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Comparative Analysis of Maximum Ratio Combining and Equal Gain Combining Diversity Technique for WCDMA: A Survey

Sarita Rohilla[1] Dipesh Kumar Patidar[2] Naresh Kumar Soni[3]
[1,2,3]Department of Electronics
[1]JNU Jaipur, [2]Poornima Institute of Engg. & Tech. , [3]JNU Jaipur

ABSTRACT: *Wide Code Division Multiple Access (WCDMA) is a third generation wireless communication system. However for any wireless communication system there are various factors such as fading, interference and scattering that degrade the performance of the system. Diversity is an influential communication technique that provides wireless link enhancement at a relatively low cost. It has been used to mitigate the fading problem in wireless channel. This survey provides overview of different diversity techniques to overcome the effect of fading .The Maximum Ratio Combining (MRC) is one of the combining technique used to improve the performance of wireless communication system. In WCDMA, each user is assigned a unique code that identifies the user to the system and this code is used to modulate and demodulate the user's data. In many diversity techniques space diversity technique is very effective due to its simplicity and bandwidth efficiency. It can be implemented at both the transmitting and the receiving end. The Maximum Ratio Combining performance is the best compare to Equal Gain Combining and Selection Combining in Rayleigh fading channel. For the same SNRs signals to both branches, the output of maximal ratio combiner is more than equal gain combiner. This is due to ability of updating the weight coefficient in Maximal Ratio combining technique.*

Keywords: *Fading, Multi Path Propagation, Diversity Technique, Maximum Ratio Combining (MRC), Equal Gain Combining (EGC), Selection Combining (SC).*

I. INTRODUCTION

1.1 History of WCDMA

Bell laboratories developed the cellular concept in the 1960s and AT&T proposed the concept of cellular mobile system to the Federal Communication Commission (FCC) in 1968s. The first cellular system was Advance Mobile Phone System (AMPS). The AMPS allocated 60 KHz of bandwidth to each voice user in each cell and this allocation consisted of two 30KHz Channels: One for the uplink and other for downlink [1]. The AMPS phones were two way FM radios and share spectrum amongst users and this technology become Frequency Division Multiple Access (FDMA). The first digital cellular phone standard IS-54 supported three users in each 30 KHz of bandwidth used in AMPS system [2]. Wireless communication technologies have developed very rapidly in the recent years to improve the performance of the system. In CDMA, a signal was multiplied by a pseudo-noise code sequence with a higher rate than the data rate of message. The resultant signal appeared as random and the process was reversed at receiver and the original signal was extracted. Use of unique code lead to repetition of the same frequency in all cells. However, each user transmitted all of the time over all of the frequency but used one of ten available orthogonal codes to ensure that there was no interference with the other nine using orthogonal code [3]. In CDMA, a single 1.25 MHz radio channel carries 64 simultaneous voice channels [4]. The CDMA has two types non-orthogonal and orthogonal. Generated by pseudo-noise was called non-orthogonal CDMA. In orthogonal CDMA, all users are perfectly uncorrelated to one other and aligned in time to retain their orthogonality. The narrowband message signal is multiplied by a very large bandwidth signal called the spreading signal. In spread spectrum technique each users is multiplied with pseudo-noise code sequence and increase the bandwidth of users . The 3rd Generation Partnership Project (3GPP) and 3rd Generation Partnership Project two (3GPP2) had developed Wideband Code Division Multiple Access (WCDMA) technology. Now the WCDMA technology is used in third generation wireless system to achieve data transmission at variable rate with different mobility and quality of services (QoS) standard cell for increasing the transmission rate from the 14.4 kb/s voice rate currently support up to 384 kb/s for mobile users and 2 Mb/s for portable terminals. WCDMA is the second 3Gair interface standard based on CDMA. WCDMA is an asynchronous scheme and uses a 5MHz carrier frequency. The use of a wider carrier aims to provide support for high data rates. However using wider carriers requires more available spectrum. WCDMA is considered to be wideband technologies based on the direct sequence spread spectrum transmission scheme, where user information bits are spread over a wide bandwidth by multiplying the user data with quasi-random bits called chips derived from CDMA spreading codes. In order to support very high bit rates (up to 2 Mbps), the use of a variable spreading factor is supported. The chip rate 3.84 Mcps leads a carrier bandwidth of 5MHz [5, 6]**.** The key operational features of the WCDMA radio interface are:

1. Supported of high data rate transmission: 384 kbps with wide area coverage, 2Mbps with local coverage.
2. Providing high service flexibility is supporting multiple parallel variable rate services on each connection.
3. Supported both Frequency Division Duplex (FDD) and Time Division Duplex (TDD).
4. Built in support for future capacity and coverage enhancing technologies such as adaptive antennas, advanced receiver structures and transmitter diversity.
5. Efficient packet access.

1.2 Problems Associated With Wireless Communication

When a signal is transmitted from source to destination through the channel, There are two main aspects related to performance of wireless communication, first is the phenomenon of fading: the time-variation of the channel strengths due to the small-scale effect of multipath fading, as well as larger scale effects such as path loss via distance attenuation and shadowing by obstacles and second is unlike in the wired world where each transmitter-receiver pair can often be thought of as an isolated point-to-point link, the wireless users communicate over the air and there is significant interference between them in wireless communication. One of the most powerful techniques to mitigate the effects of fading is to use diversity combining of independently fading signal paths. Other aspects that may also affect the performance of wireless communication are Path loss and Noise [8].

1.2.1 Fading

In wireless communications, fading is deviation of the attenuation affecting a signal over certain propagation media. The fading may vary with time, geographical position or radio frequency, and is often modeled as a random process. The time variation of received signal power caused by changes in the transmission medium leads to Fading. In a fixed environment, received signal is affected by changes in atmospheric conditions, such as rainfall [4]. In wireless systems, fading may either be due to multipath propagation, referred to as multipath induced fading or due to shadowing from obstacles affecting the wave propagation, sometimes referred to as shadow fading. In a wireless mobile system a signal can travel from transmitter to receiver through multiple reflective paths which is known as multipath propagation. Multipath propagation causes fluctuations in signal's amplitude, phase and angle of arrival creating multipath fading. There are basically three propagation mechanisms playing a role in the multipath fading, viz. reflection, diffraction, scattering.

(a) Reflections occur when a propagating electromagnetic signal encounters a smooth surface which is large relative to the signal's wavelength. This usually happens when the signal enters a building and the reflection may occur at the wall of the building.

(b) Diffraction occurs at the edge of a dense body which is larger compared to the signal's wavelength. Diffractions will result in the bending of the signal making it possible for the receiver to receive the signal even when there no direct path between the transmitter and receiver. It usually occurs on irregular surfaces such as sharp edges.

(c)Scattering usually occurs when the signal is subjected to a large number of objects smaller than the signals wavelength thus causes the incoming signal to spread out (scatter) into several weaker outgoings in all directions. This happens usually when the signal passes through a medium containing vegetations, forest, clouds and etc.

1.2.2 Interference

Interference is the major limiting factor in the performance of cellular system. Source of interference include another mobile in the same cell. Interference on voice channel cause cross talk. On control channel, interference leads to missed and blocked calls to errors in the digital signaling. The two major types of system-generated cellular interference are co-channel interference and adjacent channel interference. Co-channel interference (intra-cell) is due to the signal from the other users in the home cell. Co-channel interference is estimated by Carrier-to-interference ratio.

1.2.3 Noise

Noise in wireless communication systems is any unwanted fluctuation, instability or disruption that induces itself within the transmitted data signal via different mediums and interfering objects. This abrupt fluctuation is also a basic characteristic of data signals, which are modulated electromagnetic waves that travel through the air from electronic communication devices and circuits [8].

(a)Thermal noise is produced from random electron motion and is characterized by a uniform distribution of energy over the frequency spectrum with a Gaussian distribution. Every electronic equipment or transmission medium contributes thermal noise to a communication system as long as the temperature of that device or medium is above absolute zero. Thus it cannot be eliminated.
(b)Impulse noise is a non-continuous series of irregular pulses or noise "spikes" of short duration, broad spectral density and of relatively high amplitude. It is usually caused by communication.
(c)White noise is a random signal with a flat power spectral density which means that the signal contains equal power within a fixed bandwidth at any centre frequency. White noise draws its name from white light in which the power spectral density of the light is distributed over the visible band in such a way that the eye's three color receptors are approximately equally stimulated. A random signal is considered "white noise" if it is observed to have a flat spectrum over a medium's widest possible bandwidth.

II. OVERVIEW OF DIVERSITY TECHNIQUES

In wireless applications, due to multipath propagation fading strictly impacts the system performance. Diversity is the technique which is used in wireless communications systems to improve the performance over a fading radio channel. Diversity techniques has a significant role to play in wireless communications systems for a host of applications such as digital cellular networks, mobile radio, wireless LAN's, wireless local loops, digital audio, television broadcasting systems, indoor wireless and personal communication systems [9].The effects of fading can be moderate during the use of diversity techniques in such systems via accurately designed signal processing algorithms at both the transmitters and receivers. The basic concept of diversity is that if one signal path undergoes a deep fade at a particular point of time, another independent path may have a strong signal. Here receiver is provided with multiple copies of the same information signal which are transmitted over two or more real or virtual communication channels. Thus it can be considered as the diversity is the repetition or redundancy of information. Mainly the diversity decisions are made by the receiver and are unknown to the transmitter [10]. Diversity techniques are based on different structures where receiver gets several signals bearing the same information, through independently fading channels.

III. DIVERSITY TECHNIQUES

The various kinds of diversity techniques, used for wireless communication systems, are discussed here in this section:

3.1 Frequency Diversity

In this technique the same information signal is transmitted on multiple frequency slots and the frequency separation between them being at least the coherence bandwidth Δf_c of the channel as shown in Fig. 1. In practice, frequency diversity is usually achieved by using spread spectrum signals, i.e. direct sequence, frequency hopping or multicarrier spread spectrum modulation.

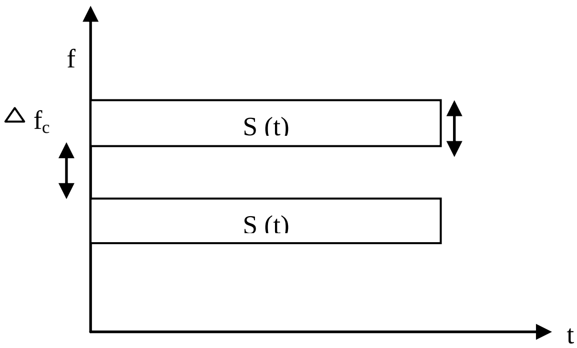

Fig. 1: Frequency diversity [10]

Spread Spectrum Modulation and Orthogonal Frequency Division Multiplexing (OFDM) are considered as frequency diversity techniques. OFDM exploits frequency diversity by providing simultaneous modulation signals with error control coding across a large bandwidth, so that if a particular frequency undergoes a fade, the composite signal will still be demodulated [3]. Spread spectrum techniques are ineffective when the coherence bandwidth of the channel is larger than the spreading bandwidth or equivalently. To reduce the effects of time delay spread, frequency hopping or direct sequence spread-spectrum modulation can be used. Frequency diversity is accompanied by the additional cost of increased complexity at both the transmitter and receiver, along with the fact that it may be difficult to implement in bandwidth-limited systems.

3.2 Time Diversity

In time diversity, the same information signal is transmitted in different time slots. The separation between the time slots has to be at least the coherence time Δt_c as shown in Fig. 2. The time interval depends on the fading rate and increases with the decrease in the rate of fading [3]. A coding structure such as interleaving is often used to realize time diversity where the receiver knows the code before any transmission takes place. Time interleaving, together with error correction coding can provide diversity improvement [7].

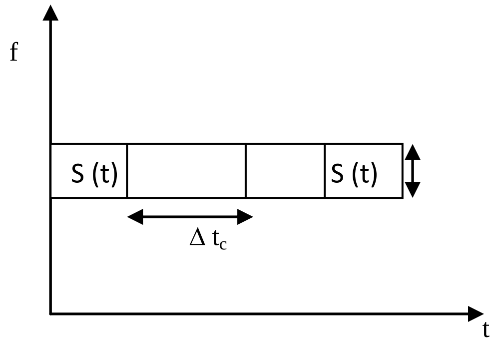

Fig. 2: Time diversity [10]

If the channel is time varying, each copy will experience different channel conditions and by which there will be multiple, independently faded copies of the transmitted signal at the receiver. Time diversity technique is usually effective for fast fading environment where the coherence time of the channel is small .For slow fading channel, a very large time delay is required, which may create significant problems for delay sensitive applications such as voice transmission.

3.3 Space Diversity

Space diversity also known as antenna diversity and it uses two or more antenna to improve the quality and reliability of a wireless link. Space diversity especially used in urban and indoor environment, because there is not a clear line of sight (LOS) between transmitter and receiver. The signal which may be reflected along the multiple paths is designed with phase shift, time delay and got attenuated. The space diversity scheme is much effective for mitigating these multipath situations because multiple antennas at the receiver can afford several observation of the same signal. So in most scattering environments, antenna diversity is a practical, effective and widely used technique for reducing the effect of multipath fading. When multiple antennas are used at the receiver, the scheme becomes receive diversity and for transmit diversity, multiple antennas are used at the transmitter as shown in Fig. 3 and Fig. 4.

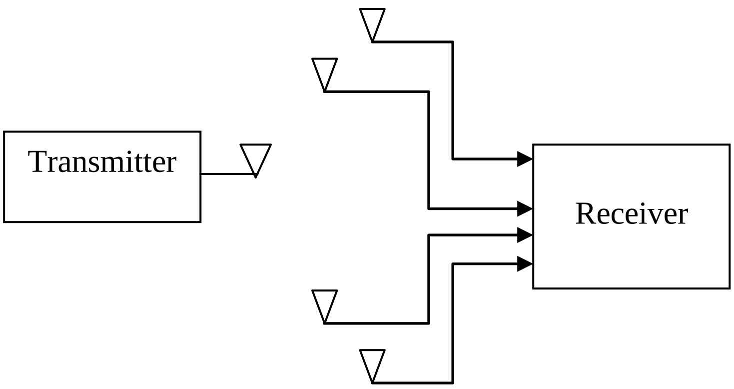

Fig. 3: Receive diversity [10]

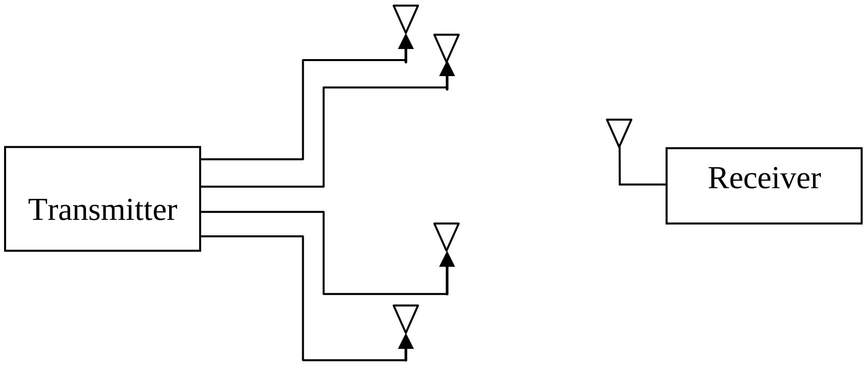

Fig. 4: Transmit diversity [10]

3.4 Polarization Diversity

In recent times, polarization diversity is used to mitigate multipath fading. At the base station, this reduces the size of the antenna. e space diversity technique is often used in the base station but this technique requires two horizontally separated antennas per sector. Polarization diversity technique contains a dual polarized antenna, in which only one antenna per sector is required. In space diversity, the diversity antennas to be spaced apart, whereas the polarization diversity technique uses all antennas with coincident phase centers.
Signals transmitted in either horizontal or vertical electric fields are uncorrelated at both the mobile and base station receivers. The horizontal and vertical polarization components, Ex and Ey, transmitted by two polarized antennas at the base station and received by two polarized antennas at the mobile unit, can provide two uncorrelated fading signals. The decorrelation for the signals in each polarization is caused by multiple reflections in the channel between the mobile and base station. After sufficient random reflections, the polarization state of the signal will be independent of the transmitted polarization. In this technology the electric and magnetic fields of the signal carrying the information are modified and number of such signals are used to send the same information and thus orthogonal type of polarization is obtained.

IV. DIVERSITY COMBINING METHODS

A classification of diversity schemes can be made based on combining methods. In order to get the diversity gain, the signals from multiple channels have to be combined, and the combining method affects the performance of the diversity technique. The diversity combining methods increases the overall received power. These methods are used to combine several copies of the transmitted signal, which undergo independent fading. The three types of diversity combining methods are discussed here.

4.1 Selection Combining (SC)

In selection combining scheme, the branch that receives the signal with the largest signal-to-noise ratio is selected at any time from a collection of antennas and connected to the demodulator. The receiver monitors the signal-to-noise ratio of both channels and connects the branch with largest SNR to the demodulator at any instant in time. In order to prevent phase discontinuities when the receiver switches between both branches, which occurs when one signal falls below the other and receiver switches to the strongest branch, the signals in both channels are constantly co-phased.

4.2 Maximum Ratio Combining (MRC)

In maximum ratio combining, all the branches are used simultaneously. Each of the branch signals is weighted with a gain factor which is proportional to its own SNR. Then co-phasing and summing is done for adding up the weighted branch signals in phase. The Fig.1.8 shows the configuration for a two-branch diversity system. The both branches are weighted by their respective signal-to-noise ratios. The branches are then co-phased prior to summing in order to insure that all branches are added in phase for maximum diversity gain. The summed signals are then used as the received signal and connected to the demodulator.

4.3 Equal Gain Combining (EGC)

In Equal gain combining (EGC), the outputs of different diversity branches are first co-phased and weighted equally before being summed to give the resultant output. After that the resultant output signal is connected to the demodulator. The weights are all set to one with the requirement that the channel gains are approximately constant and this is usually achieved by using an automatic gain controller (AGC) in the system. Some practical applications of EGC include the use of regenerative circuits to co-phase the received carriers. However, the implementation of EGC diversity is cumbersome due to the additional circuitry required in order to co-phase the signal in each branch.

V. CONCLUSION

WCDMA used for high data rates and allow more users to simultaneously access the network, but performance of WCDMA is limited by interference, fading and scattering. In this review work various diversity techniques were reviewed to overcome the fading problem. Each technique has its own unique advantage but in comparison to other diversity techniques, maximum ratio combining technique is superior to other in many aspects. The MRC technique has high diversity gain and high signal to noise ratio compared to other diversity techniques.

REFERENCES

[1] Holma H. and Toskala A. "WCDMA for UMTS ",John Wiley & Sons Ltd,2002.

[2] Wang X., "Wireless communication systems: advanced techniques for signal reception", Prentice, 2004.

[3] Milstein L.B, "Wideband code division multiple access", IEEE Journal on Selected Areas in Communications, vol.18, no.8, pp-1344-1354, 2000.

[4] Rappaport T.S., Wireless Communication, Principles & Practice, Prentice Hall, Upper Saddle River, NJ, 2nd edition, C.2002.

[5] Dahlman E, Gudmundson B, Ilsson M. and Skold J., " UMTS/IMT-2000 Based on Wideband CDMA",IEEE Communications Magazine, vol. 36,no.9, pp. 70-80, 1998.

[6] Dahlman E., Beming P., Knutsson J., Ovesjo F.,Persson M. and Roobol C. "WCDMA The Radio Interface for Future Mobile Multimedia Communications", IEEE Transactions on Vehicular Technology, vol. 47, no. 4, pp. 1105-1118, 1998.

[7] Proakis J.G.: Digital Communications, McGraw-Hill, 1995.

[8] William C.Y.:"Mobile communications engineering theory and applications", Second edition, Tata McGraw Hill, New Delhi, 2008.

[9] Kadhim M.A. and Ismail W.,"Performance diversity techniques for wireless communication system", Journal of Telecommunications, vol. 4, no. 2, pp.1-6 2010.

[10] Srivastava N., **"**Diversity schemes for wireless communication a short review", Journal of Theoretical and Applied Information Technology, vol.15, no.2,pp.134-143, 2010.