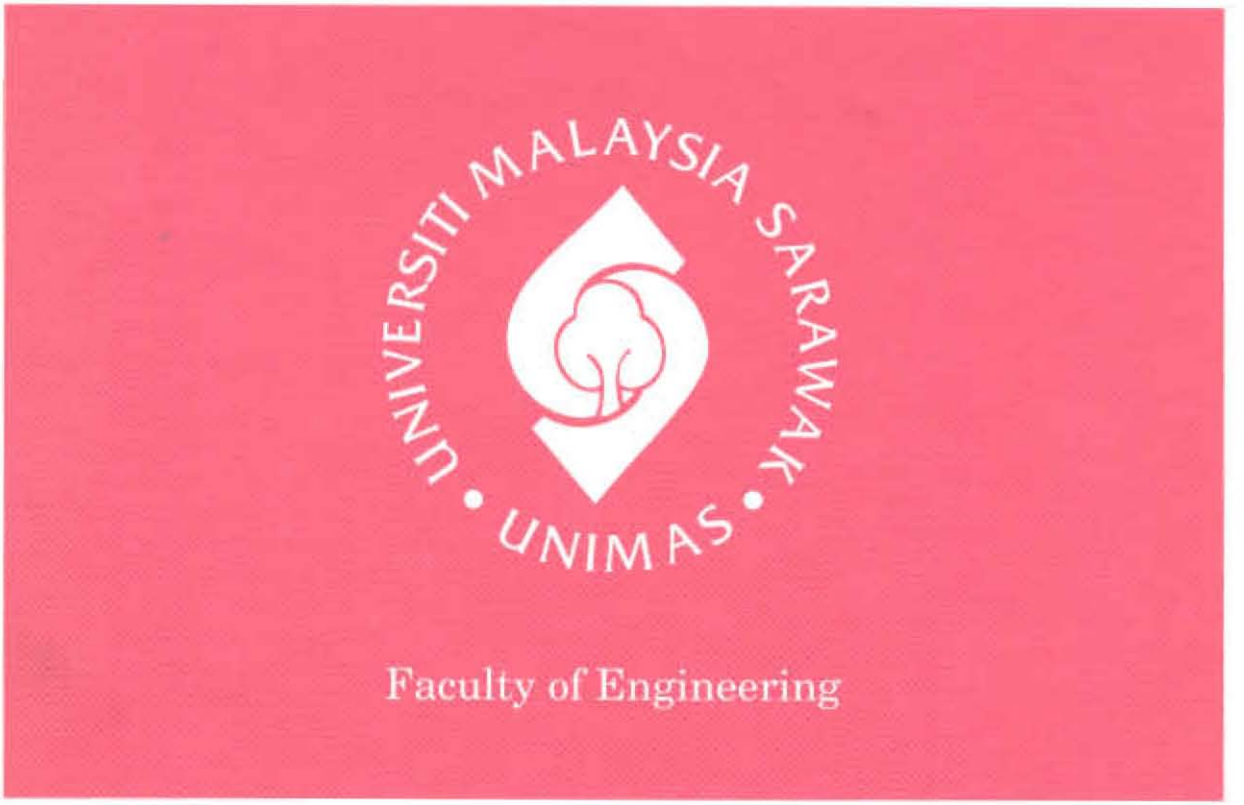

ADVANCED WCDMA MULTIMEDIA RECEIVER

Helmi Bin Beladi

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2004

Bachelor of Engineering with Honours
(Electronics and Telecommunication Engineering)
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UNIVERSITI MALAYSIA SARAWAK

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This project is submitted in partial fulfilment of
the requirements for the degree of Bachelor of Engineering with Honours
(Electronics & Telecommunications Engineering)

Faculty of Engineering
UNIVERSITI MALAYSIA SARAWAK
2004

Specially Dedicated To:
My beloved parents, friends and Ayang

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ABSTRAK

Pada hari ini, sistem komunikasi tanpa wayar menjadi teknologi yang amat penting dibandingkan dengan teknologi sebelum ini. Teknologi ini meningkat dengan begitu mendadak disebabkan oleh permintaan daripada pengguna. Ia amat mudah di mana ia membolehkan pengguna membawa perkakasan ke mana-mana tempat pada bila-bila masa kerana penghantaran maklumat adalah melalui ruang udara. Tujuan projek ini adalah untuk meneroka asas-asas tentang *Wideband Code Division Multiples Access (WCDMA)*. Penyelidikan juga merangkumi pemahaman yang lebih mendalam tentang teknologi ini, teknologi lain yang sedia ada dan cara ia dikendalikan. Projek ini juga memperkenalkan pandangan umum tentang sifat-sifat *WCDMA* yang berkaitan dengan *smart antenna*, teknologi pemprosesan isyarat dan sistem untuk penyebaran maklumat. Penjelasan yang ringkas tentang kuasa kawalan, proses *hand-off*, proses penyebaran dan modulasi dalam rangkaian *uplink* dan *downlnk*, proses pengkodan dan keupayaan pada bahagian penerimaan maklumat juga dibincangkan. Oleh kerana teknologi generasi tiga (3G) ini belum dilaksanakan di Malaysia, ia menyukarkan saya untuk menguji tahap keupayaan sebenar pada bahagian penerimaaan.

ABSTRACT

Nowadays, mobile communication system is becoming a very important technology compared to the previous technology. This technology is developing rapidly due to the demands from users. The technology itself is very mobile and since the transmission medium is through airspace, mobile communication is indeed a convenience and an essential tool for the modern society. The purpose of this project is to explore fundamentals of Wideband Code Division Multiples Access (WCDMA). The research includes description and understanding of WCDMA technology, different technologies which have been used and how these technologies work. This project also introduce the general idea of WCDMA characters with respect to the smart antenna, signal processing technologies and the system for distributing information. A brief explanation on power control, hand-off process, spreading and modulation process in uplink and downlink channel, coding process and the performances of the receiver side are also being discussed. Since this third Generation (3G) technology have not been implemented in Malaysia, it is difficult for me to test the actual performance of the receiver side.

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INTRODUCTION

1.1 INTRODUCTION

The goal for the next generation of mobile communications system is to seamlessly provide a wide variety of communication services to anybody, anywhere, anytime. The intended services for next generation mobile phone users include services like transmitting high speed data, video and multimedia traffic as well as voice signals. The technology needed to tackle the challenges to make these services available is popularly known as the Third Generation (3G) Cellular Systems. The first generation systems are represented by the analog mobile systems designed to carry the voice application traffic. Their subsequent digital counterparts are known as second generation cellular systems. Third generation systems mark a significant leap, both in applications and capacity, from the current second generation standards. Whereas the current digital mobile phone systems are optimized for voice communications, 3G communicators are oriented towards multimedia message capability.

1.2 FIRST GENERATION CELLULAR SYSTEMS

The first generation cellular systems generally employ analog Frequency Modulation (FM) techniques. The Advanced Mobile Phone System (AMPS) is the most notable of the first generation systems. The AMP was developed by the Bell Telephone System. It uses FM

technology for voice transmission and digital signaling for control information. Other first generation systems include:

i. Narrowband AMPS (NAMPS)

ii. Total Access Cellular System (TACS)

iii. Nordic Mobile Telephone System (NMT-900)

All the first generation cellular systems employ Frequency Division Multiple Access (FDMA) with each channel assigned to a unique frequency band within a cluster of cells.

1.3 SECOND GENERATION CELLULAR SYSTEMS

The rapid growth in the number of subscribers and the proliferation of many incompatible first generation systems were the main reason behind the evolution towards second generation cellular systems. Second generation systems take the advantage of compression and coding techniques associated with digital technology. All the second generation systems employ digital modulation schemes. Multiple access techniques like Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA) are used along with FDMA in the second generation systems. Second generation cellular systems include:

i. United States Digital Cellular (USDC) standards IS-54 and IS-136

ii. Global System for Mobile communications (GSM)

iii. Pacific Digital Cellular (PDC)

iv. cdmaOne

1.4 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:

i. Voice quality comparable to Public Switched Telephone Network (PSTN).

ii. Support of high data rate. The following table shows the data rate requirement of the 3G systems:

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

Table 1.1 3G Data Rate Requirements

iii. Support of both packet-switched and circuit-switched data services.

iv. More efficient usage of the available radio spectrum

v. Support of a wide variety of mobile equipment

vi. Backward Compatibility with pre-existing networks and flexible introduction of new services and technology

vii. An adaptive radio interface suited to the highly asymmetric nature of most

viii. Internet communications: a much greater bandwidth for the downlink than the uplink.

1.5 EVOLUTIONS OF 3G TECHNOLOGY

Figure 1.1 shows the evolution to third generation (3G) technology. Analog cellular systems are commonly referred to as first generation (1G) systems. The digital systems such as GSM, PDC, cdmaOne and US-TDMA are second generation (2G) systems. 3G systems are designed for multimedia communications with high bit rate. These 3G systems are such as WCDMA, EDGE and cdma2000. The differential between 3G and other previous technology networks is how the data move from one station to other station.

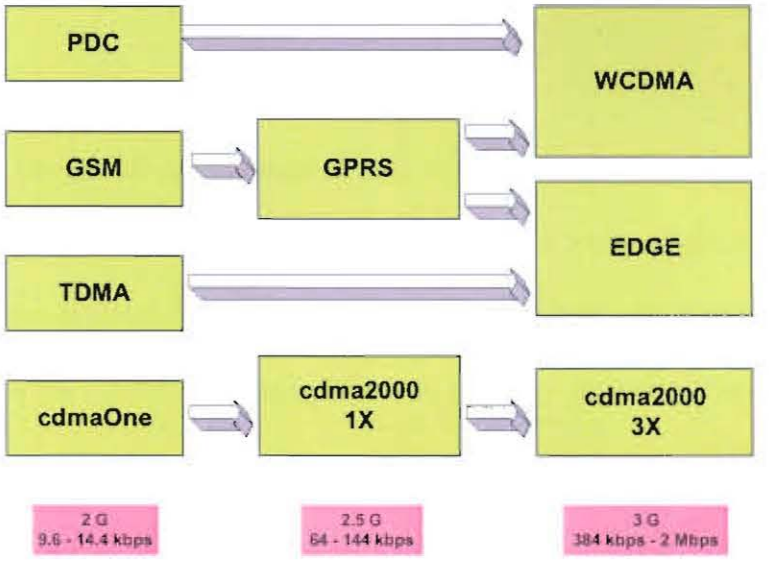

Figure 1.1 Evolution to 3G technology

1.6 THIRD GENERATION (3G) TECHNOLOGY

In the International Telecommunications Union (ITU), 3G networks are called International Mobile Telecommunications-2000 (IMT-2000), and in Europe, Universal Mobile Telecommunications System (UMTS). IMT-2000 will provide a multitude of services, especially multimedia and high-bit-rate packet data. Wideband Code Division Multiple Access (WCDMA) has emerged as the mainstream air interface solution for the

third-generation networks. In Europe, Japan, Korea, and the United States, WCDMA systems are currently being standardized. Japan's NTTDoCoMo became the first operator in the world to launch a high speed 3G service base on WCDMA technology.

The 3G IMT-2000 is the standardization and system development of the next-generation mobile communication system. They began in response to the rising need in recent years to achieve high speed data communications capable of supporting mobile phone subscribers and developing a common platform that would enable mobile phone subscribers to use their mobile terminals in any country across the world.

1.7 IMT-2000

IMT-2000 have been made research and development efforts, with the aim to offer high speed, high quality multimedia services that provide a wide range of content including voice, data and video in a mobile environment. The aims of IMT-2000 are:

i. Personal Communication Services through Improved Spectrum Efficiency (Personalization)

ii. Global, Seamless Communication Services (Globalization)

iii. Multimedia Services through High Speed, High Quality Transmission (Multimedia)

1.8 WCDMA IN THIRD GENERATION SYSTEMS

Analog cellular systems are commonly referred to as first generation systems. The digital systems currently in use, such GSM, PDC, cdmaOne and US-TDMA are second generation systems. These systems have enabled voice communications to go wireless in many of the leading markets and customer are increasingly finding value also in other

services such as text messaging and access to data networks, which are starting to grow rapidly.

3G systems are designed for multimedia communications: with them person-to-person communications can be enhanced with high quality images and video and access to information and services on public and private networks will be enhanced by the higher data rates and new flexible communication capabilities of 3Gsystems. This, together with the continuing evolution of the second generation systems, will create new business opportunities not only for manufacturers and operators but also for the providers of content and applications using these networks.

1.9 WCDMA

WCDMA has a bandwidth of 5 MHz. The nominal bandwidth for all third-generation proposals is 5 MHz. There are several reasons for choosing this bandwidth.

i. Data rates of 144 and 384 Kb/s.

ii. Lack of spectrum calls for reasonably small minimum spectrum allocation, especially if the system has to be deployed within the existing frequency bands occupied already by 2G systems.

iii. The 5 MHz bandwidth can resolve more multipaths than narrower bandwidths, increasing diversity and thus improving performance. Larger bandwidths of 10, 15, and 20 MHz have been proposed to support higher data rates more effectively.

1.9.1 Characteristics of WCDMA

WCDMA has the following technical characteristics.

i. Highly Efficiency Frequency Usage.

In theory, the potential capacity of the system should be regarded the same even like Time Division Multiple Access (TDMA) and Frequency Division Multiple Access (FDMA) are applied. While Code Division Multiple Access (CDMA) should be interpreted as referring to how easy it is to improve the efficiency of frequency usage.

ii. Freedom from Frequency Administration

Allows adjacent cells to share the same frequency, no frequency allocation plan is required. It is same like the previous technologies. It also provides many types of handover such as soft and inter-system handover.

iii. Low Mobile Station Transmit Power

By technologies like RAKE reception, this system can improve reception performance and reduce the transmission power on mobile station. WCDMA has fast closed loop and open loop power control procedures.

iv. Resources Used Independently in Uplink and Downlink

The spreading factor can be set independently between uplink and downlink for each user, and thereby set different speeds in uplink and downlink. The speeds in downlink channel are faster than the uplink channel.

1.9.2 Differences between WCDMA and 2G Air Interfaces

The differences between WCDMA and 2G air interfaces are described in table 1.2 and 1.3. GSM and IS-95 (standard for cdmaOne systems) are second generation considered below. Table 1.2 lists the main differences between WCDMA and GSM and table 1.3 those between WCDMA and IS-95. Only the air interfaces is considered in this comparison.

	WCDMA	GSM
Carrier spacing	5 MHz	200 kHz
Frequency reuse factor	1	1-18
Power control frequency	1500 Hz	2 Hz or lower
Quality control	Radio resource management algorithms	Network planning (frequency planning)
Frequency diversity	5 MHz bandwidth gives multipath diversity with RAKE receiver	Frequency hopping
Packet data	Load-based packet scheduling	Time slot based scheduling with GPRS
Downlink transmit diversity	Supported for improving downlink capacity	Not supported by the standard, but can be applied.

Table 1.2 Main differences between WCDMA and GSM air interfaces

Transmit diversity is included in WCDMA to improve the downlink capacity to support the asymmetric capacity requirements between downlink and uplink. Transmit diversity is not supported by the 2G standards. The mixture of different bit rates, services and quality requirements in 3G systems requires advanced radio resource management algorithms to guarantee quality of service and to maximize system throughout.