WCDMA SIMULATION FOR TRANSMITTER PART AND BER PERFORMANCE IN AWGN, RAYLEIGH CHANNEL, AND RICIAN

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To my dearest parents, supervisor and friends

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ABSTRACT

In Code Division Multiple Access (CDMA) system, there is a phenomenon where distortion of the signal occurs while propagating through wireless communication system caused by fading channel. Fading is a fluctuation in received signal's amplitude, phase and angle of arrival due to multipath reflective paths. The project is to simulate the transmission in three different fading channels, Additive White Noise Gaussian (AWGN), Rayleigh fading and Rician. The transmission will be implemented in both CDMA and WCDMA (additional of *W* for *Wideband*) in order to compare the performance between the two systems. The observation and evaluation is done over Bit Error Rate (BER) performance in these channels. To simulate for high data rate WCDMA system, Quadrature Phase Shift Keying (QPSK) modulation scheme is considered to modulate the signal. Computer simulation tool, MATLAB, will be used throughout the research to distribute the signal and evaluate the BER performance. The simulation will be conducted using Simulink, a simulation method where a transmission system is create by setting up the appropriate blocks and its parameter. A study of BER performance in different fading channels is important to evaluate which fading channel gives the worst performance. Besides, the different technology and chip rate of CDMA and WCDMA systems makes a study in these systems is relevant for evaluation purpose.

ABSTRAK

Di dalam sistem Pemodulatan Pembahagian Kod Pelbagai Capaian Lebar Jalur Luas (*Code Division Multiple Access - CDMA)*, terdapat fenomena gangguan atau pengecilan pada signal yang berlaku semasa signal merambat di dalam sesebuah sistem transmisi yang di sebabkan oleh saluran kelenturan (*fading channel*). Kelenturan merupakan anjakan dari segi amplitud, fasa dan sudut bagi sesebuah signal yang sampai di penerima berdasarkan kelenturan pelbagai laluan pantulan (multipath reflective fading). Justeru, projek ini adalah bertujuan untuk mensimulasikan transmisi di dalam tiga saluran kelenturan yang berlainan, iaitu Pertambahan Bunyi Hingar Putih Gaussian (AWGN), kelenturan Rayleigh (Rayleigh fading) dan Rician. Transmisi akan dilakukan dalam CDMA dan WCDMA (tambahan *W* mewakili *Wideband*) bagi tujuan mengadakan perbandingan di antara kedua-dua sistem ini. Pemerhatian dan penilaian dilakukan ke atas prestasi Kadar Kesilapan Bit (*Bit Error Rate – BER*) dalam ketiga-tiga saluran ini. Bagi mensimulasikan kadar tinggi data (*high data rate*) untuk sistem WCDMA, skim modulasi QPSK akan digunakan untuk memodulatkan signal. Sepanjang kajian, MATLAB – sebuah alat simulasi computer, akan digunakan bagi penghasilan signal dan penilaian untuk prestasi BER. Simulasi ini dijalankan menggunakan Simulink, sebuah cara simulasi di mana sistem-sistem transmisi dibentuk dengan blok-blok dan ciri-ciri (*parameter*) yang sesuai. Kajian mengenai prestasi BER di dalam tiga saluran kelenturan yang berlainan adalah penting bagi menilai saluran kelenturan yang manakah menunjukkan prestasi yang buruk. Selain itu, perbezaan teknologi dan kadar chip di antara sistem-sistem CDMA dan WCDMA mencetuskan kerelevanan kajian ini di buat.

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LIST OF ABBREVIATION

2G	Second Generation
3G	Third Generations
3GPP	3rd Generation Partnership Project
AM	Amplitude Modulation
ARIBA	Association of Radio Industries and Businesses
ASK	Amplitude shift keying
ATIS	Alliance for Telecommunications Industry Solutions
AWGN	Additive White Noise Gaussian
BER	Bit Error Rate
BPSK	Binary phase shift keying
CDMA	Code Division Multiple Access
DS-CDMA	Direct Sequence Code Division Multiple Access
ETSI	European Telecommunications Standards Institute
FDD	Frequency Division Duplex
FM	Frequency modulation
FSK	Frequency shift keying
GSM	Global System for Mobile
HCS	Hierarchical Cell Structure
HSDPA	High Speed Downlink Packet Access
ITU	International Telecommunication Union
MMS	Multimedia Messaging Service
MUD	Multi-user Detection
PSK	Phase shift keying
PSTN	Public Switched Telephone Network
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying

SMG	Special Mobile Group
TDD	Time Division Duplex
UMTS	Universal Mobile Telecommunication System
UTRA	UMTS Terrestrial Radio Access
WCDMA	Wideband Code Division Multiple Access

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Over the past decade, the growth of wireless communication shows the great achievement. This significant increase in subscribers and traffic, new bandwidth consuming applications such as gaming, music down loading and video streaming will place new demands on capacity. Thus, Wideband Code Division Multiple Access (WCDMA) is the answer to the capacity demand that is the provision of new spectrum and the development of a new technology. WCDMA was developed in order to create a global standard for real time multimedia services that ensured international roaming. With the support of ITU (International Telecommunication Union) a specific spectrum was allocated – 2GHz for 3G telecommunication systems. The work was later taken over by the 3GPP (3rd Generation Partnership Project), which is now the WCDMA specification body with delegates from all over the world.

This project will perform CDMA and WCDMA MATLAB simulation model in terms of bit error rate performance (BER). The project contents are include the design of spreader, QPSK Modulator, SNR, BER for AWGN channel, BER for Rayleigh channel and BER for Rician channel. The CDMA and WCDMA simulation is done by varying various parameters in terms of getting the BER performance in

different conditions by using the program itself. The result will be compared with the theoretical result for AWGN channel, Rayleigh channel and Rician channel.

1.2 OBJECTIVE

While the countries world wide, including Malaysia, began the usage of high-speed network 3G, the citizens don't have clear idea about 3 G technologies. Most of them only notice that 3G is all about the video conference through the mobile phone, without understanding deeply about this system.

The current 2.5 G system, though provides some of the benefits of 3G, is not sufficient to transmit video application/multimedia because its data rate is slow. The speed of 2.5G is only between 30kbps to 90 kbps, which only supports simple application of mobile communication system, such as MMS, short audio/video clips and ring tone downloads.

This project is to study the technologies of 3G, especially the leading 3G standard; Wideband Code Division Multiple Access (WCDMA). This study will do the simulations of CDMA and WCDMA.

As well as to conduct a research over the 3G, this project will design a 3G system that capable to achieve 384kbps to 2Mbps of data rate. This range of data rate seamlessly integrates a wide variety of communication services such as high speed data, video and multimedia traffic as well as voice signals.

1.3 SCOPES OF WORK

The research project is started with literature review on high data rate modulation schemes, CDMA, WCDMA, and fading effects on channel. Then, a simulation model of CDMA and WCDMA is implemented.

The simulation is done under noise and multipath fading channel using MATLAB 7. The simulation method that will be used in this project is Simulink. A distributor of the signal must be selected. For signal propagation towards the fading channel, the designation of modulation and spreader is required. The QPSK modulation scheme will be used for modulation purpose. In the spreader part, the Walsh code is considered to be included as channel coding method. Every part of the system will be designed with an internal subsystem. Finally, when the necessary simulations are done, analysis, comments and conclusion will be drawn based on the simulation results.

Six models of CDMA and WCDMA system will be created in order to simulate the performance in the channels, which are:

1. CDMA system in AWGN channel
2. CDMA system in Rayleigh fading channel
3. CDMA system in Rician channel
4. WCDMA system in AWGN channel
5. WCDMA system in Rayleigh fading channel
6. WCDMA system in Rician channel

The specific chip rate will be used, which is 3.84Mbps for WCDMA and 1.22MBps for CDMA so that the different of performance of two systems would be observed.

CHAPTER 2

LITERATURE REVIEW

2.1 BACKGROUND STUDY

2.1.1 Code Division Multiple Access and WCDMA

Code Division Multiple Access (CDMA) is a multiple access technology where the users are separated by unique codes, which means that all users can use the same frequency and transmit at the same time. With the fast development in signal processing, it has become feasible to use the technology for wireless communication, also referred to as WCDMA (wideband CDMA) and CDMA2000. In cdmaOne and CDMA2000, a 1.25 MHz wide radio signal is multiplied by a spreading signal (which is a pseudo-noise code sequence) with a higher rate than the data rate of the message. The resultant signal appears as seemingly random, but if the intended recipient has the right code, this process is reversed and the original signal is extracted. Use of unique codes means that the same frequency is repeated in all cells, which is commonly referred to as a frequency re-use of 1. WCDMA is a step further in the CDMA technology. It uses a 5 MHz wide radio signal and a chip rate of 3.84 Mcps, which is about three times higher than the chip rate of CDMA2000 (1.22 Mcps).

The main benefits of a wideband carrier with a higher chiprate are:

- Support for higher bit rates
- Higher spectrum efficiency thanks to improved trunking efficiency (i.e. a better statistical averaging)
- Higher QoS

Further, experience from second-generation systems like GSM and cdmaOne has enabled improvements to be incorporated in WCDMA.

The key properties for general wideband CDMA include:

Improved performance over 2G systems

- Improved capacity
- Improved coverage
- Fast power control in the downlink
- Seamless inter-frequency handover

High degree of service flexibility

- Multirate services: with maximums of 64-384 Kb/s for full coverage and 2 Mb/s for limited coverage.
- Packet access mode

High degree of operator flexibility

- Support of asynchronous inter-base-station operation (for ETSI/ARIB WCDMA)
- Support of different deployment scenarios, including hierarchical cell structure (HCS) and hot-spot scenarioes
- Support of new technologies like multi-user detection (MUD) and adaptive antenna arrays.

2.1.2 Third Generation Cellular Systems

Third generation cellular systems are being designed to support wideband services like high speed Internet access, video and high quality image transmission with the same quality as the fixed networks. The primary requirements of the next generation cellular systems are:

- Voice quality comparable to Public Switched Telephone Network (PSTN).
- Support of high data rate. The following table shows the data rate requirement of the 3G systems

Table 2.1: 3G Data Rate Requirements

Mobility Needs	Minimum Data Rate
Vehicular	144 kbps
Outdoor to indoor and pedestrian	384 kbps
Indoor Office	2 Mbps

- Support of both packet-switched and circuit-switched data services.
- More efficient usage of the available radio spectrum
- Support of a wide variety of mobile equipment
- Backward Compatibility with pre-existing networks and flexible introduction of new services and technology
- An adaptive radio interface suited to the highly asymmetric nature of most Internet communications: a much greater bandwidth for the downlink than the uplink.

Research efforts have been underway for more than a decade to introduce multimedia capabilities into mobile communications. Different standard agencies and governing bodies are trying to integrate a wide variety of proposals for third generation cellular systems. **Figure 2.1** shows the evolution of third generation cellular systems:

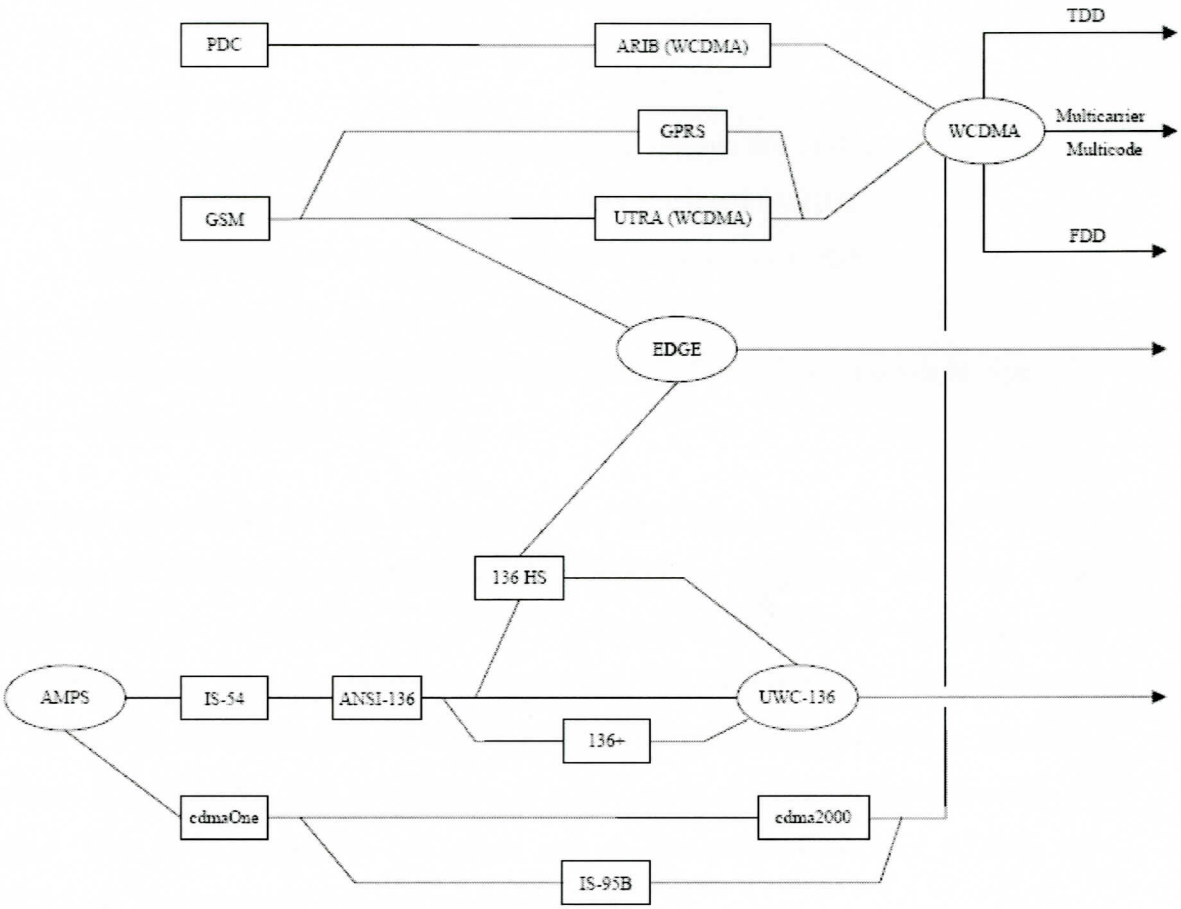

Figure 2.1: Evolution of 3G

2.1.3 WCDMA: Air Interface for 3G

One of the most promising approaches to 3G is to combine a WCDMA air interface with the fixed network of GSM. Several proposal supporting
WCDMA were submitted to the International Telecommunication Union (ITU) and its International Mobile Telecommunications for the year 2000 (IMT2000) initiative for 3G.

Among several organizations trying to merge their various WCDMA proposals are

- Japan's Association of Radio Industry and Business (ARIB)
- Alliance for Telecommunications Industry Solutions (ATIS)
- T1P1
- European Telecommunications Standards Institute (ETSI) through its Special
- Mobile Group (SMG)

All these schemes try to take advantage of the WCDMA radio techniques without ignoring the numerous advantages of the already existing GSM networks. The standard that has emerged is based on ETSI's Universal Mobile Telecommunication System (UMTS) and is commonly known as UMTS Terrestrial Radio Access (UTRA). The access scheme for UTRA is Direct Sequence Code Division Multiple Access (DS-CDMA). The information is spread over a band of approximately 5 MHz. This wide bandwidth has given rise to the name *Wideband* CDMA or WCDMA. There are two different modes namely

- Frequency Division Duplex (FDD)
- Time Division Duplex (TDD)

Since different regions have different frequency allocation schemes, the capability to operate in either FDD or TDD mode allows for efficient utilization of the available spectrum. A brief definition of FDD and TDD modes is given next.

FDD: The uplink and downlink transmissions employ two separated frequency bands for this duplex method. A pair of frequency bands with specified separation is assigned for a connection.