CHAPTER 1
INTRODUCTION

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1.1 INTRODUCTION

In this age of information transfer, communication system is the backbone of all activities of interaction. The rapid growth of the developments into practical communication systems linking the entire globe has stimulated a bursting growth of complex social and economic activities. This growth has subsequently had a tremendous effect on the growth of the communication industry with no end in sight for the foreseeable future. Various communication systems had their beginning with the discovery of various electrical, magnetic, and electrostatic phenomena prior to the twentieth century. Starting with Samuel Morse's invention of the telegraph in 1837, a remarkable rate of progress has occurred. The telephone came along in 1876. The first complete system of wireless communication was provided by Marconi in 1894.

Wireless communications is one of the most active areas of technology of modern times. The demand for new wireless capacity is growing at a very rapid pace. Wireless communication can result into transmission and reception of voice signals with no constraint on the location of the user resulting into the concept of mobility. The traditional resources that can add capacity to the wireless systems are most severely limited in the deployment of modern wireless networks. Given these circumstances, there has been considerable research effort in recent years aimed at developing new wireless capacity through deployment of greater intelligence in wireless networks. So, advanced receiver signal processing methods are developed, which are chosen primarily to address the physical properties of wireless channels, mainly, multipath fading, dispersion and
interference. This thesis deals with the methods to reject interference and study effects of fading.

In the study of communication systems, the classical Additive White Gaussian Noise (AWGN) Channel with statistically independent Gaussian noise samples corrupting the data samples free of Intersymbol Interference (ISI) is the usual starting point for analyzing the basic performance relationships. In a wireless mobile communication system, a signal can travel from transmitter to receiver over multiple reflective paths, this phenomenon being called as multipath propagation. The effect can cause fluctuations in the received signal's amplitude, phase and angle of arrival giving rise to multipath fading. Multipath fading is classified into Rayleigh fading and Rician fading and these fading are further classified into frequency non-selective fading and frequency-selective fading.

Wireless system designers have always had to contend with interference from both the natural sources and other users of the medium. Thus the wireless communication design cycle consists of measuring or predicting channel impairments, and signal pre-conditioning at the transmitter and processing at the receiver to reliably reconstruct the transmitted information. In this work, rejection of digital signaling in the presence of interference has been analyzed over Rayleigh fading channels.

1.2 NEED OF WORK DONE

Because of limited spectral bandwidth and frequency reuse in different cells, users experience co-channel interference. Also, due to the presence of different users on the channel, there is multiple access interference. Narrowband interference is the consequence of different communication applications over the same frequency bandwidth. Work has been done previously to examine secure communication under such impairments, but it needs further investigation.

Variation of channel with time, co-channel interference and intersymbol interference constitute the three major sources of impairment in wireless channels. These pose several challenges, both from theoretical perspective and from a practical standpoint. Channel time variation causes the received signal strength to wax and wane with time. This fluctuation of the received signal strength can be overcome by time
diversity, frequency diversity or space diversity. Performance of these digital transmission systems needs to be improved. So, there is need to understand these issues.

In many areas of land mobile radio usage, the high density of communication traffic is becoming the source of interference problems. The growth of this interference is so rapid and widespread that it is becoming the major limitation to the use of radio for land mobile communications. Hence, there is need to study methods to mitigate it.

Typically, interference from outside the cell in the cellular network is not decoded and is treated part of noise. So, the interference is interpreted as additive noise with unknown distribution. If the major impairment for communication is interference, the system is said to be interference-limited. Therefore, understanding transmission and detection schemes in additive non-Gaussian environments becomes important. These challenges necessitate the study of algorithms that are close to theoretical limits.

Fading occurs on strong signals and weak signals. Fading has always been encountered when the signals being received originate from a transmitting station located at a distance that requires the radio waves to propagate through the ionosphere. As the signals fade down to the noise level much of the information is lost until the signal level increases above the noise again. Sometimes, deep fades last for half a minute or more, causing the entire message to be lost. Increasing power does little to improve the distortion caused by fading. Hence there is need to study various measures that can be taken to reduce the effects of fading.

Adaptive techniques are rapidly emerging in the field of signal processing in communications. This is due to robust adaptive processing methods and also due to the fact that the hardware devices used to implement modern communication systems is very well suited to realize the adaptive algorithms of such systems. Hence, there is need to have knowledge of these algorithms in modern control theory. It will reveal the possibilities and the limitations of the use of adaptive methods of communication systems.

There is dire need to improve the extent of rejection of interference and the arrest of fading in the wireless networks. In the present work, effort has been made to improve upon the existing available systems in rejecting the problems of interference and study the effects of fading.
1.3 OBJECTIVE OF THE WORK

Co channel interference, Multiple Access Interference (MAI) and Intersymbol Interference (ISI) are the major source of interference in wireless networks with Rayleigh fading channels. Minimum Mean Square Error (MMSE) criterion is the method to mitigate Multiple Access Interference (MAI). MMSE criterion can be implemented in two ways: adaptive method and code aided techniques and can be applied to Rayleigh fading channels. The second problem affecting system performance is fading which can be mitigated by diversity techniques. The maximal ratio combining scheme is used for the above said purpose.

The objectives of the present thesis are

1. To develop and analyze mathematical model of adaptive MMSE receiver to suppress interference and to operate in dynamic environments found in mobile communications. The mathematical model developed will be further analyzed keeping into consideration all practical parameters. The improvement in performance of system is shown in terms of probability of error.

2. To develop a mathematical model and analyze the same for code aided MMSE receiver for suppressing Multiple Access Interference (MAI) in a better fashion than the conventional methods. The analysis is carried out keeping Signal to Interference Ratio (SIR) and fading parameter/fading severity as the measuring metric keeping into consideration the parameters: probability of error, processing gain, signature sequence code, interfering tone power, fading parameter, number of users and mean square error. The results are derived for tone interfering signals, which are one and two in number respectively.

3. To study effects of fading on maximal ratio combining diversity system. The system having correlated and unequal power branches, which are two in number has been considered. This will be studied for various fading conditions i.e. slow and flat fading, slow and frequency selective fading and fast fading. Also, the effect of taking different digital signaling techniques (BPSK and QPSK) will be taken into account. The probability density function and fading severity/fading parameters are the measuring yardsticks. Analysis of the above mentioned conditions will be carried out mathematically. The results will be presented in the form of graphs.
1.4 ORGANISATION OF THESIS

This thesis is divided into six chapters. The first chapter gives the need, objective of the work and the organization of the thesis.

The second chapter is an introduction to the wireless communications. It explains fading and types of fading channels. The transmission of Direct Sequence Spread Spectrum Multiple Access (DS/SSMA) over fading channels is presented. Also, diversity is explained as a method to reduce fading. The evolution of mobile communications over various generations is considered. Finally, types of interference, which are present in such systems is treated.

This chapter deals with small scale fading and methods to mitigate it. The four functions that make the wide sense stationary uncorrelated scattering channel are explained. Two main methods to combat fading are explained.

In the third chapter, the extensive literature survey carried out has been discussed. The relevant literature related to the areas of Multi-User Detection (MUD) Fading and Diversity Reception has been studied and reviewed.

The fourth chapter deals with the proposed work on the linear MMSE detector. The working of the detector is analyzed. A simple MMSE technique using a bank of filters is proposed. The system model for MMSE receiver is discussed and its performance explained. The effect of fading parameter has been considered and mathematical models for adaptive and code-aided receiver have been developed. The performance of the receiver is analyzed, results of the work are presented and are compared with the conventional methods.

In the fifth chapter, mathematical model of maximal ratio combiner receiver has been developed. Mathematical model for symbol error probability for BPSK and QPSK is presented. In the end results have been presented and discussed.

The sixth chapter concludes the work with a summary of the results. It also covers the future scope of the work. In the end list of relevant references has been attached.