Channel State Information for Pre-Equalization in MIMO-OFDM System

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ABSTRACT
Due to multipath fading and inter-symbol interference, the high speed transmitted data extends to several symbol periods. Signals which travel through several paths get reflected by different objects and signals taking less direct path arrive at receiver later and are often attenuated. Traditional systems employ some improvement techniques to deal with multipath signals; one technique is to use multiple antennas to capture the strongest signal at each moment of time, another technique adds delays to back align the signals. This paper presents the use of channel state information for estimating the channel impulse response and its use in channel equalization on the transmitter side.

General Terms
Channel Equalization, MIMO-OFDM system, Channel State Information

Keywords
Channel Estimation, Channel Impulse Response, Channel State Information, Inter-Symbol Interference Pre-Equalization

1. INTRODUCTION
Multiple Input Multiple Output (MIMO) systems takes advantage of multipath propagation signals by sending and receiving more than one data signal in the same frequency band at the same time by using multiple transmit and receive antennas. Orthogonal frequency division multiplexing (OFDM) is also has capability to handle the effect of ISI and Inter-carrier interference (ICI). OFDM converts the frequency selective wide band signal into frequency flat multiple orthogonally spaced narrow band signals also resulting in high bandwidth efficiency. Signal parameters on which multipath channel have effect are independent path gain, independent path frequency offset, independent path phase shift, independent path time delay. To remove ISI from the signal, many kinds of equalizers can be used [1]. Different techniques are used to handle the changes made by the channel; receiver requires knowledge over CIR to combat with the received signal for recovering the transmitted signal. CIR is provided by the separate channel estimator. Usually channel estimation is based on the known sequence of bits, which is unique for a certain transmitter and is repeated in every transmission burst. Which enables the channel estimator to estimate CIR for each burst separately by using the known transmitted signal and the corresponding received signal. In MIMO systems, the equalizer module reconstructs the transmitted signals from the weighted sums of signals transmitted by different antennas, using the estimate provided by the channel estimator and received signal.

To achieve high performance of equalizer, the receiver needs to know the impact of channel, the problem is how to extract this information in an efficient way. Usually known symbols are multiplexed into the data sequence in order to estimate the channel. From these symbols, all channel attenuations are estimated. The behavior of channel is described by its impulse response and also there is some additive noise which is often modelled as additive white Gaussian noise (AWGN) representing different disturbances in the system. A new approach in obtaining the channel condition in the transmit side is to use the explicit feedback from the receiver side, as illustrated in Figure 1 [3].

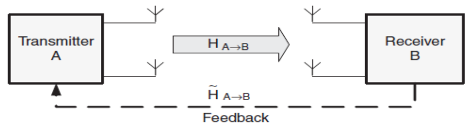

Figure 1: Channel Estimation on Transmitter Side using Feedback from Receiver

Its main drawback is that additional resource is required for transmitting the feedback information. The amount of feedback information increases with the number of antennas.

Therefore, the overhead problem can become critical when it comes to multiple antenna systems. When channels are subject to fast fading, the coherence time is small, which requires more frequent feedback. The estimated CSI at the receiver can be compressed to reduce the feedback overhead. A good literature on exploitation of CSI for channel estimation can be found in [4-16].

2. EXPLOITING CSI FOR PRE-EQUALIZATION
CSI can also be used at the transmitter for spatial-multiplexing MIMO systems with the channel gain of $H \in C^{N_R \times N_T}$ with $N_R \geq N_T$. One way to use CSI on the transmitter side is the modal decomposition of the matrix $V \in C^{N_T \times N_T}$ which must be used as a pre-coding matrix on the transmitter side. Among various possible methods that use CSI for the spatial-multiplexing system, we will focus on the linear pre-equalization method.

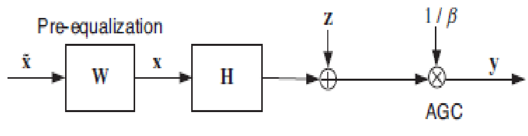

Figure 2: Pre-Equalization

Figure 3 illustrates the implementation of pre-equalization on the transmitter side. The pre-equalization can be shown by a pre-equalizer weight matrix $W \in C^{N_T \times N_T}$ and hence the pre-coded symbol vector $x \in C^{N_T \times 1}$ can be expressed as

$$x = W\tilde{x} \tag{1}$$

where $\tilde{x}$ is the original symbol vector used for transmission. In case where the zero-forcing (ZF) equalization is employed, the corresponding weight matrix can be given as

$$W_{ZF} = \beta H^{-1} \tag{2}$$

where β is a constant which meets the total transmitted power constraint after pre-equalization and it is given as

$$\beta = \sqrt{\frac{N_T}{T_r\left(H^{-1}\left(H^{-1}\right)^H\right)}} \tag{3}$$

To mitigate the effect of amplification by a factor of β at the transmitter, the received signal must be divided by the same factor. The received signal y will be than given by

$$y = \frac{1}{\beta}\left(HW_{ZF}\tilde{x} + z\right) \tag{4}$$

$$= \frac{1}{\beta}\left(H\beta H^{-1}\tilde{x} + z\right) \tag{5}$$

$$\tilde{x} + \frac{1}{\beta}z \tag{6}$$

$$\tilde{x} + \tilde{z} \tag{7}$$

Except ZF pre-equalization, MMSE pre-equalization can also be used. In this case

$$W_{MMSE} = \beta \times \arg_w \min \ \mathrm{E}\left\{\left\|\beta^{-1}\left(HW\tilde{x} + z\right) - \tilde{x}\right\|^2\right\} \tag{8}$$

$$= \beta \times H^H\left(HH^H + \frac{\sigma_z^2}{\sigma_z^2}I\right)^{-1} \tag{9}$$

It is calculated by above Equation but we canreplaced H^{-1} with [17]

$$H^H\left(HH^H + \frac{\sigma_z^2}{\sigma_z^2}I\right)^{-1} \tag{10}$$

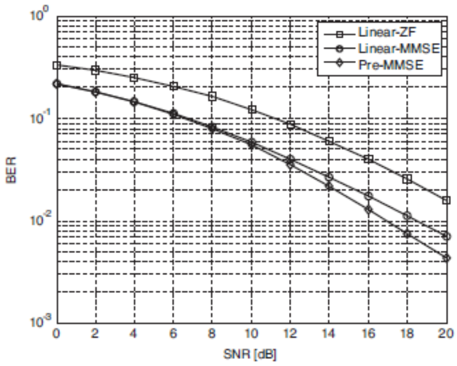

Figure 3: Performance Comparison of Post-Equalization and Pre- Equalization Techniques

Figure 4.shows the performance comparison of post-equalization and pre- equalization techniques. From figure 4 it can be concluded that the pre-equalization scheme on the transmitter side performs better than the receiver-side equalization. It is due to the fact that the receiver-side equalization suffers from noise enhancement during the course of equalization.

3. CONCLUSION

Channel impulse response can be estimated on receiver side as well as on transmitter side. The CSI can be send back to transmitter using feedback and can be exploited for pre-equalization. In this paper CSI has been exploited for pre-equalization. Results show that pre-equalization out performs the conventional post-equalization approach.

4. REFERENCES

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