UPLINK CHANNEL POWER CONTROL IMPROVEMENT IN DS-CDMA SYSTEM USING CHANNEL PREDICTIONS

IBTESAM. A. OTHMAN

A project report submitted in
fulfillment of requirement for the award of the
Degree of Master of Electrical Engineering

Faculty of Electrical and Electronic Engineering
University Tun Hussein Onn Malaysia

January 2013

ABSTRACT

In cellular systems all Mobile's Station (MS) signals should arrive to Base Station (BS) at equal power, if not the weaker one will be blocked and the strong signals will interference with each other. The research areas include coding and improving power control for uplink channel schemes in cellular systems. Commonly the uplink channel power control schemes utilizes Signal to Interference Ratio (SIR) to design a Power Control Command (PCC) to adjust the transmit power of the mobile station in cellular systems.

Conventional SIR based uplink channel power control schemes updates the transmitting power based on the current channel state, in the fact the state of channel will be changed when the transmission is made; the channel is already in its next state. The state is different from previous one. That causes the SIR to drop or rise drastically and lead to Near-Far effect interference resulting in power escalation and making the DS-CDMA system go unstable.

To overcome these problems, a new approach method has been developed, based on linear quadratic Gaussian (LQG) control and Extended Kalman filter for channel prediction, this method dependent on the channel state instead of the current. Using the proposed method the next state of uplink channel can be predicted and update the power accordingly. This will give us a more stable SIR behavior and leads to stable DS-CDMA system.

The simulation of this research is performed using Matlab to show the result of building a DS-CDMA system link with existing SIR based uplink channel power control schemes, implementing the predictive approach for uplink channel power control achieved the signal to interference ratio (SIR) as close as possible to the predefine level in order to maximize a DS-CDMA systems capacity and performance. That is clearly shown in the results when compared with the conventional methods.

CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

SIR	-	Signal to Interference Ratio
PCC	-	Power Control Command
DS-CDMA	-	Direct Spread-Code Division Multiple Access
MT	-	Mobile Terminal
BS	-	Base Station
MS	-	Mobile Station
LQG	-	Linear Quadratic Gaussian
TDMA	-	Time Division Multiple Access
GSM	-	Global System for Mobile
PDC	-	Personal Digital Cellular
FDMA	-	Frequency Division Multiple Access
ISDN	-	Integrated Services Digital Network
DSSS	-	Direct Sequence Spread Spectrum
FHSS	-	Frequency Hopping Spread Spectrum
PN	-	Pseudo-Noise
S/I or SIR	-	Signal-To-Interference
PC	-	Power Control
CLPC	-	Closed Loop Power Control
MUX	-	Multiplexer
DEMUX	-	Demultiplexer
PCM	-	Pulse Code Modulation
LQE	-	Linear_Quadratic Estimator
LQR	-	Linear_Quadratic Regulator
KF	-	Kalman Filter
EKF	-	Extended Kalman Filter
d B	-	decibel
MHz	-	Mega Hertz
GHz	-	Giga Hertz

ms	-	meli second
MMSE	-	Minimum Mean Squared Error
AR	-	Auto Regressive
GUI	-	Graphical User Interfaces

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

1.1 Overview

Power is one of the basic factors that must be taken into account when designing a communication system. By reducing it as much as possible to achieve a successful communications system economically.

The research areas include coding and improving uplink channel power control schemes in mobile system. Commonly the power control schemes uses a Signal to Interference Ratio (SIR) to design a Power Control Command (PCC) to adjust the transmit power of the mobile station in mobile system.

Mobile communication systems based on DS-CDMA as the controlling air interface solution in mobile telecommunications plane (Pasad, 1998). DS-CDMA is an attracting technique, since it allows high capacity and supports variable bit-rate user transmissions. New aspects need to be carefully taken into consideration when a DS-CDMA air interface is designed. In particular, equal power levels must be received at the base station (BS) from different Mobile Terminals (MTs) in a cell (uplink), if not the weaker one will be blocked and the strong signals will interfere with each other and making the system unstable.

In conventional methods, each transmitted signal from Mobile Station (MS) will be affected by different propagation such as path loss like (reflection, diffraction and absorption) that appear in reverence link (mobiles to base station).

These channel changes may cause the SIR to drop or rise drastically and lead to uncontrollable Near-end-Far-end interference resulting in power escalation and making the system unstable. This critical problem is within the power control of uplink channel where orthogonal spreading codes cannot be used and channel variations and distances cause severe interference between users. Without a proper power control scheme the communication system would not be able to handle as many users.

To overcome power escalation and improve the recovery from deep fading (deviation of the attenuation affecting a signal over certain propagation media) a new approach power control method has been developed. Based on linear Quadratic Gaussian (LQG) control and Extended Kalman filter for uplink channel prediction this method designs the PCC based on the coming channel state instead of the current. This research will explain the components of this method, about how Extended Kalman filter works to predict the status for the channel and apply in Matlab to see the results obtained and the difference between the results of a new approach method with the conventional methods.

1.2 Problem Statements

Today wireless communications and especially the mobile telecommunications systems are based on Direct Spread Code Division Multiple Access (DS-CDMA) technique. In a DS-CDMA communication system, several users that transmit simultaneously share the same radio bandwidth. In order to maintain the quality of a connection, the signal-to-interference ratio at the receiver (base station) should be kept over a required value. Therefore, transmitter power includes a major controllable recourse for the improvement of the user’s radio link performance (Bambos, 1998) (Ariyavisitakul, 1994).

The problem in transmission power on the uplink channel for a DS-CDMA system is increased because slow SIR recovery due to path loss. All MS's signals will be affected by different propagation from wireless channel and signal power may drop, that lead to severe interference from other users and causes low capacity for DS-CDMA system.

These users will in their turn start compensating by increasing power, may lead to power escalation or positive feedback, which may have whole system go unstable. It is known that any communication system in order to be successful, the power consumption must be as low as possible. Therefore, this research work aims to reduce the power consumption to the minimum.

Having a new approach power control method based on Linear Quadratic Gaussian (LQG) control and Extended Kalman filter for channel prediction, this method designs the PCC based on coming channel state instead of the current. By using the proposed method the next states of the channel can be predicted and update the power accordingly.

This method explains how the Extended Kalman filter work to the predicted state of channel. The results using Matlab are shown to see the signals through the transmission and compared to the results before and after using this method. The result shows a more stable SIR behaviour and, more importantly, faster SIR recovery from channel variations. This will result in a more stable DS-CDMA system.

1.3 Project Objectives

The objectives of this research are:

i. To Simulate a DS-CDMA system based on a new approach. method by using Matlab.
ii. Reduce the power consumption.
iii. To get faster SIR recovery.
iv. To avoid interference between users.
v. To maximize the capacity and better performance for DS-CDMA system.
vi. To achieve stable DS-CDMA system.

This requires an optimal power control scheme. A power control scheme based on LQG control and Extended Kalman filter to predict the channel were suggested. This method was tested by building a simulated DS-CDMA link with existing SIR based uplink power control schemes, implementing the predictive approach for power control and compares it to the conventional method. Depending on the results from the comparison it may be concluded that the suggested method of power control performs better.

1.4 Project Scopes

The scopes of this project have various strategies such as:

i. Use of DS-CDMA in the system.

All users send the information simultaneously on the same bandwidth. Because the DS-CDMA system is inherently interference limited, it is important to keep the transmission power of each mobile user as low as possible.

ii. Utilization of power control.

This is to control the transmitted power from mobile user to base station that mean make SIR work in desired value. This process has three loops: open loop, outer loop and close loop. This research is interested to deal with SIR which based on closed loop that has three steps: fixed step size, quantized step size and ideal step size.

iii. Choose of an Extended Kalman filter to predict the state of channel.

Extended Kalman filter is known as non-linear quadratic estimation. It is used to estimate a signal in a presence of Gaussian noises. Power control system is designed by adding an Extended Kalman filter to achieve a perfect performance.

iv. Simulation and verification.

This method is simulated and verified using Matlab. A significant difference between the previous methods and a new approach method was observed.

CHAPTER II

LITERATURE REVIEW

2.1 History of wireless communication

The history of wireless communications began in 1886 when H. Hertz generated and, thus, proved the presence of J. C. Maxwell's theoretically predicted electromagnetic waves. In the following year G.Marconi showed the possible of wireless communications, as clearly documented by the words delivered before the Royal Institution in 1897 from the Technical Director of the British Post Office, who supported G. Marconi:

"It is curious that hills and apparent obstructions fail to obstruct... Weather seems to have no influence; rain, fogs, snow and wind, avail nothing... The distance to which signals have been sent is remarkable. On Salisbury Plain Mr. Marconi covered a distance of four miles. In the Bristol Channel this has been extended to over eight miles and we have by no means reached the limit. It is interesting to read the surmises of others. Half a mile was the wildest dream."

In 1901 G. Marconi established a radio connection over the Atlantic. Sequence results, research and development led to use one of the most widely applications in the wireless communication system, that of radio broadcasting. Using this medium, G. Marconi in 1937, said in a radio message:

“Radio broadcasting, however, despite the great importance reached and the still unexplored fields open to investigation, is not, in my opinion, the most significant application of modern Communications, because it is a one way communication only. Greater importance is related, in my opinion, to the possibility offered by radio of exchanging communications anywhere the correspondents are located, in the middle of the ocean, in the ice pack in the pole, in the desert plains or over the clouds in an airplane."

These words should prove to be true and one hundred years after G. Marconi's first experiments, the market of wireless mobile communications with duplex transmission is one of the fastest expanding of the world. The establishment for a widespread of wireless mobile communications was laid with the standardization of the first generation cellular mobile radio systems in the 1980s. The origins of digital communications go back to the work of S. Morse in 1837, demonstrating an electrical telegraphy system. The so-called Morse code represents the letters of the alphabet by sequences of dots and dashes and was the major of modern variable-length source coding.

The rapid development in the area of micro electronics with a continuous increase in device density of integrated circuits and the development of low-rate digital speech coding techniques made completely digital second generation cellular mobile radio systems created. Various second generation cellular systems were developed in the 1990s. Most of these systems use time Division Multiple Access (TDMA), such as the Global System for Mobile Communications (GSM) and the Digital Cellular System 1800 (DCS1800) in Europe, the Interim Standard (IS-54) in the USA, and the Personal Digital Cellular (PDC) system in Japan. With TDMA, the time axis is subdivided into different non-overlapping time slots where each user has time slot; TDMA is combined with Frequency Division Multiple Access (FDMA) to reduce the hardware complexity of an otherwise extremely broadband system and to increase the flexibility of the system.

Parallel to the TDMA based second generation standards, the IS-95 was developed in the USA, used Code Division Multiple Access (CDMA) with direct sequence (DS) spectrum spreading, combined with FDMA. The origins of CDMA go back to the beginnings of spread spectrum communications in the first half of the 20st century. Primary applications of spread spectrum communications put in the development of secure digital-communication systems for military use. Since the second half of the 21st century, spread spectrum communications became of great interest also for commercial applications, including mobile multi-user Communications.

The spectrum spreading is achieved by using a spreading code that is independent of the message and is known to the receiver. The receiver uses a synchronized replica of the spreading code to despread the received signal allowing recovery of the message. The operation of the spread spectrum technique to enable multiple users a simultaneous access to the channel is called CDMA.

The increasing interest for CDMA digital mobile-communication systems has lead of late to the consideration of optimizing the power control. As the CDMA systems are originally interference limited, it is importance to keep the transmission power of each mobile user as low as possible (Gilhousen et al., 1991).

This is critical in the uplink transmission (from mobile to base station), where all the mobile units need to be controlled by the base station to keep the received power level from each mobile unit constant in the average. The need for power control has been widely studied, and the capacity of a CDMA system is found to greatly depend on the power control function (Tongus & Wang, 1994).

Power control in cellular networks has been widely studied since the late 1980s as an important mechanism to control Signal-to-Interference Ratio (SIR). Specifically, in the past system designer’s choices where driven by their knowledge, designed the power control planners use the signal to interference ratio (SIR) to design a Power Control Command (PCC), to set the power sent from mobile stations to base station. However, this design gave a clear problem that is the slow SIR recovery due to the factors affecting on the signal during propagation inside the channel. Such as non linearity, fading, and interference from other users. These designees base the PCC on the current channel state when in fact the channel state will be changed when transmission occurs. That led to make the SIR drop or rise drastically and also lead to Near-Far-effect interference. In turn will increase the power sent by mobiles to overcome this problem that produces power escalation and making the system unstable. Solution for the escalation power and unstable system should be selected by improving the sending power from mobile stations to base station by taking into account the basic features of channel. This research shows an important issue to improving the uplink power control channel for DS-CDMA system. Here focusing on the uplink prediction channel and representation how the prediction can be done by using linear Quadratic Gaussian (LQG) control and Extended Kalman filter to get a stable DS-CDMA system.

2.2 Code Division Multiple Access system (CDMA)

In CDMA system each user uses a different code to modulate their signal. Choosing the codes used to modulate the signal is very important in the performance of CDMA systems. The best performance will occur when there is good separation between the signal of a desired user and the signals of other users.

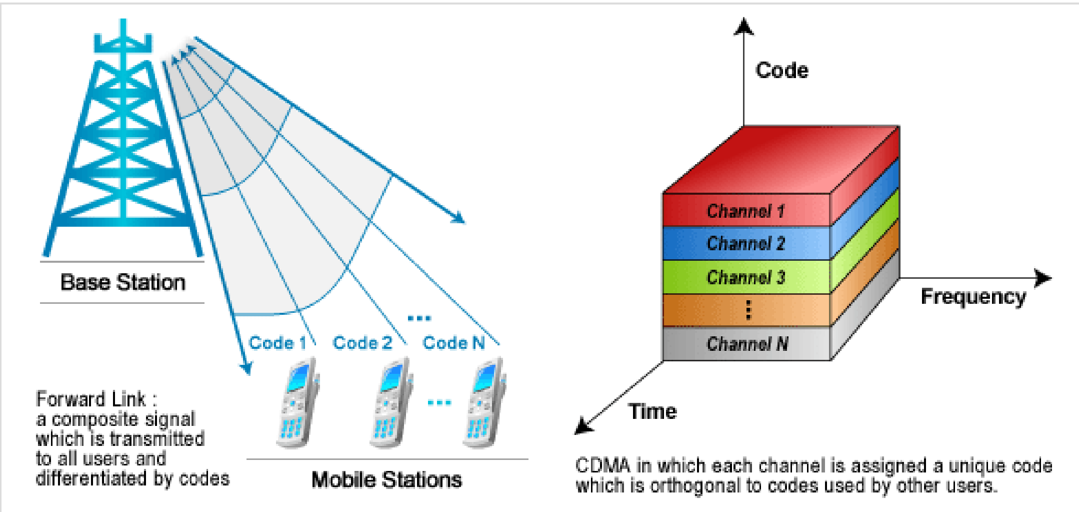

Figure 2.1: The CDMA system.

In fact, CDMA, TDMA and FDMA have exactly the same spectral efficiency but practically, each has its own challenges, power control in the case of CDMA, timing in the case of TDMA, and frequency generation/filtering in the case of FDMA.

TDMA systems must carefully synchronize the transmission times of all the users to ensure that they are received in the correct time slot and do not cause interference. Since this cannot be perfectly controlled in a mobile environment, each time slot must have a guard-time, which reduces the probability that users will interfere, but decreases the spectral efficiency. Similarly, FDMA systems must use a guard-band between adjacent channels. The guard-bands will reduce the probability that adjacent channels will interfere, but decrease the utilization of the spectrum.

With these considerations, CDMA has been selected as the best system used in wireless communication. This system has several advantages:

- High purity in the transfer of voice and data.
- Safer with effective protection against leakage illegal for calls or data.
- Number of unsuccessful calls less the equivalent of 15 times for traditional mobile.
- Telephones are working with very low frequency signals, which make use of safer on the health of people with consideration to radiation as it provides battery consumption.
- Effective use of frequency waves (frequency band).
- Does not need to frequency planning.
- The ease and flexibility in developing the system upgraded and updated.

These features gave the motivation to choose the CDMA system. There are two types of CDMA systems deployed in practice:

- Direct Sequence Spread Spectrum (DSSS).
- Frequency Hopping Spread Spectrum (FHSS).

Frequency Hopping Spread Spectrum (FHSS) or Frequency Hopping Code Division Multiple Access (FH-CDMA), in which a broad slice of the bandwidth spectrum is divided into many possible broadcast frequencies. In general, frequency-hopping devices use less power and are cheaper, but the performance of DS-CDMA systems is usually better and more reliable.

2.3 Direct Sequence Code Division Multiple Access (DS-CDMA)

Direct sequence spread spectrum, also known as Direct Sequence Code Division Multiple Access (DS-CDMA) is one of two processes to spread spectrum modulation for digital signal transmission over the airwaves. In direct sequence spread spectrum, the stream of information to be transmitted is divided into codes every user have special code.

A data signal at the point of transmission is combined with a higher data-rate bit sequence (also known as a chipping code) that divides the data according to a spreading ratio. The redundant chipping code helps the signal resist interference and also enables the original data to be recovered if data bits are damaged during transmission.

Spread spectrum first was developed for use by the military because it uses wideband signals that are difficult to detect and that resist attempts at jamming. In recent years, researchers have turned their attention to applying spread spectrum processes for commercial purposes, especially in local area wireless networks.

2.3.1 Features of DS-CDMA System

Direct Sequence (DS) Code Division Multiple Access (CDMA) is a promising technology for wireless environments with multiple simultaneous transmissions because of several features:

i. The signal occupies a bandwidth much greater than that which is necessary to send the information. This results in many benefits, such as immunity to interference and jamming and multi-user access.
ii. The bandwidth is spread by means of a code which is independent of the data.
iii. The receiver synchronizes to the code to recover the data. The use of an independent code and synchronous reception allows multiple users to access the same frequency band at the same time.
iv. In order to protect the signal, the code used is pseudo-random. It appears random, but is actually deterministic, so that the receiver can reconstruct the code for synchronous detection. This pseudo-random code is also called Pseudo-Noise (PN).

2.3.2 Implementing DS-CDMA Technology:

The Figure 2.2 shows a simplified Direct Sequence Spread Spectrum system. For clarity, the figure shows one channel operating in one direction only.

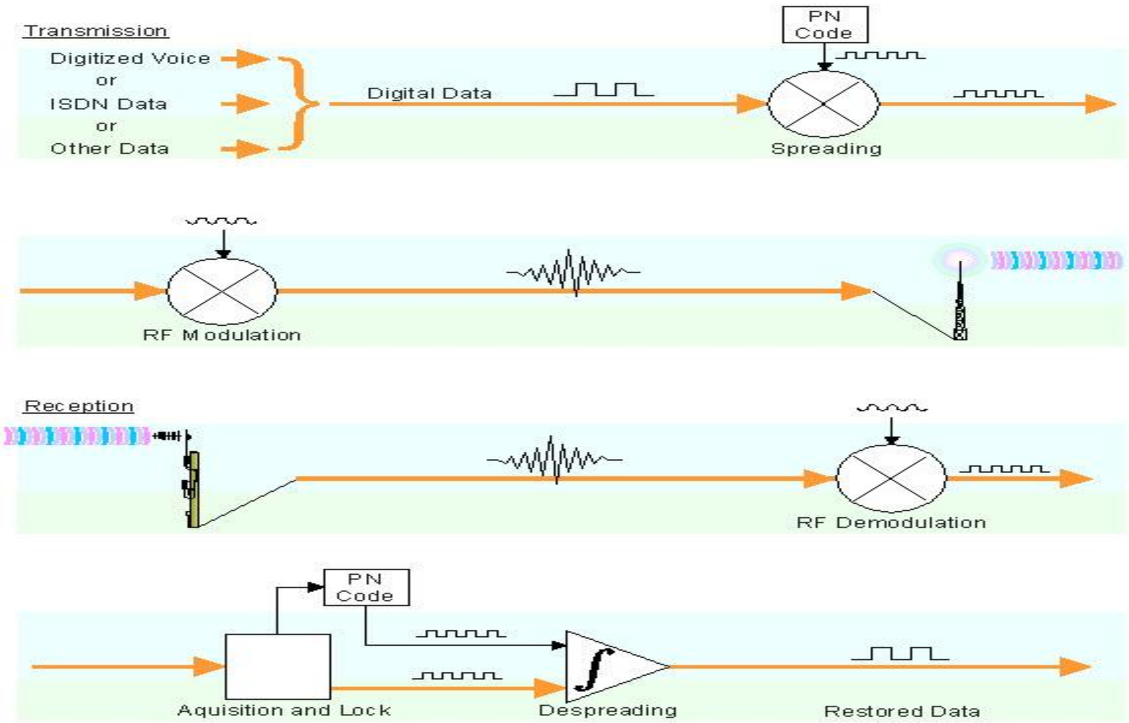

Figure 2.2: Direct sequence spread spectrum system.

The DS-CDMA system works directly on 64 kbit/sec digital signals. These signals can be digitized voice, Integrated Services Digital Network (ISDN) data is a set of communication standards for simultaneous digital transmission of voice, video, data, and other network services, etc.

Signal transmission consists of the following steps:

- A pseudo-random code is generated, different for each channel and each successive connection.
- The Information data modulates the pseudo-random code (the Information data is “spread”).
- The resulting signal modulates a carrier.
- The modulated carrier is amplified and broadcast.

Signal reception consists of the following steps:

- The carrier is received and amplified.
- The received signal is mixed with a local carrier to recover the spread digital signal.
- A pseudo-random code is generated, matching the anticipated signal.
- The receiver obtained the received code and phase locks its own code to it.
- The received signal is associated with the generated code, extracting the Information data.

2.4 Factors Affecting On Transmitting Signal

The main difference between a wireless communication system and a wire-line system is the channel. A wire has stationary characteristics, whereas the wireless channel changes with time since the environment between the transmitter and the receiver changes. These changes event over time in unpredictable ways due to user movement. This section describes some of the basic channel impairments.

There are many factors that affect the way in which transmitting signals propagate. These are determined by the medium through which the transmitting signals travel and the various objects that may appear in the path. The properties of the path by which the mobile signals will propagate set the level and quality of the received signal. mobile signals are affected by the phenomena of reflection, refraction, diffraction, absorption interference scattering and noise (Muhammad, 2008).

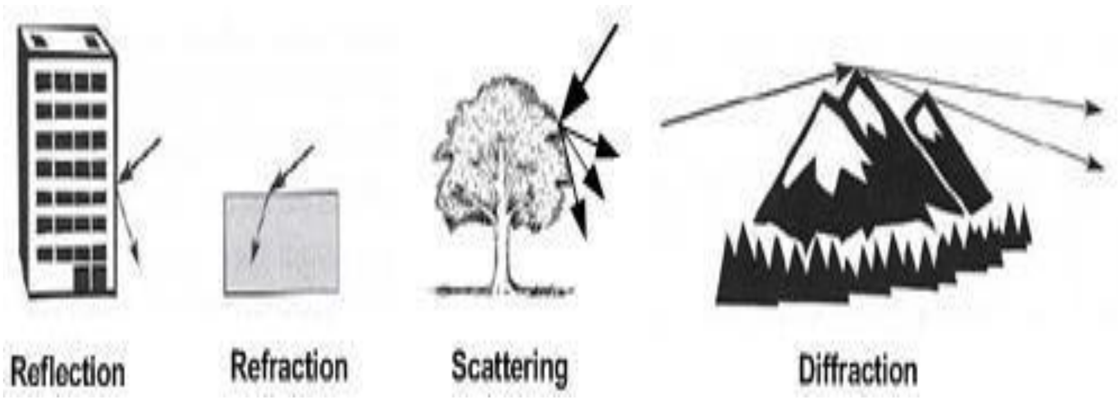

Figure 2.3: Illustration of reflection, refraction, scattering and diffraction phenomena.

The resultant mobile signal may also be a combination of several signals that have travelled by different paths. These may add together or subtract from one another, and in addition to this the signals travelling via different paths may be delayed causing distorting of the resultant signal. It is therefore very important to know the likely signal propagation characteristics that are likely to dominate.

2.4.1 Reflection

Reflection of signal is an everyday occurrence. Mirrors are commonplace and can be seen in houses and many other places. Shop windows also provide another illustration for this phenomenon, as do many other areas.

When reflection occurs, it can be seen that the angle of incidence is equal to the angle of reflection for a conducting surface. When a signal is reflected there is normally some loss of the signal, either through absorption, or as a result of some of the signal passing into the medium. A variety of surfaces can reflect mobile signals. For long distance communications, the sea provides one of the best reflecting surfaces. Other wet areas provide good reflection of wireless signals. Desert areas are poor reflectors and other types of land fall in between these two extremes. In general, though, wet areas provide better reflectors.

For relatively short range communications, many buildings, especially those with metallic surfaces provide excellent reflectors of wireless signal. There are also many other metallic structures such as warehouses that give excellent reflecting surfaces. As a result of this signals travelling to and from cellular phones often travel via a variety of paths.

2.4.2 Refraction

It is also possible for mobile signal to be refracted. The concept of light waves being refracted is very familiar, especially as it can be easily shown by placing a part of stick or pole in water and leaving the remaining section in air. It is possible to see the apparent change or bend as the stick enters the water. Mirages also demonstrate refraction and a very similar effect can be noticed on hot days when a flashing effect can be seen when looking along a straight road. Mobile signal affected in the same way. It is found that the direction of an electromagnetic wave changes as it moves from an area of one refractive index to another.

2.4.3 Diffraction

This phenomenon occurs when mobile signals facing obstacles. On facing an obstacle during propagation in a homogeneous medium, a mobile signal changes in amplitude and phase and penetrates the shadow zone.

A wireless signal that meets an obstacle has a natural slope to bend around the obstacle as illustrated in figure 2.4. The bending, called diffraction, results in a change of direction of part of the wave energy from the normal line-of-sight path. This change makes it possible to receive energy around the edges of an obstacle as shown in view A or at some distances below the highest point of an obstruction, as shown in view B.

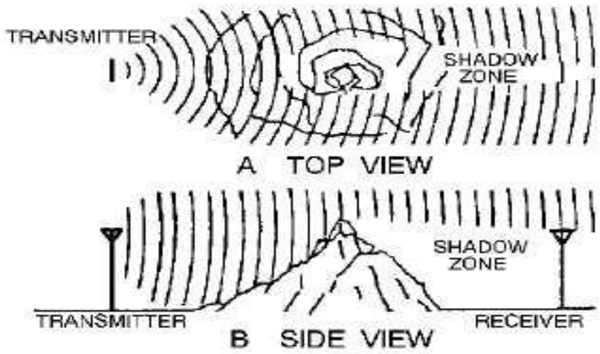

Figure 2.4: The diffraction around an object.

2.4.4 Absorption

When a mobile signal reaches an obstacle, some of its energy is absorbed and converted into another kind of energy, while another part is attenuated and continues to propagate, and another part may be reflected.

2.4.5 Scattering

Scattering is a general physical process. where some forms of radiation, such as mobile signal, light, sound, or moving particles, are forced to deviate from a straight path by one or more localized non-uniformities in the medium through passing. The types of non-uniformities which can cause scattering, sometimes known as scattering centres, are too numerous to list, but a small sample includes particles, bubbles, droplets, density fluctuations in fluids, surface roughness, cells in organisms, and textile fibers in clothing.

2.4.6 Interference

Interference is a major concern in this research. Where interference mean one users signal may be interfered by other users signals this is called Near-Far-effect interference. All mobiles transmit their signal with the same power without taking into consideration the fading and the distance from the base station, it means Mobile Station (MS) close to Base Station (BS) has much lower path loss than those of the Mobile Station (MS) that are far away. If all mobile stations uses the same transmitted power, the mobile's close to Base Station (BS) would effectively jam the signals from the mobile's which farther (Kumar &Kumar, 2010). This problem is known as the Near-Far effect interference as shown in following Figure 2.5.

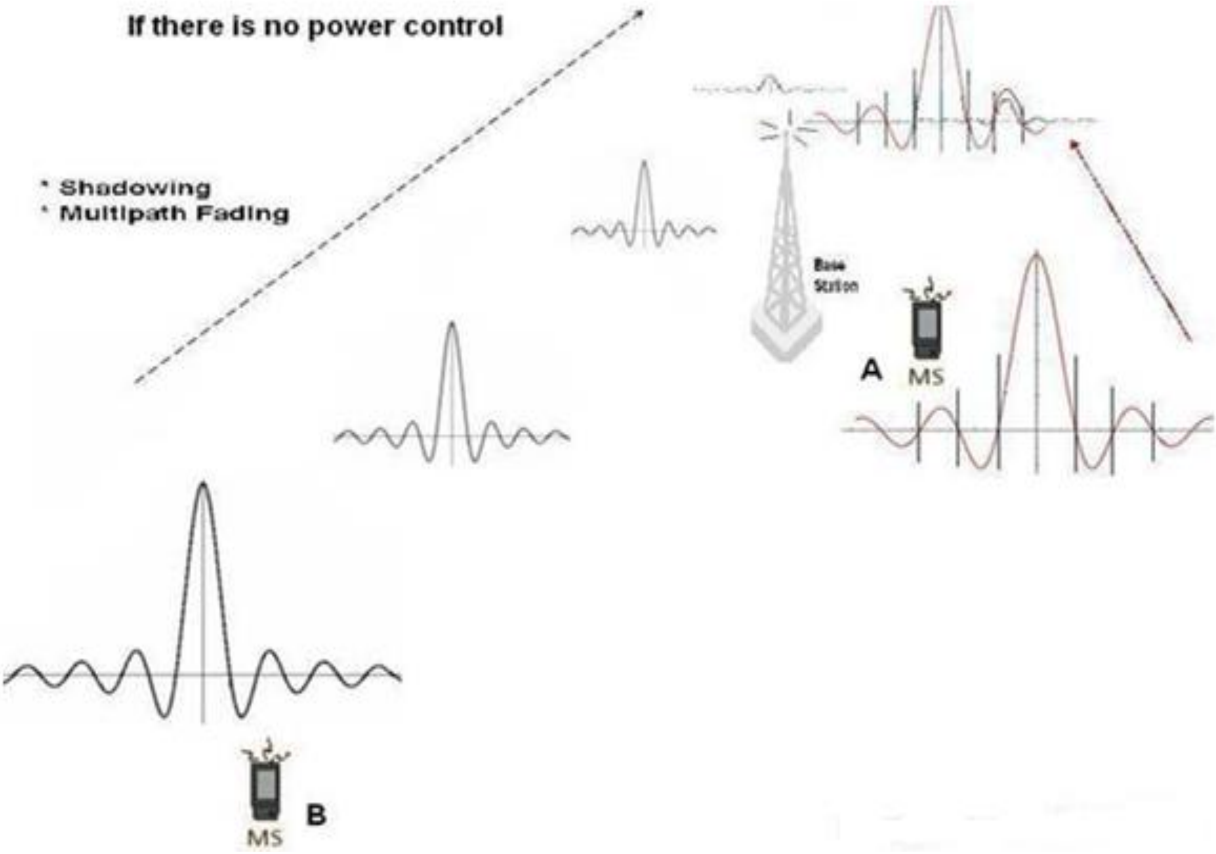

Figure 2.5: Effect of Near-Far interference.

The reverse link (mobile to base station) necessitates power control to solve the Near-Far problem. All mobiles transmit on the same channel at the same time but with different codes. Therefore users may interfere with each other.

The power control manages problems mentioned above by adjusting transmits power in order to achieve some predefined performance level such as Signal to Interference Ratio (SIR) as shown in following figure 2.6.

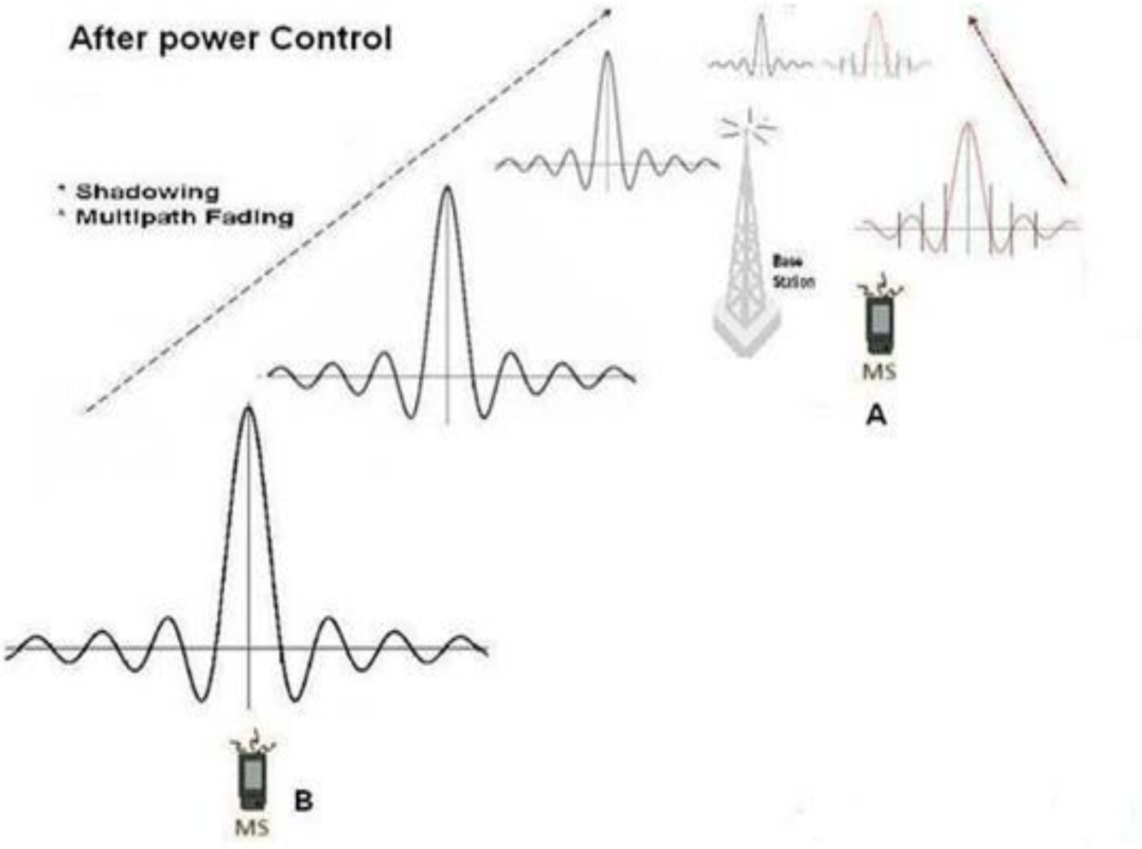

Figure 2.6: The power control overcomes Near-Far effect interference.

2.4.7 Noise

Noise is mostly unwanted random addition to a signal. Noise is anything that interferes with a message being transmitted from a sender to a receiver. It results from both internal and external factors.

2.4.7.1 White noise

White noise is a signal (or process), named by analogy to white light, with a flat frequency spectrum. In other words, the signal has equal power in any band of a given bandwidth (power spectral density). For example, with a white noise audio signal, the range of frequencies between 40 Hz and 60 Hz contains the same amount of sound power as the range between 400 Hz and 420 Hz.

2.5 Signal-To-Interference Ratio (SIR)

Signal-to-interference ratio (S/I) is the ratio of power in a signal to the interference power in the channel. The signal-to-interference ratio (S/I or SIR) for a mobile :

$$\frac{S}{I} = \frac{S}{\sum_{i=1}^{i_0} I_{io}} \qquad (2.1)$$

S: the desired signal power.

I_{i_0}: The interference power caused by the interference.

i_0: The number of interference.

The signal-to-interference ratio has been considering the most efficient standard for several methods aiming at reducing the effects of interference, e.g. variety reception, dynamic channel allocation and power control.

Several methods and techniques have been developed to combat the effects of interference, to increase system capacity and improve communication quality in cellular radio systems. Many such techniques have used the Signal to Interference Ratio (SIR) to estimate signal quality, and where it has been assumed that the receivers (base stations in the uplink and mobile stations in the downlink) can measure this parameter in real time during operation (Andersin et al, 1996).

2.6 Uplink Channel

The Information travels in two directions in a network: uplink (mobile-to-base station) and downlink (base station-to-mobile). The mathematical formulations of these problems are similar in satellite communications; they differ in cellular wireless systems. In cellular communications networks, an uplink special concern is consumption of mobile battery power. Also, downlink codes are synchronous and can be made orthogonal; but uplink codes arrive at the base station asynchronously, resulting in cross correlation and hence high in-cell interference potential unless power is adequately controlled. For this reason this research concentrates on the uplink channel.

The requirement of the dynamic range of uplink power control can be of the order of 80dB. In down link since all signals transmitted by Base Station (BS), propagate through same radio channel before reaching to Mobile Station (MS). They submit the same attenuation and so power control is not needed. The dynamic range of downlink power control is usually smaller than in uplink (typically 20-30 dB) (Khan & Jain, 2009).

The uplink and downlink signals do not interfere with each other; separate frequencies are used for uplinking and downlinking.

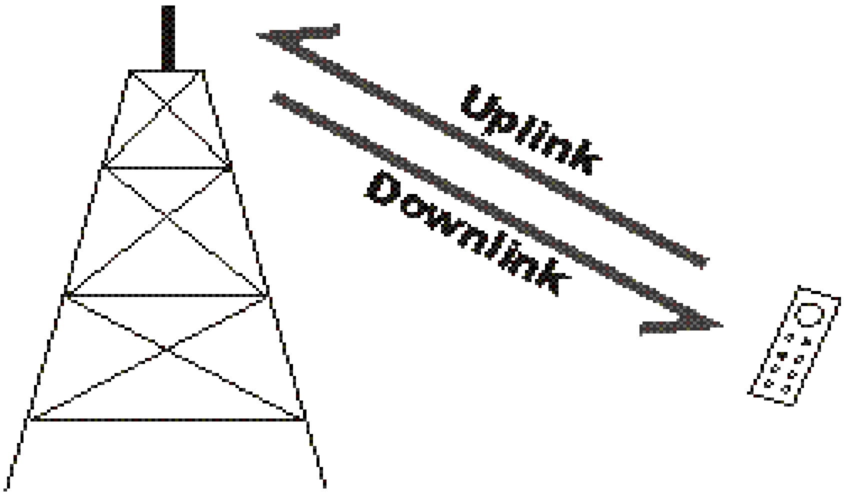

Figure 2.7: The uplink and downlink method.

The uplink part of a network connection is used to send, or upload, data from a mobile device to a base station. The uplink power control is critical for the capacity of DS-CDMA system. Signals from different mobile users are also subject to different propagation mechanisms, resulting in different propagation path losses and independent fading that lead to unequal received power levels at the base station. Due to non-orthogonal spreading sequence and unequal received power levels in the reverse link, interference becomes a serious problem. Figure 2.8 illustrates the process of uplink channel for DS-CDMA system.

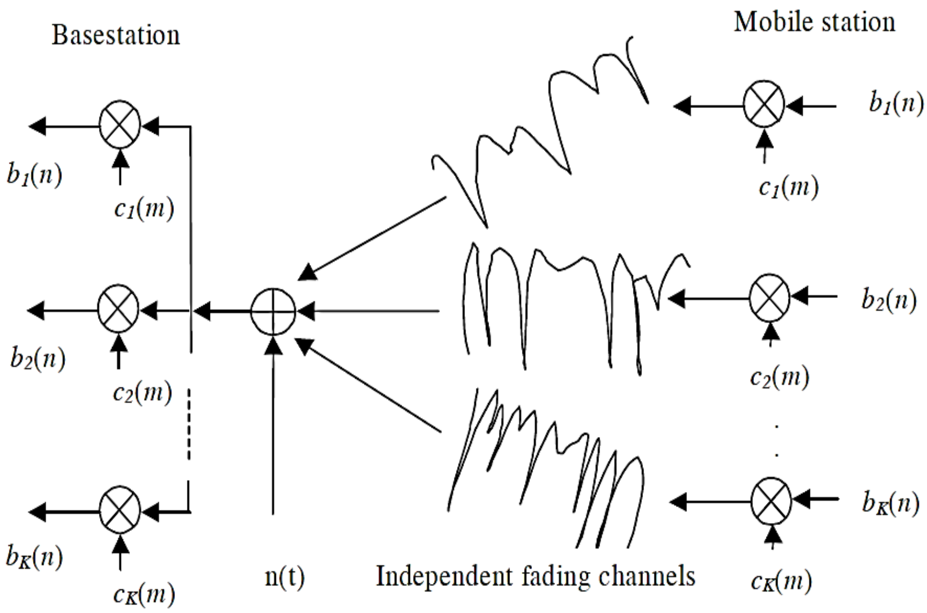

Figure 2.8: Uplink DS-CDMA channels in a wireless communication system.

If the received power levels at the base station are not equal, the correlating receiver may not be able to detect the weak user's signal due to high interference from other users with higher power levels. Clearly, if a user is received with a weak power, it will suffer from the interference generated by stronger users' signals. Therefore power control in the uplink is very important to keep the interference acceptable to all users and to obtain a great channel-capacity improvement.

Actually, the received signal from a user that is close to the base station can be much stronger than the signal received from those distant users. This is called the Near-Far problem, which may cause a distant user to be dominated and jammed by the nearby users. If power control is not performed, only users associated with the highest received power will be able to communicate with the base station without being jammed by other users. Therefore, this will clearly decrease the capacity of the DS- CDMA system.

In fact it is easy to show that the system capacity of a multiuser DS-CDMA system is optimum when the signals from all users are received with an equal level, which is only achievable with a perfect uplink power control scheme.

The uplink power control is needed to regulate the transmitting power from each mobile accordingly to its channel characteristics to achieve the goal of all mobile station signals arrive at the base station at equal power and synchronously.

2.7 Power Control

The requirement of Power Control (PC) in the uplink Direct- Sequence Code-Division Multiple-Access (DS-CDMA) system is a critical limitation. Power control is needed because all users share the same bandwidth and, thus, inter-user interference is must to occur. Without power control, a signal received by the Base Station (BS) from a nearby the Mobile Station (MS) will dominate the signal from a far-away Mobile Station (MS), resulting in the so-called Near–Far effect interference. The objective of power control is to control the transmitted power by the mobile units so that the average power received from each unit is generally constant (Aldajani & Sayed, 2003).
Some of the main advantages of power control can be summarized as follows:

- Interference management: Due to the broadcast nature of wireless communication, signals interfere with each other. This problem is especially acute in interference-limited systems, such as DS-CDMA systems where perfect orthogonality among users are difficult to maintain. Power control helps ensure efficient spectral reuse and desirable user experience.

- Energy management: Due to limited battery power in mobile stations, handheld devices, or any “nodes” operating on small energy budget, energy conservation is important for the lifetime of the nodes and even the network. Power control helps minimize a key component of the overall energy expense.

- Connectivity management: Due to uncertainty and time variation of wireless channels, even when there is neither signal interference nor energy limitation, the receiver needs to be able to maintain a minimum level of received signal so that it can stay connected with the transmitter and estimate the channel state. Power control helps maintain logical connectivity for a given signal processing scheme (Tan, 2008).

The purpose of power control is to adjust each user's transmitting power and make each user's signal-to-noise ratio reached a threshold value. At the same time, it can adjust the total transmitting power and reduce interference. There are three types of power control algorithms: open-loop, closed-loop, and outer-loop power control. The open-loop power control is designed to overcome the Near-Far problem, while the closed-loop power control aims at reducing the effect of Rayleigh fading. The outer-loop power control is used in a closed-loop power control to adjust the target SIR or signal strength.

For example, open loop power control can be used in uplink. Mobile station can measure the propagation loss between the user and the base station according to the pilot signal strength received and determine the size of the mobile station's transmitting power. In order to further improve the control setting must use closed loop power control.

Base station can get an estimated value of signal-to-interference ratio by measuring the signal that received from the mobile station at regular intervals. Then it compares the estimated value and the signal-to-interference ratio threshold that has been set (Ma et al., 2012).

2.7.1 Closed Loop Power Control

Power control on the reverse link is critical because the received signals come from different mobile terminals that fade independently and deal with the rapid signal variations, which cannot be eliminated by the forward link. Since multipath fading is uncorrelated between the reverse and forward links, feedback from the base station is required to control the mobile transmit power. The closed loop power control scheme is described in Figure 2.9.

REFERENCES

Prasad, R. (1998): An Overview of CDMA Evolution Toward Wideband CDMA.

1(1): 2 - 29.

Bambos, N.(1998): Toward Power-Sensitive Network Architectures in Wireless Communications :Concepts,Issues,and Design Aspects. 5(3): 50 - 59.

Ariyavisitakul, S. (1994): Signal and Interference Statistics of a CDMA System with Feedback Power Control. II. 42(234): 597 - 605.

Gilhousen. K. S., Jacobs. I. M., Padovani, R., Viterbi. A. J., Weaver. L. A, Jr. & Wheatley, C. E., III. (1991): On The Capacity of A Cellular CDMA System. 40 (2) : 303 - 312.

Tonguz, O. K & Wang, M. M.(1994): Cellular CDMA Networks Impaired By Rayleigh Fading: System Performance with Power Control. 43(3): 515 - 527.

Muhammad, B. (2008): Closed Loop Power Control for LTE Uplink. Master.Thesis. Blekinge Institute of Technology School of Engineering .

kumar, K. & Kumar, A.(2010): Adaptive-step reverse link closed loop power control for CDMA system. Computer and communication technology (ICCCT).PP.56-59.

Andersin, M., Mandayam, N. B. & Yates, R. D. (1996): subspace based estimation of the signal to interference ratio for TDMA cellular systems.Rutgers University. The state University of New Jersey.

Khan,M.A.R & Jain,P.C.(2009): A Simple Modified Fixed Step Size Power Control Algorithm for CDMA Cellular Systems. multimedia, signal processing and communication technologies. pp .134 - 137.

Aldajani, M.A. & Sayed, A.H.(2003): Adaptive Predictive Power Control for the Uplink Channel in DS-CDMA Cellular Systems. 52(6):1447 - 1462.

Tan,W.T.(2008): Power Control in Wireless Cellular Networks. USA. University of Maruland. University of Maryland.

Ma,W,Yang, H & Liu, H.(2012): Joint Power Control in CDMA Cellular Wireless Communication System . system scinence and engineering (ICSSE). PP.404 - 408.

Kurniawan, A., Perreau ,S., Choi, J. & Lever, K. (2000): SIR-Based Power Control in Third Generation CDMA Systems. Seoul. South Korea.institute for telecommunications research cooperative research centre for satellite systems.

Sanchez, M., Cinthia,J., Rivera,L., J,M., Delgado, C., & Daniel,U.(2012): A Cross-Layer Power Allocation Scheme for CDMA Wireless Networks. American control conference (ACC). PP. 2018 - 2023.

Sung,C.W.& Wong,W.S.(1999): A Distributed Fixed-Step Power Control Algorithm with Quantization and Active Link Quality Protection.48(2):553-562.

Taylor, I.M.&Labrador, M.A.(2011): Improving The Energy Consumption in Mobile Phones by Filtering Noisy GPS Fixes with Modified Kalman Filters. Wireless Communications and Networking Conference (WCNC).PP.2006-2011.

Zhiwen, Z. & Leung,H. (2001): Adaptive Blind Equalization for Chaotic Communication Systems Using Extended Kalman Filter. 48(8): 979 - 989.

Welch,G. & Bishop,G.(2006): An Introduction to the Kalman Filter.Department of computer science university of north Carolina at chapel Hill.pp.7-8.

Garcia, V., Lebedev, N. & Gorce, J.-M. (2012): Model Predictive Control for Smooth Distributed Power Adaption. Wireless Communications and Networking Conference (WCNC). PP. 421-426.

Julier, S.J., Uhlmann, J.K. & Durrant-Whyte, H.F.(1995): A New Approach for Filtering Nonlinear Systems. American Control Conference. Proceedings of the Volume: 3.PP.1628-1632.

Perreau, S., Anderson, M.D. & White, L.B.(2002): Adaptive Power Control for CDMA Systems Using Linear Quadratic Gaussian Control . Signals, Systems and Computers. Conference Record of the Thirty-Sixth Asilomar Conference on Volume: 1.PP.87-91.