"I admit that I had read this report and in my opinion this report is sufficient in the manner of scope and quality, to be awarded with Bachelor Degree of Electronic Engineering (Industrial Electronics)".

Signature : _____

Supervisor Name : Zahariah Manap

Date : 31 MAC 2005

A MICROCELL/MACROCELL CELLULAR ARCHITECTURE IN A HIERARCHICAL TOPOLOGY CELL

MOHD ZULKIFLIE ALI BIN MOHD GHAZALY

This Report Is Summited In Partial Fullfillment Of Requirement For The Bachelor Degree of Electronic Engineering (Industrial Electronic)

Fakulti Kejuruteraan Elektronik & Kejuruteraan Komputer
Kolej Universiti Teknikal Kebangsaan Malaysia

March 2005

"I admit that this report is done my own effort accept for the summary and statement which I had already mention the source from".

Signature : 

Author Name : Mohd Zulkiflie Ali Bin Mohd Ghazaly

Date : 31 MAC 2005

Specially dedicated to my beloved family and Noraisah Kamarudin

ACKNOWLEGMENT

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MOHD ZULKIFLIE ALI BIN MOHD GHAZALY
NO. 1275, JLN SENAI UTAMA 1/1, TMN SENAI UTAMA,
81400 SENAI, JOHOR BAHRU, JOHOR.

ABSTRACT

Ever since the first analogue mobile cellular was launched 15 years ago, the growth and demand for the cellular communications have never reached its saturation stage. The technological change from analogue to digital and now merging of cellular mobile and Personal Communications System (PCS) have already taken place. All of these changes will tremendously increase in the number of mobile communication users but it still can be considered a costly and inefficient revolution. One way to decrease total system cost and improves efficiency in future mobile communication system is a structure with cells covering the same area. This is often referred to as a Hierarchical Cell Structure (HCS). This gives the possibility of system where Micro cells (mC) provide the capacity such as hot spots and macro cells (MC) provide large area coverage. Other reasons for an HCS could be, to handle fast moving terminals, to handle new type of services such as higher data rates in small areas or private systems such as home base station. In this project, a programme that simulate algorithm used in HCS will be develop using Matlab.

ABSTRACT

Sejak selular mudah alih analog pertama diperkenalkan 20 tahun dahulu, perkembangan dan permintaan terhadap komunikasi selular tidak pernah mencapai tahap optimum. Perubahan demi peubahan dalam teknologi senantiasa berlaku, daripada sistem analog kepada system digital sehingga kemunculan selular mudah alih dan Sistem Komunikasi Peribadi. Segala perubahan teknologi telah memberi impak penambahan bilangan pengguna komunikasi mudah alih namun demikian ia memerlukan kos yang tinggi and merupakan suatu revolusi yang kurang efisien. Satu kaedah untuk mengatasi masalah ini demi sistem komunikasi mudah alih masa hadapan adalah dengan mengaplikasikan suatu struktur yang mengandungi sel yang akan meliputi kawasan yang sama. Kaedah ini dikenali sebagai Struktur Sel Hierarkikal (SSH). Ini menyediakan suatu kebarangkalian kepada sistem di mana mikrosel menyediakan kapasiti seperti tumpuan utama, dan makrosel pula menyediakan kawasan yang mempunyai liputan yang luas. Fungsi lain ke atas aplikasi SSH adalah untuk mengendalikan terminal yang sentiasa bergerak pantas selain untuk mengendalikan perkhidmatan-perkhidmatan baru seperti perkhidmatan yang mempunyai kadar maklumat yang tinggi di kawasan yang kecil atau sistem peribadi seperti stesen pangkalan di rumah. Dalam projek ini,satu aturcara yang akan mensimulasikan algoritma yang digunakan di dalam SSH akan dibina dengan menggunakan Matlab.

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ABBREVIATION

CDMA	-	Code Division Multiple Access
DCCH	-	Dedicated Control Channel
PCS	-	Personal Communication System
HCS	-	Hierarchical Cell Structure
mC	-	Microcell
MC	-	Macrocell
MAHO	-	Mobile Assisted Handoff
GUI	-	Graphic User Interface

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CHAPTER I

INTRODUCTION

1.0 Introduction

Cellular radio system is a new design of communication that is getting popular in this new century. Eventhough the system has been developed years ago, new research is still being developed to upgrade the system performance in order to fulfill the borderless demand from of user. A body of world telecommunication which is called Conference of European Posts and Telegraph (CEPT) has introduced the first standard of digital mobile radio that is called Global system of Mobile (GSM). With this initiative more standard have been designed such as Digital Cellular System (DCS 1800) to enhance more national roaming besides global roaming.

Malaysia is aware about the needs of this telecommunication demand so a guideline called National Act of Telecommunication was been established in 1994 and it was a starting point of the basic of country's telecommunication development. In 1996, located in CyberJaya Cyber City, Multimedia Super Corridor (MSC) was officially launched in Malaysia to show the world that Malaysia is on the way to embark a new arena of compatible competitor in telecommunication among developing country.

Nevertheless, no matter how well a system is being built, there would definitely a slight weakness in the system. This includes the weakness in limited signal of frequency spectrum, received signal losing problem, handover problem and signal interference. Large dynamic range of received signal, the suppression of interband interference may not be sufficient to provide adequate Signal to Interference Ratio (SIR) all the times. Different mobile device have different capability to capture the signal from the Base Station (Bs). So the low capability and efficiency to signal captured have caused HCS less adapted to the device. In HCS, the structure of hexagonal is introduced as a cell for durability to find the signal received or Power Received (Pr) by the Bs. The efficiency of HCS also depends on SIR. In PCS environment, a mix of MCs and mCs as well as public and private systems might cover a geographic area. PCS uses HCS to accomplish this by identifying neighboring cells as preferred, regular or non-preferred.

1.1 Problem Statement

Large dynamic range of received signal, the suppression of interband interference may not be sufficient to provide adequate Signal to Interference Ratio (SIR) all the times. Different mobile device have different capability to capture the signal from the Base Station (Bs). So the low capability and efficiency to signal captured have caused HCS less adopted to the device. In HCS, the structure of hexagonal is introduced as a cell for durability to find the signal received or Power Received (Pr) by the Bs. The efficiency of HCS also depends on SIR. In PCS environment, a mix of MCs and mCs as well as public and private systems might cover a geographic area. PCS uses HCS to accomplish this by identifying neighboring cells as preferred, regular or non-preferred.

1.2 Objective Project

Mainly the objectives of this project is describe below :

a) To study the architecture, protocols, cell structure and algorithms used in PCS.
b) To study the architecture and algorithms used in the HCS.
c) To develop a simulator for the algorithms used in a mC/MC cellular architecture by using Matlab.
d) To analyze the performance of the algorithms used in a mC/MC cellular architecture.

1.3 Scope of Project

This is a project that was related to a wireless communication device usage. Mainly it focuses more to the mobile cellular device which had shown the most outstanding development in the century. And the research was developed to monitor the downlink or forward link (Base to Mobile) signal transfer only. Calculation was made on the Signal to Interference Ratio (SIR) and also on monitoring the power received by each mobile in the service area using the Power Received (Pr) formula. Then a program is developed with the assistance of MATLAB for all the algorithms that was being used. The servicing area was implemented by using the Hexagonal geometry architecture for Hierarchical Cell Structure. For this project, the main target user is going to be the mobile service provider or telecommunication provider such as Celcom, Maxis, Digi and others.

1.4 Methodology

In the nature of cell selecting, there are 3 types of cell. They are most preferred cell, regular cell and non-regular cell. All these three offer different type of characteristic. After study all these architecture and algorithm, a module of simulator will be built. The examples of the module are show in Figure 1.1

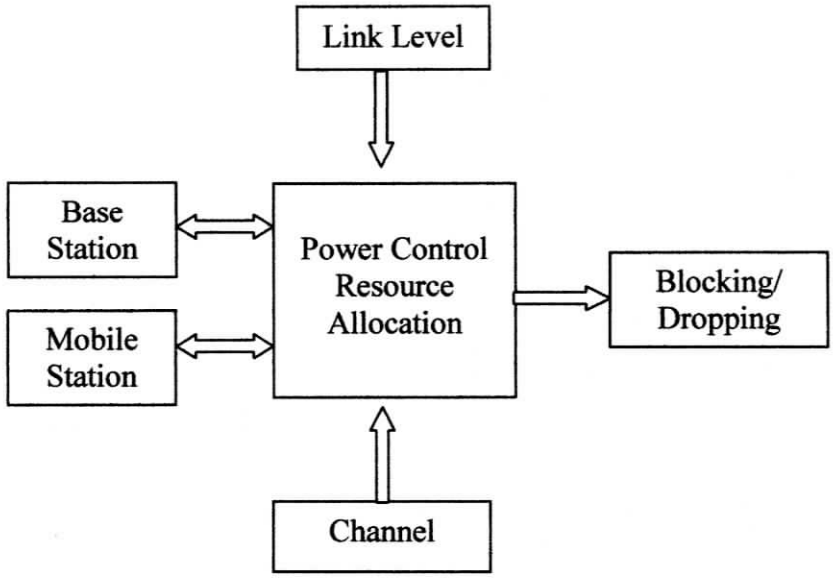

Figure 1.1: Module For Simulator

Since HCS is using hexagonal architecture, a hexagonal geometry is show as:

$$Q = \frac{D}{R} = \sqrt{3N} \qquad (1.0)$$

Where

N = cluster size

D = distance between centers of the nearest co-channel cells

R = radius of the cell

In order to create a simulator to this project, MATLAB software shall be used. A subroutine to draw the architecture of the mC and MC will be built by using Equation (1.0). Inside the mC and the MC, Bs will be placed in.

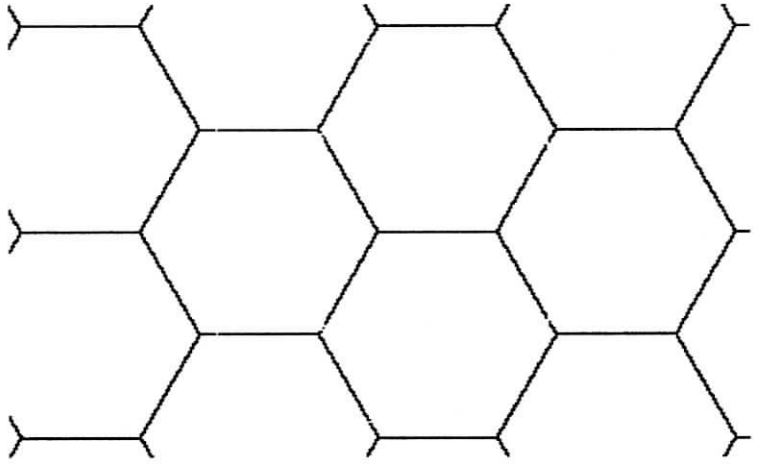

Figure 1.2 : Structure of mC and MC.

From the Figure 1.2, it shows the structure of MC and six by six square mC. The Bs of the mC are indicated by the cross mark and the Bs of the MC are indicated by the circle mark.

Each Bs will produce their own signal power. The average received power, Pr at a distance, d from the transmitting antenna will be calculated using this equation

$$\mathrm{Pr} = Po\left(\frac{d}{d_o}\right)^{-n} \tag{1.2}$$

Or

$$\mathrm{Pr}(dBm) = Po(dBm) - 10n\log\left[\frac{d}{d_o}\right] \tag{1.3}$$

Where

Po = power received at a close-in point in the far field region of the antenna at a small distance.

d_o = the smallest distance of Po from the transmitting antenna

n = path loss exponent

The SIR for a mobile receiver will be calculated using this equation:

$$SIR = \frac{S}{\sum_{i=1}^{i_o} I_i} \quad (1.4)$$

Where

S = the desired signal power from the desired BS

I_i = the interference power caused by the i th interfering co-channel cell Bs.

Path Loss Calculation :

$$L(dB) = 40\times\left(1-4\times10^{-3h}\right)\times\log_{10}10(r)-18\log_{10}(h)+21\log_{10}10(f)+80dB \quad (1.5)$$

Where

r = distance between base station and mobile station (km)

f = carrier frequency (MHz)

h = base station antenna height (m)

1.5 Report Summary

This report consists of five chapters. Chapter 1 explained about the introduction of the research where the objectives, scope of research and methodology is explained thoroughly. Chapter 2 is mainly about the concept and research background of PCS and HCS. It tells about the capabilities, operations, configuration and it principle with cell and it's mobile.

Methodology is explained in Chapter 3 where all the process in finding the required result were shown. All the parameter used for this project was also described in full presentation. It includes the result of the simulation with the cell, distance of cell, mobile location, signal to interference ratio and power received by the mobile.

Then in Chapter 4 shows all the result of this research. The result was explained with the aid of graph and simulation's result. And lastly this research was concluded in Chapter 5. In this chapter all the suggestion were interpreted thoroughly besides presenting the conclusion. The suggestion is mainly for the purpose for future research.

CHAPTER II

CONCEPT AND RESEARCH BACKGROUND

2.1 Overview of PCS Technology

The Telecommunications Industry Association (TIA) IS–136 specification is the basis of the time-division multiple access (TDMA) PCS air-interface technology. IS–136 is designed to operate in both the 800-MHz and the 1900-MHz frequency bands, thus providing seamless operation on cellular and PCS systems.

2.2 The Digital Control Channel (DCCH)

The DCCH forms the core of the IS–136 specification and is the primary enhancement to TDMA digital-wireless technology. It is a new control-channel mechanism added to the analog control channel (ACC), the analog voice channel (AVC), and the digital traffic channel (DTC) of the TDMA air interface. The IS–136

DCCH TDMA technology provides the platform for PCS, introducing new functionalities and supporting enhanced features that make PCS a powerful digital system.

2.3 Dual-Band Dual-Mode Operation

PCS dual-band phones operating at 800 MHz and 1900 MHz enable users to receive full PCS features and services for IS–136 systems wherever they roam. The dual-mode capability provides service continuity and interoperability between analog and digital networks. As a result, a PCS phone can provide access to all outdoor wireless services, be used in a private in-building system, and serve as a flat-rate digital cordless phone at home.

2.4 Features and Capabilities

Table 2.1 shows the capabilities of the feature in PCS.

Table 2.1 : PCS Features and Capabilities

Feature	**Capability**
sleep mode	extends phone standby time and enhances battery life
short message service	transfers alphanumeric messages to and from cellular

(SMS)	and PCS phones
voice and data privacy	increases resistance to eavesdropping
superior voice quality	results in less background noise and fewer dropped calls
Hierarchical environment	provides support for macrocell-microcell operation
intelligent rescan	allows tighter control of system selection
private and residential system IDs	provide more simplified and controlled wireless office service (WOS) and personal base station (PBS) features
seamless roaming	enables roaming between frequencies using dual-band phones and provides support for international roaming
circuit-switched data support	provides highly reliable data transmission for wireless e-mail, faxing, and Internet access
authentication	increases phone security and resistance to cloning
calling number identification (CNI)	allows callers to be identified before answering
message waiting indicator (MWI)	notifies users that they have voice-mail messages
text dispatch service	Live operators take caller messages and send text messages to the PCS phone.