Pilot Assisted Channel Assessment for MIMO-OFDM over Dispersive Fading Channels

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***Abstract*—The mobile network is the most establishing communication technology nowadays, In order to support its high speed data rate in real time process it often use adaptive algorithms. . But in fact, the performance of frequency selective fading channels are not effective while enduring adaptive algorithms. In this suggested method, a better channel assessment is implemented for frequency selective fading channels with an adaptive synchronization algorithm. A correlation factor is introduced to minimize the ISI (intersymbol interference) with the calculation of coarse channel length. In this suggested paper, a mixed form of blind and data aided method are used for channel assessment. The simulation results shows that the implemented channel assessment method is highly accurate with grater tracking speed and lower calculation complexity compared to the existing adaptive algorithms. Where, the previous studies never focused on a specific channel model than its parameters of interest. The theory and results are mentioned and discussed in the paper.**

Keywords-Channel Estimation, OFDM, Rayleigh fading, Adaptive algorithm, Multiple Input Multiple Output (MIMO).

I. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is one of the most promising techniques in communication fields over asymmetric digital sub carrier lines, high speed digital sub carrier lines, broadcasting of digital audio and video. The synchronization errors may develop intercarrier interference (ICI) and intersymbol interference (ISI) which may further lead to divert the orthogonality of sub carriers. So choosing a synchronization technique is highly important.

In OFDM systems, the non-data-aided and data-aided algorithms are proposed. In data-aided scheme, the symbol synchronization could be work down with the training symbols or pilot symbols at the receiver. Although data-aided algorithms could provide a better estimation on symbol synchronizations, it introduces much more redundant information in OFDM systems [4].

To improve the bandwidth efficiency of the OFDM system, data-aided algorithms have been proposed. Within data aided synchronization algorithms, time and frequency offsets are estimated through the property of time repetition cycle of guard interval without any training symbols [3]. We focus on data-aided methods, as it is more accurate than blind method.

In digital radio transmission, the information symbols are sending by means of particular selected waveforms that modulate a carrier signal with an appropriate selected frequency. In most systems variable factors imposed by the radio environment and hardware imperfections generate fluctuations in how these waveforms actually are received. Because of these fluctuations, the receiver's knowledge of the transmitter's symbol rate, carrier frequency, and waveform constellation is not always sufficient to assure reliable detection [4]. In order to detect the information symbols reliably, the receiver may need to counteract the channel uncertainties.

Synchronization with the remote transmitter and equalization of the channel are often necessary [6].The synchronization concept exploits a redundancy that is present in most OFDM signals and known as the cyclic prefix. This redundancy facilitates the estimation of symbol time and carrier frequency offsets. The channel estimation concept exploits the frequency correlation of the channel. In many OFDM systems this concept can improve channel estimation significantly, even if the channel statistics are not exactly known at a receiver.

Multicarrier communication (MC) has become widely using because of its capability to deal with channel dispersion, built MC communication desirable for high data rate applications [1]. To eliminate the ISI in between well transmitted MC blocks; a guard interval is infused between the MC blocks. The well accepted guard interval method is the cyclic prefix (CP), IN which the final samples of every MC block are copied and inserted at the starting of the MC block.

OFDM is a data pack transmission technique. In the base band, the carrier signals area group of nearly placed high frequency signals which modulated with data symbols. At the transmitter, the OFDM signal undergoes several multipliers with low rate data streams which associated with a sub carrier. It is possible to completely remove the ICI and ISI of an OFDM symbol with the properties of cyclic prefix, but it compensate some transmission energy at the same time [3].

II. MIMO-OFDM CHANNEL ESTIMATION DESIGN

In each OFDM signal, parallel data streams get modulated by equal number (N) of orthogonal sub carriers. The base band sub carrier can be expressed as

$$\phi_k(t)=e^{j2\pi f_k t} \quad (1)$$

Here the k^{th} sub carrier frequency is represented as fkt. And N modulated subcarriers multiplexes with a baseband symbol.

$$s(t)=\frac{1}{\sqrt{N}}\sum_{k=0}^{N-1} x_k\,\varphi_k(t), 0<t<NT \quad (2)$$

In which x_k is the kth transmitted information symbol and the length of OFDM symbol taken as NT. It has an equally spaced subcarrier frequencies f_k .

$$f_k=k/NT \quad (3)$$

It drive the subcarriers $\phi_k(t)$ orthogonal within the limit $0 < t < NT$. The signal segregates the information's from the frequency so the total allotted spectrum can be use in an efficient way by overlapping subcarriers.

The reception of OFDM symbols are done by a filter bank. But in practical a T-spaced sampling with orthogonal components is considered. Now the in-phase of symbols can be given as (dispersions like additive noise not considered),

$$s(nT)=\frac{1}{\sqrt{N}}\sum_{k=0}^{N-1} x_k e^{j2\pi\frac{nk}{N}}, 0\le n\le N-1 \quad (4)$$

Where x_k is the constellation symbols of inverse discrete fourier transform. Correspondingly, the received sampled bundles of data are decoded and demodulated by DFT along with a sample matched filter

The working concept of cyclic prefix is used to extend the OFDM signal over a period Δ; a guard band with cycle extension period is placed between continuous OFDM symbols.

$$s(t)=\frac{1}{\sqrt{N}}\sum_{k=0}^{N-1} x_k e^{j2\pi f_k t};-\Delta<t<NT \quad (5)$$

A bounded channel with interval $[0,\Delta_h]$ is designed by an impulse response having finite length. The signal travel through the channel and the received data symbols on the interval $[0;\ NT]$ are calculated and it omit all the noise addition. The time period of cyclic prefix Δ is selected only if $\Delta>\Delta_h$ and then becomes,

$$r(t) = s(t) * h(t) = \sum_{k=0}^{N-1} H_k x_k e^{j2\pi f_k t};0<t\le NT \quad (6)$$

$$\text{Where } H_k=\int_0^{\Delta h} h(\tau)e^{-j2\pi f_k \tau}\,d\tau \quad (7)$$

The frequency f_k can be calculated with the fourier transform of $h(t)$. Meanwhile except $H_k x_k$, the actual transmitted signal and received signals are compared. The k^{th} sub-carrier modulate using cyclic prefix and keep the orthogonality of data symbols in lieu of x_k. Then the received signal (dispersion not considered) become,

$$y_k=H_k x_k;\ k=0,1,.....N-1 \quad (8)$$

With parallel arranged N equalizers the received information is able to recover. This one –tap equalizer is ideal for the OFDM and applications of cyclic prefix. This prefixes also use as the previously discussed guard band, which remove inter symbol interference from data signals.

Transmitting signals with cyclic prefix is not an energy efficient method, it also leads to reduced *signal-to-noise ratio* (SNR). The additional transmitting energy due to cyclic prefix can be calculated as,

$$\varepsilon_{loss}=\frac{NT}{NT+\Delta} \quad (9)$$

The same can be considered as a calculation for the reduced bit rate requirement with a cyclic prefix. That means if b bits are send by all subcarriers, for OFDM system the total bit rate become $Nb/NT+\Delta$ bits per second and for a non- cyclic prefix system it become b/T.

Because of swift timing and reduced frequency errors, Synchronization becomes the key element in OFDM. Reliable and accurate data signal transmission is achieved by filtering out the ISI and ICI from the channel. It keeps the length of channel impulse response less than the length of cyclic prefix to remove the ISI in OFDM system. But for the removal of ICI from transmission channels, the orthogonality of carriers is important if both the transmitter and the receiver operate with same carrier frequency.

There are many chances to develop a frequency offsets issues, like oscillator frequency mismatch at both ends, the Doppler shift effect in the transmitting channel, and it may happen even because of the delayed data transmission in the channel. Therefore, the calculation of frequency offset is important here. So in each OFDM, the window position of FFT and starting time of frame is calculated to obtain the timing offset at receiver end.

There are two classifications for OFDM synchronization. Both having merits and demerits. The first one is data-aided; it transmits with a pilot carrier or training sequence for the data assessment. So it has reduced calculation complexity and high accuracy but on the other side it has low data transmission rate and bandwidth wastage. Now the second one is non-data-aided; it has efficient bandwidth utilization and high transmission rate. The cyclic prefix checking is used often. On the other side it has very limited estimation range and not considerable for acquisition.

To remove ISI, the OFDM increases the symbol duration by splitting the high-rate data stream into parallel aligned lower rate data stream. Along with that the orthogonality of modulated carrier removes the ICI and allows overlapping of subcarriers.

Therefore OFDM is chosen as a promising modulation technique for broadband technology in a very scattering environment. An arrangement of many antennas at the transmitting and receiving end is used to accomplish high data rate over wireless channels. This wireless link system sometimes referred to as MA (multiple antennas) or MIMO. Uses of additional transmission power and bandwidth expansions are not required in MIMO system. The data rate of wireless digital communication can be improved with MIMO-OFDM combination.

There are two methods to collect the data for channel state information. The statistical behavior of wireless channels and the characteristics of the modulated signals are explored by the first method, which is known as blind channel estimation method. The second method is known as training-based channel estimation, which deals the training information sent by the transmitter and known a pilot at the receiver. Here the first one has an advantage that, it has no overhead loss. Since it required a long data record, only a slowly time varying channel can be considered.

Initially, continues sequence of OFDM pilot symbols called preamble is trial transmitted through the channel to estimate the channel and accordingly the channel state information. The data channel is then considered to be stable prior to the next pilot preamble OFDM symbols.

III SYSTEM MODEL

The proposed method is a hybrid of blind and training based method or data aided method. This method incorporates the advantages of both blind and data aided methods. The proposed method uses minimum preamble for estimation.

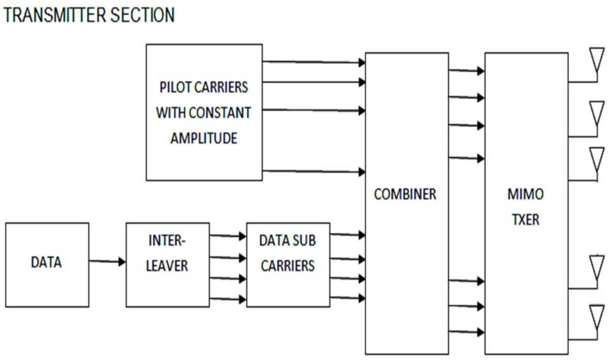

Fig.1. Block diagram of Transmitting section of Proposed Model.

At the receiver side, FFT is used for better analysis.The bandwidth requirement slightly increases since we are providing pilot carriers in between the subcarriers. The OFDM uses low data-rate symbols. Since we deal with low data-rate symbols, even if any carrier is lost due to fading, the information loss will be very low. The error probability is also reduced significantly.

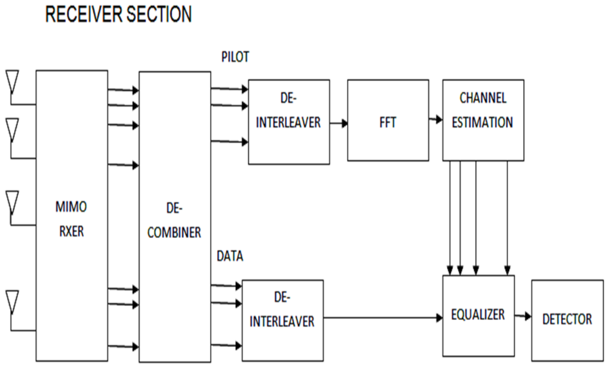

Fig.2. Block diagram of Receiver section of Proposed Model.

IV. IMPLEMENTATION

This is a simulation based project implemented using Matlab® .The Simulation Parameters are as follows:

TABLE 1: THE SIMULATION PARAMETERS

No. of Subcarriers	64
No. of pilot sub carriers	16
Cyclic Prefix length	16
No of Tx antennas(Nt)	2 (may be varied as Nr≥Nt)
No of Rx antennas(Nr)	2 (may be varied as Nr≥Nt)
Channel delay Spread	5
SNR values used for iteration	[0 5 10 15 20 25 30 35 40]
Fading	Rayleigh
No of symbol periods on each SNR value	200

V. RESULTS AND DISCUSSIONS

The constructed channel bears AWGN and Rayleigh fading.The channel coefficients are affected due to multipath and noise effects. The figure shows the BER performance of proposed and existing models.

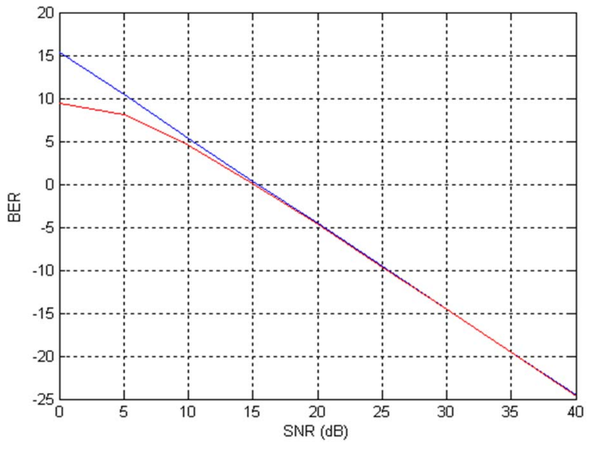

Fig.3. BER performance of existing and proposed models.

The BER analysis reveals the adequacy of proposed method in low SNR region. In low SNR region the BER value is also low and thus good channel estimation can be possible. Simulation includes construction of actual channel influenced by AWGN and Rayleigh fading. The two estimation schemes are coded. Initially the data-aided model considered then the proposed model.

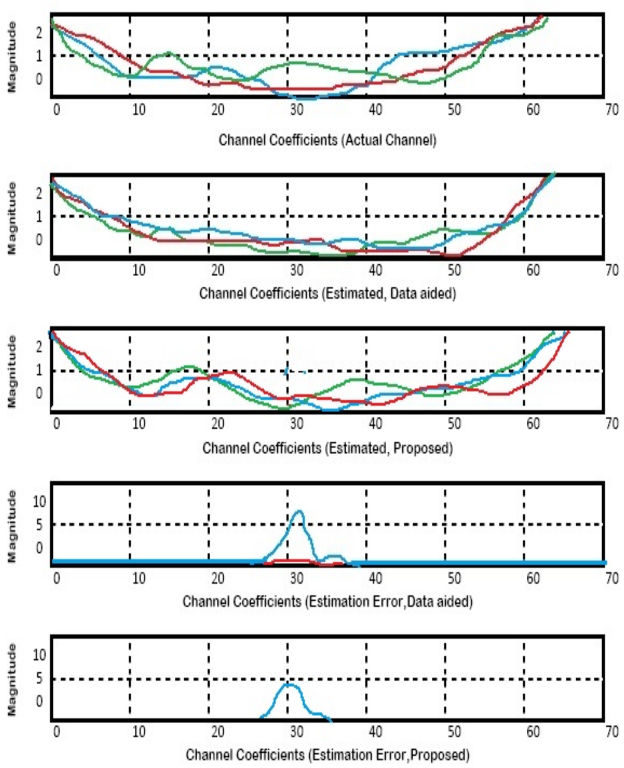

Fig. 4. Channel simulation results

The graphical Figure 4 shows the magnitude of the channel coefficients are influenced by AWGN and Rayleigh fading. First subplot is the channel coefficient versus its magnitude plot. Second subplot is the estimated channel coefficients which used data-aided method. Here also the channel length is 64.Third subplot is the estimated channel coefficients which used the proposed method, which is a combination of data-aided and blind method. Next subplot shows the estimation error when data-aided method is used. The last subplot shows the estimation error when the proposed scheme is used. It can be seen that the error value of both the schemes can be approximated. The graph not only gives the comparison between data aided channel and proposed channel, but also it estimate the error also.

TABLE II: COMPARISON BETWEEN PREVIOUS METHODS AND PROPOSED METHOD.

PREVIOUS METHODS	**PROPOSED METHOD**
Estimation complexity with each preample	Minimum Preample for estimation
FFT is not suitable for many of the previous methods	FFT used for better analysis
High data rate symbols	Low data rate symbols
High information loss due to high symbol rate and fading	Low information loss
Error probability is high due to information loss	Much reduced error probability

VI. CONCLUSIONS

Some of the most known methods have been surveyed in order to develop a new method for channel estimation which combines positive features from previously proposed methods such as blind and data aided methods for channel estimation. This method incorporates the advantages of both blind and data aided methods. This implemented method uses minimum preamble for estimation. At the receiver side, FFT is used for better analysis. The bandwidth requirement slightly increases since we are providing pilot carriers in between the subcarriers. The OFDM uses low data-rate symbols. Since we deal with low data-rate symbols, even if any carrier is lost due to fading, the information loss will be very low. The error probability is also reduced significantly.

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