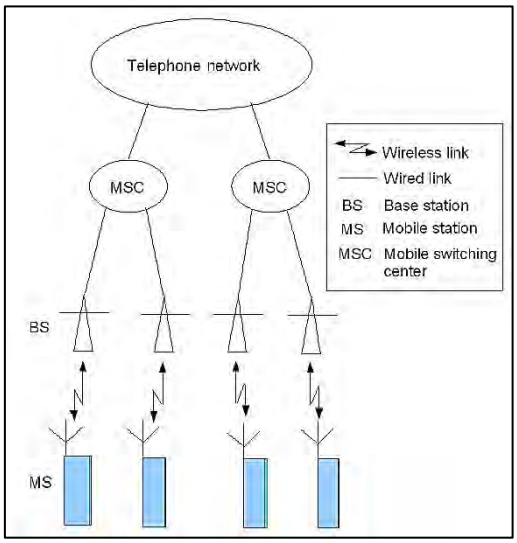

Figure 1.2: Structure of basic mobile communication [1]

Since the number of mobile users is increasing, therefore the need of the channel is increased. Mobile communication needs unused voice channel pair. Basically in communication system, there will be source and destination for the information to be transferred. The information is being transferred from source by using channel to the destination. Channel is a flow path for the information to be transferred. The channel has different range of frequency. Each frequency range has its own purpose of usage.

Therefore, as the amount of consumer increasing recently, the need for the limited existing channel is also increased.

In order to optimize the usage of channel, the strategy of channel reused is needed. Unfortunately, the strategy may lead to interference along the communication process. Interference is categorized into three types. Firstly, co-channel interference is when a communication process is occurred in the same channel is being assigned for a few cells from different BS. Secondly, adjacent-channel interference is when channel is in adjacent positions in radio spectrum is being used in a cell which in adjacent positions too, and thirdly co-site interference is when the adjacent of channel is being assigned in the same cell and they are not separated away from one to another by the smallest distance of separation in frequency range [4].

There are three models in channel assignment problem (CAP) which are Static Channel Assignment (SCA), Dynamic Channel Assignment (DCA) and Hybrid Channel Assignment (HCA). SCA is known as channel assignment that is consists of a fixed number of unused voice channels assigned in each of cell for communication process. Then for DCA is channel assignment that is temporarily being assigned in a cell along the duration of a call is being made. The channel of the call used will be changed based on the nearest location of the BS. The probability of a call is being rejected by using DCA model is reduced. For this project, SCA is used to assign the channels in cells based on the demand.

1.2 Motivation

Mobile device is widely used nowadays. By the development of technologies in mobile is increasing, wireless mobile communication is commonly used. It was caused the users growth rate reached 50 percents per year. It shows that users is increasing day by day which from 8000 users in year of 2000 until it is reached 35000 users by the end of year 2007 [1]. However, due to the limited available channels in mobile communication, it leads to plenty of problems such as call rejection or noise sound effect. Interference between channels in a call occurs when the frequency constraints are not fulfilled in the channel assignment. Hence the optimization of channel assignment is important in order to provide

a good quality service to the subscribed mobile users. Since mid-1990s, many methods have been proposed to solve the channel assignment problem [4]. Researches on channel assignment were started to be carried out as the communication problem appeared. Tabu search is a popular optimization technique that can be used to produce an optimal solution of the interference to avoid from any rejected calls due to limited existing channels assignment.

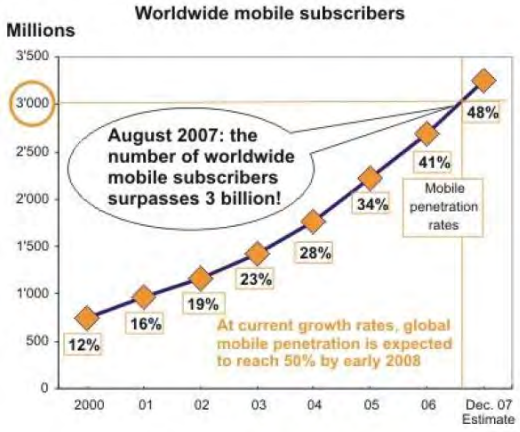

Figure 1.3: Statistics of worldwide mobile subscribers from year 2000 until 2007 [1]

1.3 Problem Statement

Practically a region is divided into N cells and there are M available channels to serve the calls. In a cell, it consists of a certain number of channels. In order to make a successful call, a channel is needed per call. The amount of available channels at a particular time depends on the usage of the line communication. If the calls being made in a time is more than the available channels, the call without getting assigned to a channel will be rejected due to no available channels in that cell. Hence, the channel assignment to call in every cell need to be optimized based on the demand from experience. Meanwhile the amount of interference occurred in the channel during a call need to be reduced.

On November 2015, United States (U.S) population statistics shown that 87 percent of people those ages 18 years old and above owned mobile phone. It stated that, an increasing percent of people owns smartphone: the survey shown that 77 percent smartphone ownership rate among those with mobile phones is a substantial increase over

the 71 percent rate reported in 2014, 61 percent in 2013, 52 percent rate in 2012, and 44 percent rate in 2011 [2].

Based on the past experience, the demand in cell j is recorded and represented by one-dimensional matrix channel demand, D_j. The constraint of the channel assigned between cell i and j is the minimum separation of the frequency, $C_{i,j}$ called non-interference constraint. It is given in a four-dimensional matrix C of row, i and column, j. The set of binary, $X_{j,k}$ shows that channel k is assigned to cell j if $X_{j,k}$ equals to value of one. Otherwise, it will be zero value.

To achieve interference-free assignment, the constraint of $C_{i,j}$ must be satisfied. However, slight interference is allowed to increase the availability of channels. If the minimum separation constraint is violated, an interference will occur and a penalty value will be imposed by cost tensor, $P_{j,i,m}$ where m is distance between channels assigned to cells i and j. The value of the cost tensor shows the degree of the interference occurred.

The penalty cost function shows the severeness of the interference occurred among the assigned channel. In this project the penalty cost function value is called cost value. The problem formulation for the static channel assignment models is stated as followed [5].

The penalty cost function is shown as follows:

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

where $m = |k - l|$.

Next, a set of binary variables is illustrated the assigned channel by:

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

where $j = 1, 2, 3, \ldots, N$; $k = 1, 2, 3, \ldots\ldots, M$.

The relationship between set of binary variables, $X_{j,k}$ and the demand requirement of the channels in each cells, D is shown as below expression:

$$\sum_{k=1}^{M} X_{j,k} = D_j \quad , \quad j = 1, 2, 3, \ldots, N ; \quad k = 1, 2, 3, \ldots, M$$

The cost tensor, P is stated as below:

$$P_{j,i,m} = \max \{ C_{j,i} - m , 0 \}$$

where $C_{j,i}$ is a matrix C with row j and column i.

A penalty cost or cost value, $F(X)$ is being charged due the interference of the channel occurred. It can be calculated based on the penalty cost function above. The higher the amount of the penalty cost, it shows that, the stronger the interference occurred of the channel among the cell. The penalty cost will be decreased when the channel k and l are far enough from each other. Then, interference will be diminished. The formula purpose is to minimize the total cost of penalty occurred.

1.4 Objectives

There are two main objectives associated with this project, which are:

a) To optimize the channel assignment in mobile communication by minimizing the interference cost value.
b) To implement tabu search in channel assignment problem.
c) To investigate the effect of demand calls and number of available channels on the cost value.

1.5 Scope

Channel assignment in this project targets the application of mobile communication where calls are being made through channels in a cell. The model used is a Static Channel Assignment (SCA) where channels are assigned based on the demands in the region. In this project, tabu search technique is being used. The coding of tabu search is produced by using MATLAB software. A penalty cost function is used to show the severeness of channels interference. As the demand recently in communication network increased, the demand of the channel assignment is varied and the affect towards the interference occurred is analysed.

1.6 Significant of Study

The main concern of this project is the optimal allocation of limited channels in mobile communication. Lower interference gives higher communication quality to mobile users. An optimal solution where the value of channel interference is minimized and at the same time the usage of available channels are maximized, will lead to efficient communication between users.

1.7 Project Outcomes

This project on optimization of channel assignment problem will be solved by running simulation to minimize interference occurred among the existing channels assign. The higher the value of the interference occurred, the lower the quality of the call. In order to get the optimal solution, the process of creating immediate neighbourhood of the current best solution in the hope of finding an improved solution is continue until a prefixed attempt limit is reached. An analysis will be carried out to investigate the effect of demand calls and number of available channels on the cost value.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

In this section, literature review on channel assignment problem from the first problem appeared and the development of heuristic techniques are presented. Heuristic techniques are popular in optimization problem and it has been applied by researchers in various types of combinatorial optimization problem, including channel assignment problem.

2.2 Literature Review

The development of mobile is basically from the improvement of the first wireless telephone system. It has been introduced and used in the year of 1877s. Communication medium is started by using Amplitude Modulation (AM) of radio frequency in early 1934. After that, the development of the frequency is improved by using Frequency Modulation (FM) [1]. As the demand of new system is need for better mobile radio network, then FM proved it gives more quality and efficient system compared to AM. It is developed by Edwin Armstrong whose witness many improvement of communication system at that time [1].

Twelve years later, mobile device has been introduced and published. At the beginning, not many people own it and make it as one of their needed [1]. Then, the awareness of people on importance of having mobile as one of the important medium for communication between two parties is increasing, the very first channel assignment

problem is occurred in early 1960s [4]. As the users of mobile increasing, the available frequency or channels is limited. It has been found that the first network shows insufficient of the frequency usage when wireless service is being used.

A survey is made to have a clear view on the smartphone usage among U.S people. It is conducted on 2015, which the survey suggested that mobile phone ownership varies slightly by race and ethnicity. It shows that as time goes by from 2011 until 2015, the smartphone usage among the race/ethnicity is increasing rapidly. Adoption of smartphones in the Mobile Survey in 2015 varies in a somewhat more pronounced way: 82 percent of Hispanic mobile phone users have a smartphone, compared to 74 percent of non-Hispanic whites and 76 percent of non-Hispanic blacks. Among those with a mobile phone, smartphone ownership is also higher (88 percent) for the "Other, non- Hispanic" group, which includes respondents who report their race as Asian, American Indian or Alaskan Native, Hawaiian, or Pacific Islander[2].

Race/ethnicity	Smartphone usage				
	2011	2012	2013	2014	2015
White, non-Hispanic	41	50	57	68	74
Black, non-Hispanic	47	54	63	66	76
Other, non-Hispanic	45	54	76	83	88
Hispanic	55	60	72	82	82
2+ races, non-Hispanic	43	59	64	65	79
Total	**44**	**52**	**61**	**71**	**77**
Number of respondents	2,002	2,291	2,341	2,603	2,244

Note: Among respondents with a mobile phone.

Figure 2.1: Smartphone usage by race/ethnicity [2]

Until today, various heuristic techniques are being used to solve variety of channel assignment crisis occurred. It is being used for the SCA or DCA models by implement it in Genetic Algorithms (GA) [6], Neural Networks (NNs), Simulated Annealing (SA) [7] [8], Tabu Search (TS) [4] [8] [9], and Artificial Intelligence (AI). The main objective of the CAP is to assign the existing channels to call so that the usage of channels is being maximized, since the channels are limited. Then, interference between the frequencies (channels) is needed to be optimized to minimum value. At the same time, the number of frequencies on each of base station must be large enough to satisfy the demand in the cell.

Based on the previous research, there are many algorithms and problem formulations can be applied in many applications problem. Heuristic techniques solve problems by giving a close-optimal solution at a relevant computational cost. It is non-algorithmic methods that are applied to algorithmically complex channel assignment problems to generate efficient solutions [3].

Besides, a research is being carried out on cellular radio of channel assignment to solve CAP by using simulated annealing technique since the previous project is based on the graph coloring algorithms. The research shows the design neighbourhood structure of channel allocation of cellular radio gives positive impact on quality and efficiency of the channel assignment [6].

Theoretically, simulated annealing is used to solve problem that involve discrete optimization problem examining the equation and the state of systems which is involved temperature. It is one of method that has ability to jump out of local minima to search for a better solution. It is applied on conditions of cooling schedule of the system which involved initial temperature and it will be solved until get the slow cooling process which the temperature is decreased [6].

The optimization problem as a cost function is representing the temperature of the system. It is a solution method that has been developed for obtaining approximate solutions to minimize the temperature as the system requirement [10]. By simulated annealing approach, it guarantees the optimal asymptotically, but the rate of cooling process is rather slow when the process of finding optimum temperature is required [10]. Meanwhile based on the research of Albert Y. Zomaya, eventhough it is solved by using simulated annealing, a problem is arise at the end of the CAP of mobile computing. It cannot prove the quality service is good and optimum allocation schemes, since its main constraint is temperature [11].

Next, a project is being done for a new strategy by applying GA method to the CAP. In that case, rather than channel assignment problem involved temperature, it is being analysed based on system that using frequency-division multiple access (FDMA) without any time-division multiple access (TDMA). It was focused on the optimum call list not necessarily optimize the frequency assignment. Their proposed algorithm produced

zero interference and able to achieve local minima during the optimization process for all the problem [6]. Eventhough it is focused on optimization of channel assignment, the usage of the frequency is not efficient. It shows that genetic algorithm only solve the channel assignment problem by allowing the co-site interference conditions.

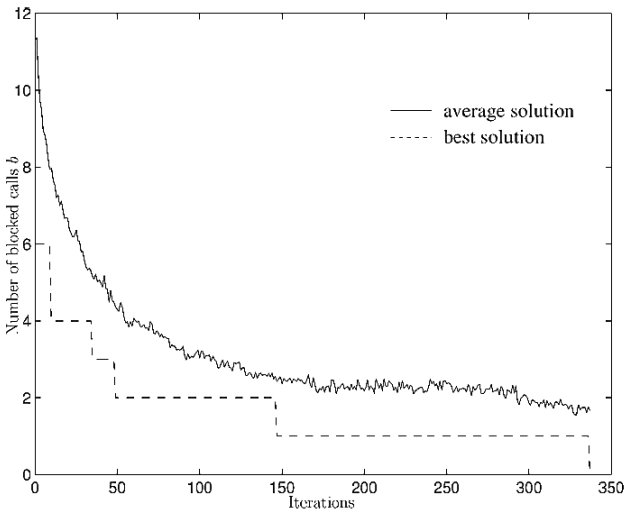

Figure 2.2: Number of blocked calls is reduced as the solution is being improved [7]

Since then, a tabu search techniques is suitable to be used in order to make the channel assignment used efficiently by allowing of any interference occurred, but for searching better solution interference free is preferable. Basically, tabu search was first explored in 1977s [5]. It is consisted of classical tabu search and reactive tabu search. Normally, classical tabu search is used to solve channel assignment problem. It is based on list of neighbourhood data with a set of critical and corresponding components referred to the channels requirement [12].

Tabu search technique is started by having an initial solution to solve the CAP. Then, arrange neighbourhood by tabu move to allocate the channel available to indicate best initial solution which is having the optimum of interference or free interference. In a better way, it is determined by avoiding from any interference occurred [3]. Tabu search is an easy approach and simple technique which can produce a better result. The research paper on tabu search started being produced on tabu search algorithm in channel assignment problem [13].

Research previously proved that tabu search have a better speed in order to generate the best solution compared to simulated annealing and genetic algorithm [14]. It is found that, tabu search technique is much better when the neighbouring allocate is included in long-term memory. Tabu search is shown to give a better result and is proven to be the most effective algorithm for CAP as it produces a better average interference value based on a few problems that is being tested [4].

Recently, a research was conducted to improve tabu search algorithm [15]. Furthermore, eventhough tabu search cannot efficiently solve the problem involving topic optima, this technique can be repeated to solve larger problem in a short time or less iterations [8]. Next, channel assignment problem in mobile communication has been improved by using reactive tabu search techniques.

Basically it has been improved based on classical tabu search which is the repeating process to search for better solution to the problem is clearly state maximum number of iterations required based on the formula of tabu tenure. The research found that, tabu tenures will be greater than the set of maximum number of iteration. It shows that, once the channel assignment is stored as tabu list, the next solution that have the same channel assign will never be considered again [9]. Then, tabu tenure is much clear to be used as reference in term of classical approach, but for better approximation of iteration number reactive approach is much better.

Based on previous research, tabu search technique will be reproduced and validated by doing analytical analysis on the relationship of number available channels and the cost value will be conducted. The repeating process to get the optimum value of interference will be needed by targeting interference free. Besides that, the usage of the existing channel will be increased by using tabu search compared to genetic algorithm.