PERFORMANCE STUDY ON HIGH DATA RATES MODULATION TECHNIQUES OF W-CDMA IN MULTIPATH FADING CHANNEL

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ABSTRACT

Downlink transmission (base station to mobile terminal) using high data rate M-ary Quadrature Amplitude Modulation (QAM) and Quadrature Phase Shift Keying (QPSK) modulation schemes are considered in a Wideband-Code Division Multiple Access (W-CDMA) system. The performances of these modulation techniques are evaluated when the system is subjected to a number of users as well as noise and interference in the channel. Additive White Noise Gaussian (AWGN) and multipath Rayleigh fading are considered in the channel. Computer simulation tool, MATLAB, will be used throughout the research to evaluate Bit-Error-Rate (BER) for W-CDMA system models. Two approaches are used in this simulation. They are simulations using Simulink and simulations using M files. A study of different modulation techniques is needed so that a W-CDMA system can choose suitable modulation technique to suit the channel quality, thus delivering optimum and efficient data rate to mobile terminal. It is discovered that the performance of 16-QAM is significantly degraded in AWGN and multipath Rayleigh fading channel compared to that of QPSK. Error correction coding is needed to be used in this system particularly with 16-QAM to ensure better performance of WCDMA system.

Index Terms – Multipath Rayleigh fading, AWGN, Direct Sequence Spread Spectrum (DSSS), Code Division Multiple Access (CDMA), BER, signal-to-noise ratio (SNR), QPSK and 16-QAM

ABSTRAK

Projek ini melibatkan kajian mengenai transmisi jalinan ke bawah (downlink) (stesen tapak ke terminal boleh gerak) yang melibatkan penggunaan teknik-teknik modulasi QPSK dan 16-QAM di dalam Pemodulatan Pembahagian Kod Pelbagai Capaian Lebar Jalur Luas (Wideband Code Division Multiple Access, WCDMA). Prestasi teknik-teknik modulasi ini dinilaikan ke atas sistem WCDMA yang dikenakan hingar dan interferen pada saluran (channel) sistem ini. Pertambahan Bunyi Hingar Putih Gaussian (AWGN) dan kelenturan pelbagai laluan Rayleigh (multipath Rayleigh fading) dipilih untuk digunakan pada saluran di dalam sistem ini. Di dalam kajian ini, program computer MATLAB telah digunakan untuk mensimulasikan sistem WCDMA untuk menilai kadar kesilapan bit di dalam sistem WCDMA. Dua kaedah telah digunakan iaitu simulasi menggunakan Simulink dan simulasi menggunakan file M. Penyelidikan terhadap teknik-teknik modulasi adalah diperlukan bagi sistem WCDMA supaya teknik modulasi yang sesuai dapat digunakan secara dinamik oleh sistem ini supaya ia dapat disesuaikan dengan keaadaan saluran. Kaedah ini adalah untuk memastikan penghantaran data daripada stesen tapak ke terminal boleh gerak adalah pada tahap yang laju, efisyen dan optimum. Keputusan simulasi computer ini telah menunjukkan penurunan prestasi bagi teknik modulasi 16-QAM di dalam saluran AWGN dan kelenturan pelbagai laluan Rayleigh jika ia dibandingkan dengan QPSK. Kod pembetulan kesilapan adalah diperlukan di dalam sistem ini terutamanya jika 16-QAM digunakan untuk memastikan sistem WCDMA berada pada keadaan yang baik.

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LIST OF ABBREVIATION

WCDMA	Wideband Code Division Multiple Access
UMTS	Universal Mobile Telecommunication System
GMSK	Gaussian Minimum Shift Keying
GSM	Global System for Mobile Communication
AWGN	Additive White Noise Gaussian Noise
QPSK	Quadrature Phase Shift Keying
QAM	Quadrature Amplitude Modulation
BER	Bit Error Rate
SNR	Signal to Noise Ratio
PN	Pesudo-Noise
AMC	Adaptive Modulation and Coding
HSDPA	High Speed Downlink Packet Access
PDF	Probability Density Function
dB	Decible
ISI	Inter-Symbol Interference

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CHAPTER 1

INTRODUCTION

1.1 Background of the Problem

W-CDMA system has been identified by Universal Mobile Telecommunication System (UMTS) as the platform of the 3rd generation cellular communication system. Unlike conventional narrowband signal of 2nd generation (2G) communication system, W-CDMA uses noise-like broadband frequency spectrum where it has high resistance to multipath fading. High data rate signal transmission can be transmitted over the air by using W-CDMA system, thus enabling large data transmission of multimedia rich applications such as high-resolution pictures and video to end-users. Thus, suitable modulation technique and error correction scheme have to be used in W-CDMA system. In 2G network, modulation scheme such as GMSK is widely used in Global System of Mobile Communication (GSM). GMSK can only deliver data rate of 1 bit per symbol. Obviously, such modulation scheme is not suitable for the next communication system. Thus, there is a need to study the performance of new modulation technique that could deliver higher data rate effectively in a multipath fading channel.

1.2 Problem Statements

To deliver multimedia content application over cellular networks, a high data rate modulation scheme is one of the important criteria besides good error correction coding. However, the implementation of high data rate modulation techniques that have good bandwidth efficiency in W-CDMA cellular communication requires perfect modulators, demodulators, filter and transmission path that are difficult to achieve in practical radio environment. Modulation scheme that capable to deliver more bits per symbol is susceptible to errors caused by noise and interference in the channel. Moreover, errors can be easily produced as the number of users is increased and the mobile terminal is subjected to mobility.

1.3 Project Objective

The objectives and aims of this project are to look at the performance of high data rate modulation techniques at channels that are subjected to Additive White Gaussian Noise (AWGN) and multipath Rayleigh fading. Modulation schemes that will be considered in this project are Quadrature Phase Shift Keying (QPSK) and 16-ary Quadrature Amplitude Modulation (16-QAM). This performance study will be carried out by varying the chip rate of pseudo-noise (PN) generator. Furthermore, multiple access scheme i.e. WCDMA will be also studied by comparing certain number of users under static and mobility environment that are subjected to AWGN and multipath Rayleigh fading. The performances of WCDMA under these channels fading are based on Bit Error Rate (BER) at downlink (base station to mobile terminal) transmission.

There will be three WCDMA wireless cellular system models that will be used in this project. The models are

1. WCDMA system in AWGN channel
2. WCDMA system in AWGN and Multipath Rayleigh Fading.
3. Multi-user WCDMA system in AWGN and Multipath Rayleigh Fading.

Relationship for multiple rays using QPSK and QAM in W-CDMA system models for the followings parameters will be obtained using MATLAB. They are:

1. Bit Error Rate (BER) versus Signal-to-Noise ratio (SNR) in AWGN channel for QPSK modulation technique.
2. BER versus SNR in AWGN channel for 16-QAM modulation scheme.
3. BER versus SNR in AWGN and multipath Rayleigh fading channel with Doppler shift (60kmph, 90kmph and 120kmph) for QPSK modulation technique.
4. BER versus SNR in AWGN and multipath Rayleigh fading channel with Doppler shift (60kmph, 90kmph and 120kmph) for 16-QAM modulation scheme.
5. BER versus SNR to compare between AWGN channel and multipath Raleigh fading channel for different number of user for QPSK modulation technique.
6. BER versus SNR to compare between AWGN channel and multipath Raleigh fading channel for different number of user for 16-QAM modulation technique.

Once data for BER and SNR under various parameters are obtained, the data are tabulated. Graphs of BER as a function of SNR under different modulation techniques as well as different velocities of mobile terminal subjected to noise and interference channel will be plotted. These graphs will be studied and compared so that a conclusion on suitable high data rate modulation scheme can be drawn.

1.4 Scope of Work

This project is an entirely simulation project using scientific computer simulation software, MATLAB 6.5.2. Two approaches will be used in this project. They are simulation using Simulink and simulation using m files. It will be simulated in multi-user environment based on Direct Sequence Spread Spectrum (DSSS), Wideband-Code Division Multiple Access (W-CDMA). There will be no error correction coding or channel coding employed for this simulation models.

There are two extreme cases of channel noise and fading that will be subjected to the W-CDMA system models. Firstly, the model is simulated with different modulation techniques under thermal noise, represented by Additive White Noise Gaussian (AWGN). Then, the channel is simulated with various different parameters using Non-Line of Sight (N-LOS) multiple reflected rays represented as multipath Rayleigh fading.

The performance of the modulation schemes are studied when the mobile terminal is static and mobile with different speeds. The performance measurement is based on BER. Thus, suitable modulations techniques will be determined and concluded based on BER that will be plotted as a function of function of SNR.

1.5 Significant of the Project Research

The current trend to achieve high data rate cellular communication drives the interest of this research. There are many ways one can improve data rate in a W-CDMA system. However, two significant areas that could give significant boost to the improvement of W-CDMA system is modulation scheme and error correction or channel coding.

There are many modulation schemes that have the potential to deliver higher data rate but there is a trade off between data rate and multipath environment. Modulation techniques that can deliver more bits per symbol normally generate lots of error when they are subjected to multipath channels. Recently, there is intensifying research about Adaptive Modulation and Coding (AMC) [14]-[16]. The principle of AMC is to change the modulation and coding format (transport format) in accordance with instantaneous variations in the channel conditions, subject to system restrictions. AMC extends the systems ability to adapt to good channel conditions. Channel conditions should be estimated based on feedback from the receiver. For a system with AMC, users closed to the cell site are typically assigned higher order modulation with higher code rates (e.g. 64 QAM with R=3/4 Turbo Codes). On the other hand, users closed to the cell boundary, are assigned lower order modulation with lower code rates (e.g. QPSK with R=1/2 Turbo Codes). AMC allows different data rates to be assigned to different users depending on their channel conditions. Since the channel conditions vary over time, the receiver collects a set of channel statistics which are used both by the transmitter and receiver to optimize system parameters such as modulation and coding, signal bandwidth, signal power, training period, channel estimation filters, automatic gain control, etc [3].

Thus, this project will scrutinize suitable modulation techniques that are capable to deliver highest data rate without compromising errors in multipath fading environment. The performance of these modulation techniques will be simulated by using computer simulation tool, MATLAB.

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