The general multidimensional linear channel model adequately represents a plethora of communication system models which utilize multidimensional transmit-receive signals for attaining increased rates and reliability in the presence of fading. The logarithmic dependence of the spectral efficiency of the transmitted power makes it extremely expensive to increase the capacity solely by radiating more power. Also, increasing the transmitted power in a mobile terminal is not advisable due to possible violation of regulatory power masks and possible electromagnetic radiation effects. Alternately, MIMO schemes if properly exploited can exhibit a linearly increasing capacity, due to the presence of a rich scattering environment that provides independent transmission paths from each transmit to each receive antenna. An idealized practical communication system assumes perfect Channel State Information (CSI) and uses a linear transmitter to maximize the reliability of the wireless multi-antenna link. However, in actual practice the CSI is incomplete. As a result of this, there is a necessity to deal with argotic and compound capacity formulations and these factors are strongly dependent on the model utilized to characterize the channel. Practical system models include quasi-static multiple-input multiple-output (MIMO), MIMO-OFDM, ISI, amplify-and-forward (AF), decode-and-forward (DF), and MIMO automatic repeat request (ARQ) models. Each of the above models introduces its own structure, its own error performance limits, and its own requirements on coding and
decoding schemes. Finding general-purpose transceiver structures with (provably) good performance in these scenarios, and with a reasonable computational complexity, is challenging. Existing MIMO systems are able to provide either high spectral efficiency (spatial multiplexing) or low error rate (high diversity) via exploiting multiple degrees of freedom available in the channel, but not both simultaneously as there is a fundamental trade-off between the two. This Diversity-Multiplexing Trade-off (DMT) is best characterized using the concepts of multiplexing and diversity gains [1]. Fundamentally, this is a trade-off between the Outage Probabilities, i.e. the probability that the fading channel is not able to support the transmission rate. In this context, this work identifies a general, explicit non-random MIMO encoder-decoder structures and also guarantee optimal diversity-multiplexing trade-off and is an effective alternative to the computationally expensive Maximum Likelihood (M-L) receiver. The results obtained lend them applicable to a plethora of pertinent communication scenarios such as quasi-static MIMO, MIMO-OFDM, ISI, cooperative-relaying and MIMO-ARQ channels.

1. OBJECTIVES OF THE PRESENT RESEARCH WORK

The main objectives of this research work are as follows

(i) To study the impact of imperfect Channel State Information (CSI) on multi-user scenario and perform the necessary changes required in transmission architecture so as to make it robust to the uncertainties of the side information available at both the Transmitter and Receiver.
(ii) To exploit the use of multiple antennas at both the transmitter and receiver and provide both an increase in reliability and also in information transmission rate.

(iii) To achieve high data rates by exploring the quality and quantity of the channel state information available at the communication ends.

(iv) To characterize the transmit covariance matrix that maximize the mutual information for the particular case of channel state uncertainty at the transmitter.

(v) To perform efficient power allocation strategies in a multi-user system with CSI uncertainty, so as to guarantee a certain quality of service per user.

(vi) To dynamically provide resource allocation so as to achieve better QoS and improve system capacity.

2. COMPONENTS OF THE THESIS

Chapter 1 describes the problem statement and proposed solution. The objectives of the present research work and its benefits are also outlined in detail in this chapter.

Chapter 2 provides a detailed literature survey on the relevant works done so far. The justification for the proposed research work is also provided through an inference from the literature survey.

Chapter 3 provides the basics of MIMO and other commonly employed schemes that are relevant to this research. Theoretical discussions related to fading effects, channel state uncertainty, etc. are also discussed in this chapter. An advantage of a MIMO system as shown in figure 1 is that, it is said to achieve multiplexing gain \( r \), and the achievable rates scale as \( r \log (\text{SNR}) \). The multiplexing gain (unique for MIMO...
systems) is defined as the increase of the rate that can be attained through the use of multiple antennas at both sides of communication links, with respect to the rate achievable with single antenna system, without utilizing additional power. Also, a MIMO communication system executes an average error probability that decays as $1/(SNR^d)$ where $d$ is the diversity gain and is based on the assumption that at least one of the paths will not be in a deep fade state.

![Figure 1: Block diagram of multiple-antenna OFDM multicast system (Chosen for study)](image)

Chapter 4 deals with the design and implementation of the following modules are presented below:

(i) MIMO-OFDM receiver with coherent detection.

(ii) Two-dimensional channel estimator: the ability to interpolate the channel estimates both in Time and frequency from the available pilots is demonstrated.
Chapter 5 explains the various metrics that are proposed for study and its relevance. The implementation of the proposed adaptive MIMO-OFDM with the 2D channel state estimator is presented in this chapter. The hardware setup is also explained in this chapter. The setup was used to study the effects of fading and channel uncertainties. Figure 4 and figure 5 shows the hardware setup consisting of transmit and receive sections along with provision for studying the effects of fading. The conditions were so chosen that, the setup was almost a representative of the practical fading and channel conditions.

Chapter 6 describes the performance analysis of the designed scheme is obtained and compared with other standard analogous schemes. This is presented in brief in section 6 of this synopsis.

Chapter 7 summarizes the work and specifies the future direction of study. In this research, an investigation of different adaptive communication techniques is presented and studied for different critical performance measures. An adaptive MIMO-OFDM scheme with two-dimensional channel state estimator is designed and implemented in this research. Critical performance measures of practical interest are evaluated for study. The design techniques presented in this thesis utilize knowledge obtained by dynamically tracking the radio channel response, and therefore optimize the user frequency, and subcarrier modulation. The modulation schemes applied to each subcarrier is independently optimized in this work, and as a result the spectral efficiency is maximized, without any tradeoff in the target Bit Error Rate (BER). Results
are demonstrated for a fading channel, and the proposed scheme results in an improvement in the Signal to Noise Ratio (SNR) required maintaining a given BER, as compared with other fixed modulation schemes. Adaptive user allocation exploits the difference in frequency selective fading between users, to optimize user subcarrier allocation. In a multipath environment the fading experienced on each subcarrier varies from user to user, thus by utilizing user/subcarrier combinations that suffer the least fading, the overall performance is maximized. The performance of the proposed scheme is studied with three other popular schemes. From the results obtained it can be inferred that the proposed scheme outperforms the other schemes and provides an overall improvement in all the metrics. The adaptive user bandwidth allocation based MIMO-OFDM scheme with 2-D channel state estimator gives the best performance compared to other schemes i.e. it has a reduced BER, effective user bandwidth allocation, uniform user data rate variations and improved Mean SNR for individual users, etc.