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Performance Enhancement of MIMO OFDM for Higher Spectral Efficiency

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Abstract

The Multiple-Input Multiple-Output based wireless system is a promising high data rate interface technology. Diversity methods provide the receiver with independently faded copies of the transmitted signal with the expectation that at least one of these replicas will be received data. This is ranges of techniques available through which these faded copies can be recovered and used as part of arrangements. This paper proposes a method based on Multiple-Input Single-Output (MISO) with Space-Time Block Coding (STBC) and Multiple-Input Multiple-Output (MIMO) set-up for use in wireless channels. A special of STBC called Alamouti code is used for exploiting in the performance of MISO and MIMO in frequency selective fading environment. The observed with and without STBC in frequency selective faded channels. The diversity gain of MISO and MIMO systems in terms of BER for High QAM modulation scheme. The obtained results demonstrate that spatial diversity along with the power of STBC significantly improves the error performance in frequency selective wireless fading channels. These techniques offer a significant gain over a traditional single input single output (SISO) channel.

Keywords: MIMO (Multiple-Input Multiple-Output), SISO, RRA, M-QAM,etc.

Introduction

Wireless communication is one of the most vivacious areas in the communication field now a day. Although the development in this area was started way back in 1960s, but a lot of research is done in this area in last decade. The reason for this is due to a variety of factors discussed below:

- The demand for seem-less connectivity has risen manifolds, mainly due to cellular telephony but expected to be soon eclipsed by wireless data applications.
- The sophisticated signal processing algorithms can be implemented with the advent of VLSI technology. Due to the success of 2G wireless standards especially CDMA it has been shown that communication ideas can be implemented in practice. The research push in the past decade has led to a much better-off set of perspectives and tools on how to communicate over wireless channels, and the scenario is still very much in the emerging stages. There are two fundamental aspects of wireless communication that make the problem demanding and motivating as compared to wire line communication.

OFDMA System model

Orthogonal Frequency Division Multiplexing (OFDM) has been successfully applied to a wide variety of digital communication applications over the past several years. While OFDM principle was adopted as a physical layer for many important communication systems such as asymmetric digital subscriber loop(ADSL), Digital Audio Broadcasting (DAB),Digital Video Broadcasting (DVB), high-definition television (HDTV), wireless local area network (WLAN)and the fourth generation of mobile cellular, the theory, algorithms, and implementation techniques of OFDM are topics of high interest.

The complex baseband OFDM signal at output of the IFFT can be written as:

$$Xn = \frac{1}{\sqrt{N}} \sum_{l=0}^{N-1} X_{l e^{j\frac{2\pi}{N}ni}} \qquad 2.1$$

At the receiver, the received OFDM signal is mixed with local oscillator signal, with the frequency offset deviated from Δf the carrier frequency of the received signal owing to frequency estimation error or Doppler velocity, the received signal is given by:

$$\hat{x}_n = (X_n \otimes h_n) e^{j\frac{2\pi}{N} n\Delta f T} + z_n$$

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the output of the FFT in frequency domain signal on the kth receiving subcarrier becomes:

$$\hat{X}_k = \sum_{l=0}^{N-1} X_1 H_1 Y_{1-k} + Z_k \quad 2.2$$

$$= X_k H_k U_0 + \sum_{l=0, l\neq k}^{N-1} X_1 H_1 Y_{1-k} + Z_k \quad 2.3$$

The first term of Equation (3.3) is a desired transmitted data symbolX_k. The second term represents the ICI from the undesired data symbols on other subcarriers in OFDM symbol H_k is the channel frequency response and Z_k denotes the frequency domain of z_n . The term $Y_{1-k}$is the coefficient of FFT (IFFT), is given by:

$$Y_{1-k} = \frac{1}{\sqrt{N}} \sum_{l=0}^{N-1} e^{j\frac{2\pi}{N} n(l-k+\Delta fT)} \quad 2.4$$

MIMO system

Multiple-Input-Multiple-Output(MIMO) communication techniques have been an important area of focus for 4th generation wireless systems. This is mainly because of their potentials for high capacity, increased diversity, and interference. The MIMO is an acronym that stands for Multiple Input Multiple Output. It is an MIMO and antenna technology that is used both in the transmitter and the receiver for wireless radio communication. The MIMO technology has attracted attention in wireless communications because it offers significant increases in data throughput and link range without additional bandwidth or transmission power. It is achieves this by higher spectral efficiency (more bits per second per hertz of bandwidth) and link reliability or diversity (reduced the effect of fading). Because the properties, MIMO is an important part of modern wireless communication such as IEEE8002.16

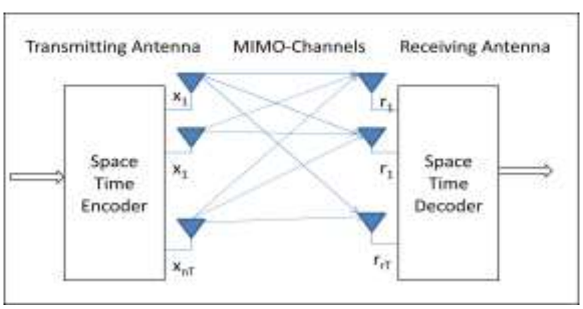

Figure MIMO system

Equalizer

The equalizer is a device that attempts to reverse the distortion suffered by a signal transmitted through a channel. Its purpose is to reduce inter symbol interference to allow the recovery of the transmitted symbols.

A. 3.8.1 Zero Forcing Algorithm

Zero Forcing algorithms is regard the signal of each transmitting antenna output as the desired signal and regard in remaining part as a disturbance, for the mutual interference between the various transmitting antennas can be completely neglected. The algorithm is as follows:

For$k = 0, 1, 2, \ldots \ldots \ldots \ldots, K-1$,

So that,

$$R(k) = [R1(k), R2(k), \ldots, RnR(k)]T \quad 3.1$$

$$X(k) = [X1(k), X2(k) \ldots, Xn(Tk)]T \quad 3.2$$

$$N(k) = [N1(k), N2(k), \ldots . NnR(k)]T \quad 3.3$$

$$H(k) = \begin{pmatrix} H(k)_{11} & H(k)_{12} & \ldots H(k)_{1nT} \\ H(k)_{21} & H(k)_{22} & \ldots H(k)_{2nT} \\ H(k)_{T1} & H(k)_{T2} & \ldots H(k)_{TnT} \end{pmatrix} \quad 3.4$$

HereR (k), X(k), N(k) respectively express output signal, the input signal and noise vector of the k sub-channels in MIMO-OFDM system, for nT transmitting antennas and nR receiving antennas, H(k) expresses channel matrix of the k sub-channels, mathematical expression of sub-channel in The MIMO-OFDM system is as follows:

$$R(k) = H(k)X(k) + N(k3.5$$

There is a linear relationship between input signal X(k) and output signal R(k), that is similar to the flat fading channel for each subcarrier channel in MIMO-OFDM system.

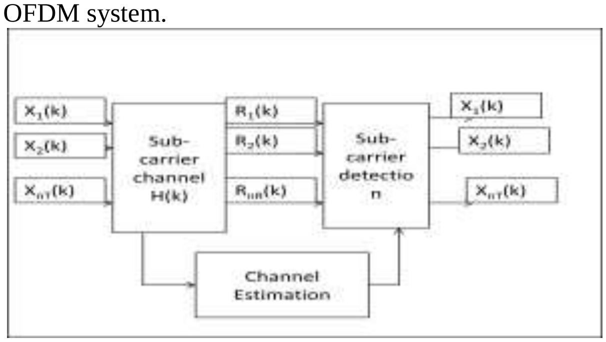

Figure 3.4: Baseband block diagram of k subcarrier channel in MIMO-OFDM syste

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Zero-forcing (ZF) detection algorithm for MIMO detection algorithm is the most simple and basic algorithms, and the basic idea of zero forcing algorithm is get rid of MIMO-channel interference by multiplying received signal and the inverse matrix of channel matrix. Zero-Forcing solution of MIMO-OFDM system is as follows:

$$XZF = H - 1\,R = X + H - 1\,N \quad 3.6$$

In which H-1 is the channel matrix for the generalized inverse matrix, the type is obtained for hard-decision demodulation after that to be the source signal estimates:

X9ZF = E(XZF)

B. Minimum Mean-Square Error (MMSE) Equalizer

Minimum Mean-Square Error (MMSE) Equalizer designs the filter to minimize probability error is the error signal, which in the filter output minus the transmitted signal. Zero Forcing Equalizer approximates the inverse of the channel with a linear filter. The name Zero Forcing corresponds to bringing down the inter symbol interference (ISI) to zero if there is no noise. When the channel is noisy, ZF receiver will amplify the noise greatly at frequencies where the channel response has a small magnitude in the attempt to invert the channel completely, in which case MMSE is more balanced, which does not usually eliminate ISI completely but instead minimizes the total power of the noise and ISI components in the output. In high Signal-Noise ratio case, MMSE's performance is close to Zero forcing Bit Error Rate (BER). MMSE (algorithm is a commonly used MIMO detection algorithm in low SNR environment and has a good bit error rate performance, complexity is also relatively low. MMSE detection solution of MIMO-OFDM Systems is as follows:

$$S_{MMSE} = (\Omega^H \Omega + \frac{\sigma^2 N}{\varepsilon^2})^{-1} \Omega^H R \quad 3.8$$

Here, E [│Xi│2] = Ü , E [│Ei│2] = &! , E[.] , mean the statistical average of random variable demand.

ZF detection completely offset the interference between different antennas (MSI), and separate different data streams by the expense of an increase in noise. While the MMSE regard the minimum mean-square error as the criterion, and the mean square error between the actual symbols sent and detector output is minimum, namely

$$GMMSE = argminG\left| Gr - s \right|^2 \quad 3.9$$

Orthogonality principle can be used:

$$.E\{(GMMSEr - s)\,rH\} = 0 \quad 3.10$$

Simplification to be:

$$GMMSE = H^H\,(HH^H + !\,\sigma^2 ln)^{-1} = H^H\,(HH^H + \sigma^2 ln)^{-1} \quad 3.11$$

Therefore, the output signal of filtering is estimated as follows:

$$S_{MMSE} = G_{MMSE} r = H^H r (HH^H + \sigma^2 ln)^{-1} \quad 3.12$$

Estimated covariance matrix is written as follow:

$$\varphi_{MMSE} = E\,\{(\hat{x} - x)(\hat{x} - x)\} = \sigma^2 (HH^H + \sigma^2 \mathrm{ln})^{-1} \quad 3.13$$

At high SNR, MMSE detection performance converges to ZF detection

WIMAX

Broadband Wireless Access (BWA) has emerged as a promising solution for last mile access technology to provide high speed internet access in the residential as well as small and medium sized enterprise sectors. As discussed above section, cable and digital subscriber line (DSL) technologies are providing broadband service. But due to the practical difficulties many urban and suburban locations may not be served by DSL connectivity as it can only reach about three miles from the central office switch. On Broadband wireless Access, because of wireless nature, it can be faster to deploy, easier to scale and more flexible, thereby giving it the potential lto serve customers not served or not satisfied by their wired broadband alternatives. IEEE 802.16 standard for Broadband wireless Access (BWA) and its associated industry consortium, WiMAX (Worldwide Interoperability for Microwave Access) forum promise to offer high data rate over large areas to a large number of users where broadband is unavailable

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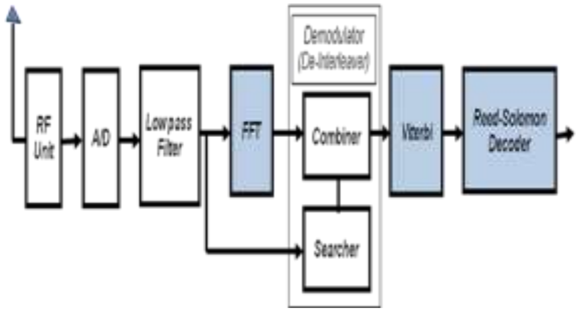

Figure. 4 WIMAX System

Results and discussion

Performance limit of system:

The AWGN channel are used to simulate the system to achieve the performance limit . The BER and spectral efficiency curve for AWGN channel are shown below

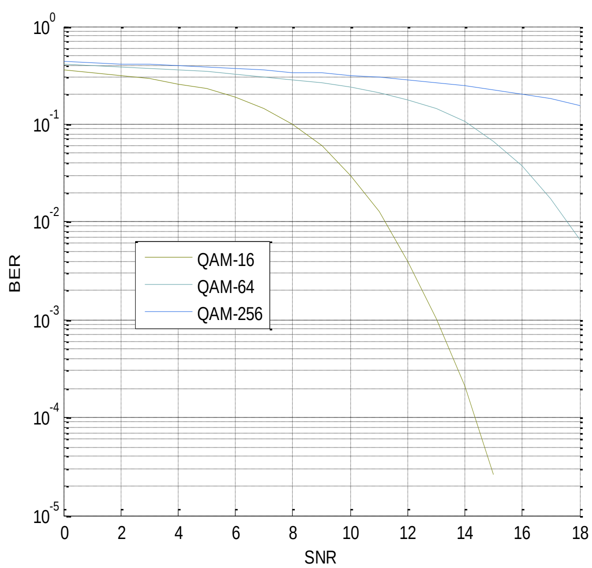

Figure 6.1 BER performance of WiMAX system over AWGN channel

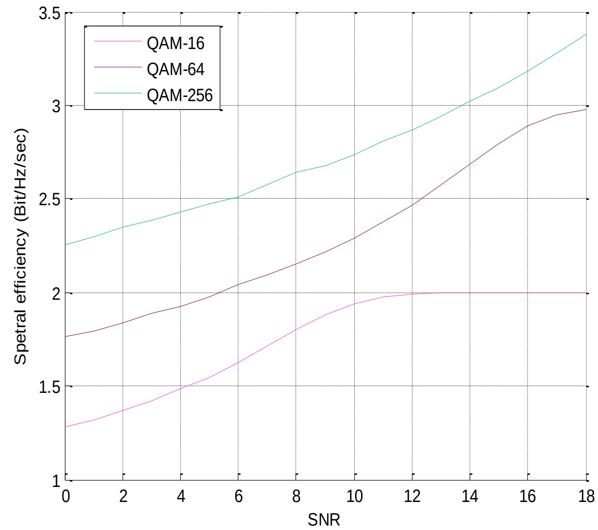

Figure 6.2 Spectral efficiency performance of WiMAX system over AWGN channel

ImageFor Transmission

Original Image ***Recived Image with error*** ***Recived Image without error***

Figure 6.3 Thumb Impression Image transmission on MIMO channel

System Performance WithMIMO 2X1(PROG-2)

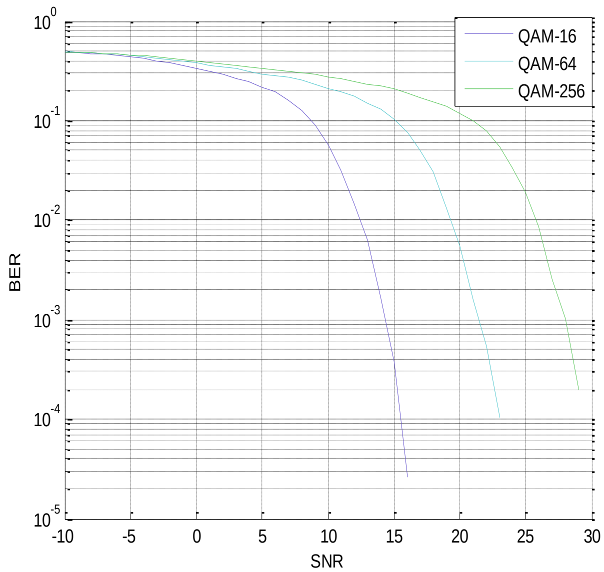

Figure 6.4 BER performance of 2 x1 MIMO WiMAX system

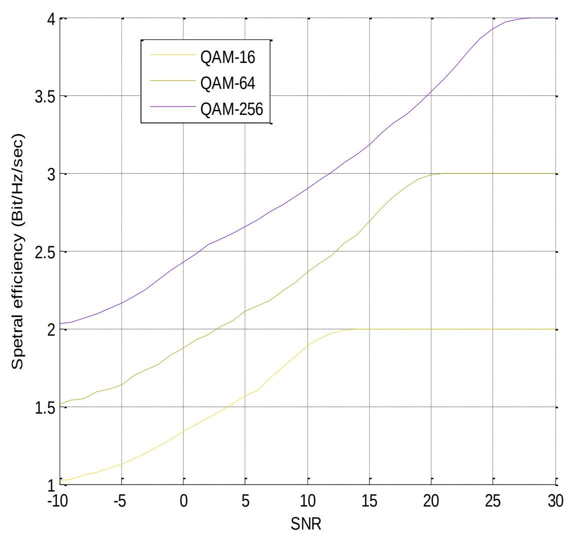

Figure 6.5 Spectral efficiency performance of 2 x1 MIMO WiMAXsystem

Conclusion

The wimax system simulation setup with Alamouti scheme has been developed. The biometric image based data transmission scheme is evaluated successfully. During simulation study various modulation scheme which supports the high data rate used for simulation and performance enhancement with different receiver diversity has been demonstrated. It is found that with increase of modulation order the capacity enhancement is low compare to BER degradation. With increase in the receiver diversity the level of BER degradation is improved.The 2x 8 antenna system are also tried in this scheme due to the higher frequency (11 GHz) used in WiMAX system.

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