INTERNATIONAL JOURNAL OF INNOVATIVE TRENDS IN ENGINEERING (IJITE) ISSN: 2395-2946
ISSUE: 74, VOLUME 50, NUMBER 01, FEBRUARY 2019

Performance Analysis of ROMP based Channel Estimations in OFDM System

Dheeraj Kumar[1] Prof. Anshuj Jain[2] Prof. Balram Yadav[3]

M. Tech. Scholar[1] Asistant Professor[2,3]

Department of Electronics and Communication

SCOPE College of Engineering, Bhopal

Abstract-To analyze the performance of Regularized orthogonal matching pursuit (ROMP)-based compressed channel estimation (CCE) with deterministic pilot patterns, we propose a mathematical framework by defining four normalized mean-square-errors (NMSEs): the total NMSE (NMSET), the NMSE on dominant channel components (NMSED), the NMSE caused by 'lost errors' (NMSEL) and the NMSE caused by 'false alarms' (NMSEF). Then, we derive a formula with a closed form for evaluating the upper-bound of NMSED in the ideal case (NMSED,UB). Using the proposed analytical framework, the main findings include: 1) the NMSED,UB is determined by the following four parameters: the deterministic pilot pattern, the maximum Doppler shift, the number of dominant multipath components and the SNR; 2) the NMSED,UB can be viewed as an approximation of practical NMSET in case that the probability of the successes of OMP exceeds a certain threshold, in which both NMSEL and NMSEF are neglectable 3) using linear regression models, the practical bit-error-rate performance also can be predicted well based on the proposed NMSED,UB. We believe that the proposed framework provides a useful tool for adaptively optimizing pilot parameters according to rapidly time-varying channel conditions when using OMP based CCEs in mobile OFDM systems.

I. INTRODUCTION

In current years, data rate is getting high in communication systems and researchers have curiosity on rapid modulation method. As a multi-carrier modulation method orthogonal frequency division multiplexing (OFDM) is reasonably interested by researchers. OFDM has been performed for a lot of applications, such as high-speed telephone-line-communication, wireless local area network digital television broadcasting, digital audio broadcasting and lines of digital-subscriber. In recent communication systems we can realize a remarkable increased ability OFDM and multiple antennas together and this enhancement obtained due to diversity of transmit and receive sides. [1]. Radio "a transmission has let people to communicate without having any physical connection between transmitter and receiver for more than hundred years. More than a century ago, it was a primary burst through and the start of a completely new industry, When Marconi managed to show a method for wireless telegraphy.

Mostly Two main problems come at time of in designing of channel estimators. The first problem is the arrangement of pilot information, where pilot means the reference signal used by both transmitters and receivers. The second one problem is the design of an estimator with both low complexity and good channel tracking ability. This two problems are interconnected. In general, the fading channel of OFDM systems may be viewed as a two dimensional (2D) signal (time and frequency). The combination of high data rates and low bit error rates in OFDM systems require the use of estimators that have low complexity as well as high accuracy, where the two constraints work against each other and a good trade-off is desirable.

As we know according to demand of today's life, data transmission at high bit rates is essential for many services such as video, high quality audio and mobile integrated service digital network. The channel impulse response can extend over many symbol periods as the data is transmitted at high bit rates, over mobile radio channels, which lead to inter symbol interference (ISI). Orthogonal Frequency Division Multiplexing (OFDM) is one of the promising candidate to assuage the Inter Symbol Interference. In an OFDM signal the bandwidth is divided into numerous narrow sub-channels which are transmitted in parallel. Each sub-channel is typically chosen narrow enough to eliminate the effect of delay spread. "

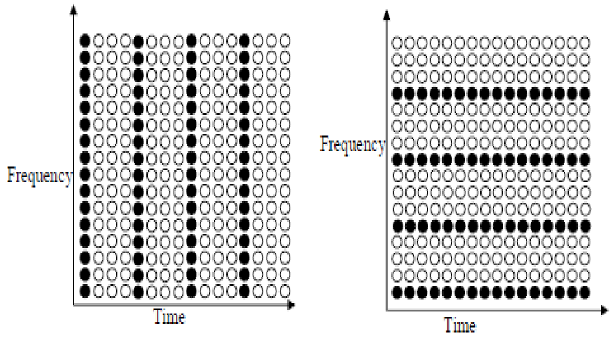
Orthogonal Frequency Division Multiplexing (OFDM) has recently been applied widely in wireless communication systems due to its high data rate transmission capability with high bandwidth efficiency and its robustness to multi-path delay. It has been used in wireless LAN standards such as American IEEE802.11a and the European equivalent HIPERLAN/2 and in multimedia wireless services such as Japanese Multimedia Mobile Access Communications.

II. MOTIVATION

High speed data transmission are the need of modern society not only for sharing the importance information only but also for entertainment. In recents years as we know how much we use the social media and the dependency on internet is rapidaly increases due to all this resons we required high speed data transfter for real time operation too. OFDM system will help to send the high speed data with low bit error rate and ISI is decreases due to ofdm system. This system, channel estimation is required to sharing the data with low error rate,lowsnr and with high speed. Researcher have to Understand the channel estimation in ofdm and how it provided must better data transfer and develop a new method which give high speed of data transmission with minimum error.

III. METHODOLOGY

A “wideband radio channel is normally frequency time andselective variant. For an OFDMmobile communication technique, channel transfer function at various subcarriers appears unequal in both time and frequency domains. Therefore, a dynamic estimation of channel is essential. Pilot-based approaches are widely used to guess channelproperties and correct received signal. In this part we have tested two types of pilot arrangements.



“ Block Type Pilot Arrangement Comb Type Pilot Arrangement

The “first kind of pilot arrangement shown in Figure 1 is denoted as block-type pilot arrangement. OFDM block required a particular pilot signal, which is sent periodically intime-domain. This kind of pilot arrangement is specifically proper for slow-fading radio channels, but training block contains all pilots, channel interpolation in frequency domain is not necessary. Therefore, this kind of pilot arrangement is quite insensitive to frequency selectivity. The second kind of pilot arrangement shown Figure 2 is denoted as comb-type pilot arrangement. The pilot arrangements are equally distributed within each OFDM block. Assuming that payloads of pilot arrangements are same, the comb-type pilot arrangement has a higher re-transmission rate. Thus the comb-type pilot arrangement system is provides superior resistance to fast-fading channels. Since only some sub-carriers contain the pilot signal, channel reaction of non-pilot sub-carriers will be estimated by interpolating neighboring pilot sub-channels. Thus comb-type pilot arrangement is sensitive to frequency selectivity when comparing to the block-type pilot arrangement system.“

Channel Estimation Based On Block-Type Pilot Arrangement

In “block-type pilot linked channel estimation, OFDM channel estimation symbols are transmitted periodically, in which all sub-carriers are used as pilots. If the channel is constant during the block, there will be no channel estimation error since pilots are sent at every carriers. The estimation can be performed by using either LSE OR Sparse. If inter symbol interference is eliminated by guard interval, we write in matrix notation:“

$$\begin{aligned} Y &= XFh + W \\ &= XH + W \end{aligned}$$

Where

$$\begin{aligned}
X &= diag\ \{X(0), X(1), \ldots\ X(N-1)\} \\
Y &= [Y(0), Y(1), \ldots\ Y(N-1)]^T \\
W &= [W(0), W(1), \ldots\ W(N-1)]^T \\
H &= [H(0), H(1), \ldots\ H(N-1)]^T = DFT_N\{h\} \\
F &= \begin{bmatrix} W_N^{00} & \cdots & W_N^{0(N-1)} \\ \vdots & \ddots & \vdots \\ W_N^{(N-1)0} & \cdots & W_N^{(N-1)(N-1)} \end{bmatrix} \\
W_N^{nk} &= \frac{1}{N} e^{-j2\pi(n/N)k}
\end{aligned}$$

Sparse Channel Estimation:

“An approach for obtaining the optimal h is to consider l0 norm minimization which aims at finding the sparsest solution in the feasible solution set.“

$$\hat{\mathbf{h}} = \arg_h \min \left(\|\mathbf{R} - \Theta\mathbf{h}\|_2^2 + \lambda\|\mathbf{h}\|_0 \right),$$

“Where ^his the estimation vector of h. However, equation is an NP-hard problem. There have many sparse approximation methods to obtain sub-optimal channel estimators, such as CoSaMP, OMP.“

“Sparsely-based estimators, our method is based on an iterative technique which improves the estimates in each step starting at an initial value. However, the sensitivity of our algorithm to this initial state is not restricting; better initial values result in faster convergence. Since the samples of the channel are in the frequency domain and the sparsely criterion is valid in the time domain, we shall switch between the two domains to benefit from both sets of information.“

To save the computational capacity for the iterations, we use a simple initial state; i.e., we begin by the spectrum of channel at the previous OFDM symbol as the initial value. At the start of the reception when there is no previous estimate, we begin by the linear interpolated version (linear interpolation between the samples taken at pilot subcarriers).“

As “stated in section II-C, the linear interpolation is not possible at the zero-padded end points; thus, we leave these parts as zero, which means we have rejected the high pass coefficients of CIR.“

Up “to this point we have not employed the samples obtainedat pilot locations which are considered as the most confident set of available data. The simple way to use them is to replace the estimated values at pilot locations with the obtained samples.“

Now“ it is turn to consider the time sparsity criterion. For this aim, we should convert the estimated spectrum into the time samples by means of the IFFT operation. If we had the exact spectrum, the signal after the IFFT would have been sparse; however, rejection of the high pass coefficients spread seach original nonzero sample over a range of the neighboring samples and existence of the additive noise changes the original zero samples into arbitrary nonzero values. Therefore, the initial sparsity criterion is no longer valid. With use of an adaptive thresholding method on the current time samples which we call MAT (Modified Adaptive Thresholding) we will find the most likely combination of the nonzero locations which form a sparse signal (will be described in the). It should be emphasized that the output of MAT is only the location of the nonzero samples, not their values.

SL0 Estimation:

The “main idea of SL0 algorithm [10] is to approximate the l0 norm by a smooth function, then utilize the gradient based methods to minimize the l0 norm.“

We define

$$v(\alpha) = \begin{cases} 1 & \alpha \neq 0 \\ 0 & \alpha = 0 \end{cases},$$

Then “the l0 norm is ||h||0=Σni=1 v (hi). The discontinuities of the function v leads to the discontinuities of the l0 norm. In order to conquer this disadvantage, a smooth estimation of the l0 norm is utilized to replace the function v.“

“Usually, the zero-mean Gaussian family is used inSL0 algorithm as the smooth function“

$$f_\sigma(\alpha) = \exp(-|\alpha|^2/2\sigma^2)$$

then

$$\lim_{\sigma \to 0} f_\sigma(h_i) = \begin{cases} 1 & h_i \neq 0 \\ 0 & h_i = 0 \end{cases}$$

Then combine (8) and (10), we can get

$$\lim_{\sigma \to 0} f_\sigma(h_i) = 1 - v(h_i).$$

Therefore by defining $F_\sigma(\mathbf{h}) = \sum_{i=1}^{N} f_\sigma(h_i)$, obtain

$$\lim_{\sigma \to 0} F_\sigma(\mathbf{h}) = \sum_{i=1}^{N} (1 - v(h_i)) = N - \|\mathbf{h}\|_0.$$

Then as a result, the l0 norm can be approximately expressed as

$$\|\mathbf{h}\|_0 \approx N - F_\sigma(\mathbf{h}).$$

We “can get the maxima of Fo by using the LS channel estimation algorithm when 0 → ∞. Then, choosing a descending series of Fo, we use a steepest ascent algorithm for maximizing Fo for each value of 0, and the initial value of this steepest ascent algorithm is the maximizer of Fo obtained for the previous value of 0.

Least Square Error (LSE) Estimation:

In wireless communication, the channel is usually unknown a priori to the receiver. Therefore to do the channel estimation, a pilot symbol aided modulation is used, where known pilot signals are periodically sent during transmission. The execution of channel estimation depends on number, location, and power of pilot symbols inserted into OFDM blocks. To mathematically analysis this, consider fading multipath channel with the multipath delay expansion τmax and the maximum Doppler frequency (fd).

$fdTdt \leq 1/2$

$\tau max\ \Delta f df \leq 1$

Where T is the OFDM block duration, Δf is the subcarrier spacing; $dt$and df are the numbers of samples between pilot symbols in the time domain and frequency domain, respectively [8].Within the OFDM symbol duration, the number of pilot symbols in frequency domain is related to the delay spread; on the other hand, the number of pilot symbols in time domain is related to the normalized Doppler frequency(fdT). Based on 2-D arrangement of pilot symbols, 2-D channel estimators are too complex in practice [9]. Therefore, channel estimation is exploited in one-dimension (1-D) for OFDM systems in general.

We have to minimize

$$\begin{aligned} J &= (Y - XH)^{\mathcal{H}}(Y - XH) \\ &= (Y^T - H^{\mathcal{H}} X^{\mathcal{H}})(Y - XH) \\ &= Y^{\mathcal{H}} Y - Y^{\mathcal{H}} XH - H^{\mathcal{H}} X^{\mathcal{H}} Y + H^{\mathcal{H}} X^{\mathcal{H}} XH \end{aligned}$$

For minimization of J we have to differentiate J with respect to H

$$\left.\frac{\partial J}{\partial H}\right|_{\hat{H}} = 0$$

That is

$$-2Y^{\mathcal{H}} X - 2\hat{H}^{\mathcal{H}} X^{\mathcal{H}} X = 0$$

$$\Rightarrow Y^{\mathcal{H}} X = \hat{H}^{\mathcal{H}} X^{\mathcal{H}} X$$

$$\Rightarrow (Y^{\mathcal{H}} X)(X^{\mathcal{H}} X)^{-1} = \hat{H}^{\mathcal{H}} (X^{\mathcal{H}} X)(X^{\mathcal{H}} X^{-1})$$

$$\Rightarrow Y^{\mathcal{H}} X X^{-1} (X^{\mathcal{H}})^{-1} = \hat{H}^{\mathcal{H}}$$

$$\Rightarrow Y^{\mathcal{H}} (X^{\mathcal{H}})^{-1} = \hat{H}^{\mathcal{H}}$$

$$\Rightarrow \hat{H} = [(X^{\mathcal{H}})^{-1}]^{\mathcal{H}} Y$$

$$\Rightarrow \hat{H} = [(X^{\mathcal{H}})^{-1}]^{\mathcal{H}} Y = X^{-1} Y$$

$$\Rightarrow \hat{H} = X^{-1} Y$$

The time domain LS estimate of h is given by

$$\hat{h} = F^{\mathcal{H}} X^{-1} Y$$

Orthogonal Matching Pursuit (OMP) Estimation:

The “Orthogonal Matching Pursuit (OMP) algorithm is an enhanced version of the MP algorithm. This can be seen in the flowchart in Figure. It works iteratively so as to recover the sparse signal h. It works through the identification of basis and their relevant coefficient, which when combined can reconstruct sparse signal. The algorithm assumes later than initialization, that all bases are orthogonal.“

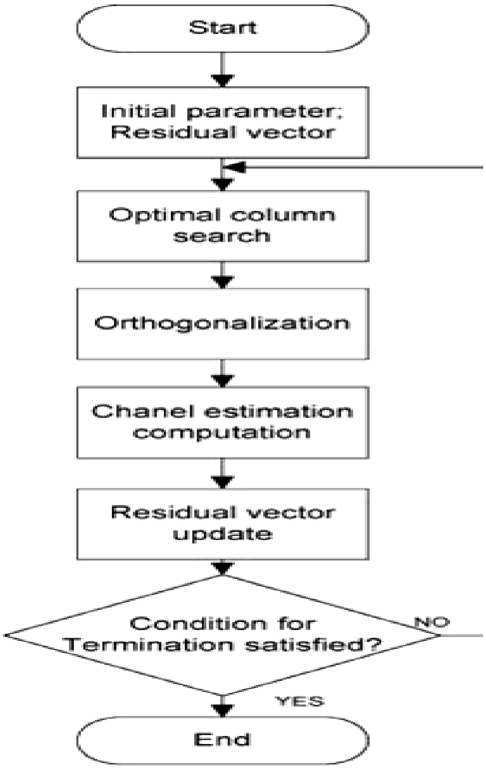


Figure 1 OMP Algorithm

Hence, “the correlation value calculated with basis informs degree to which the basis influences the signal. If correlation value is high, the basis is recognized as part of the signal. The initialization algorithm is first initialized and then the normalization to unity is assumed for all atoms.

IV. IMPLEMENTATION

To analysis and validate proposed method discuss in previous Section, we carried-out a number of simulations in MATLAB by setting the OFDM system parameters conforming to the IEEE 802.16e specifications. At the time of simulations the system, we have assumed that all of the deterministic pilot patterns are arranged as equal spaced with the largest possible gap between two adjacent pilots. However, we would like to point out that the proposed analysis framework is suitable for any kind of deterministic pilot patterns in OFDM systems. The channel model is set to the standard which is implemented in MATLAB. Channels parameters are shown in below able which are taken during simulation.

Simulation Parameters: There are many parameters which are used to compare the performance of system. some parameters which are used in this work are discuss below.

1) MSE 2) BER 3) NMSED 4) Q ANALYSIS

Channel Estimation: simulation results

1 Comparison on NMSED

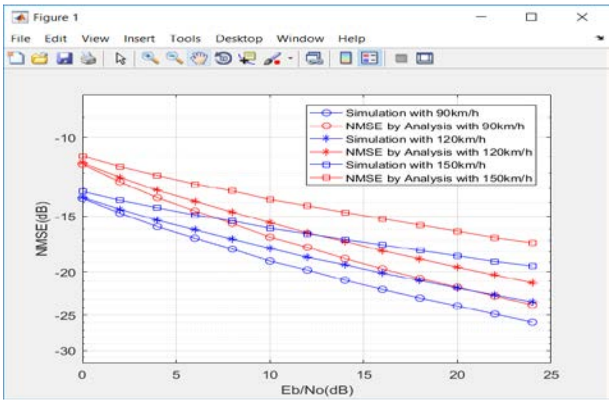


Figure 2: OMP Comparisons on NMSED with Np=32

As shown in the figure 2 the performance of NMSED with Np=32 for the OMP estimation method shows. Its x-axis shows the SNR value and y-axis shows the NMSE rate.

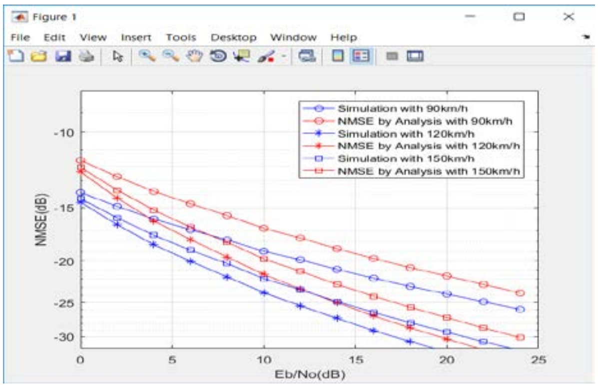


Figure 3: ROMP Comparisons on NMSED with Np=32

As shown in the figure 3 the performance of NMSED with Np=32 for the ROMP estimation method shows. Its x-axis shows the SNR value and y-axis shows the NMSE rate.

2 BER Performances

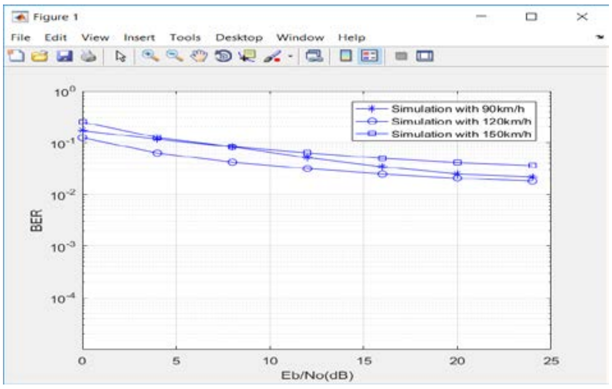


Figure 4: OMP BER performances

As shown in the figure 4 the performance of BER performances for the OMP estimation method shows. Its x-axis shows the SNR value and y-axis shows the BER rate.

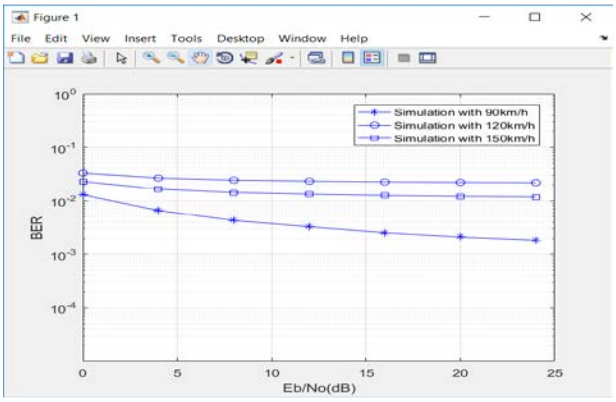


Figure 5: ROMP BER performances

As shown in the figure 5 the performance of BER performances for the ROMP estimation method shows. Its x-axis shows the SNR value and y-axis shows the BER rate.

3 Q Analysis for Scenarios with Speed

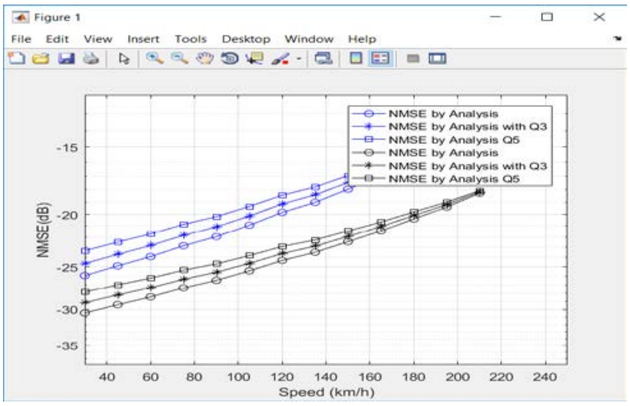


Figure 6: OMP Q analysis for scenarios with different speeds

As shown in the figure 6 the performance of Q-Analysis for the OMP estimation method shows. Its x-axis shows the Speed value and y-axis shows the NMSE rate.

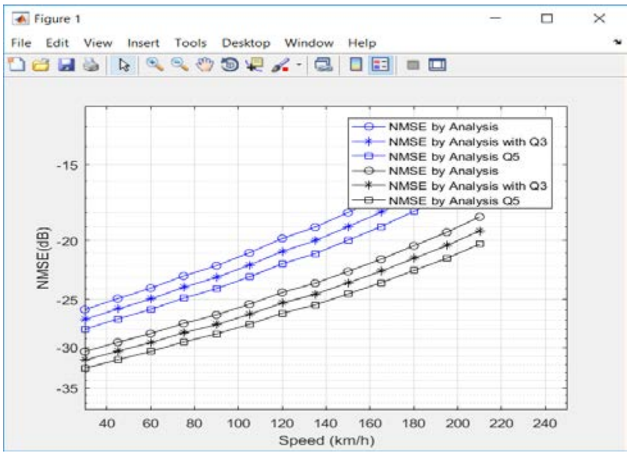


Figure 7: ROMP Q analysis for scenarios with different speeds

As shown in the figure 7 the performance of Q-Analysis for the ROMP estimation method shows. Its x-axis shows the Speed value and y-axis shows the NMSE rate.

4 Q analysis for scenarios with different Np

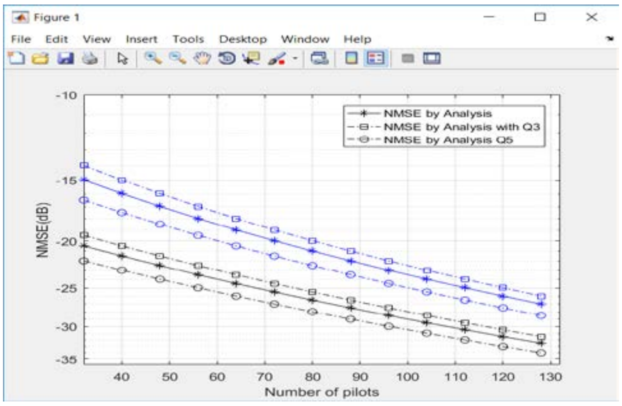


Figure 8: OMP Q analysis for scenarios with different Np

As shown in the figure 8 the performance of Q-Analysis for the OMP estimation method shows. Its x-axis shows the No of pilot's value and y-axis shows the NMSE rate.

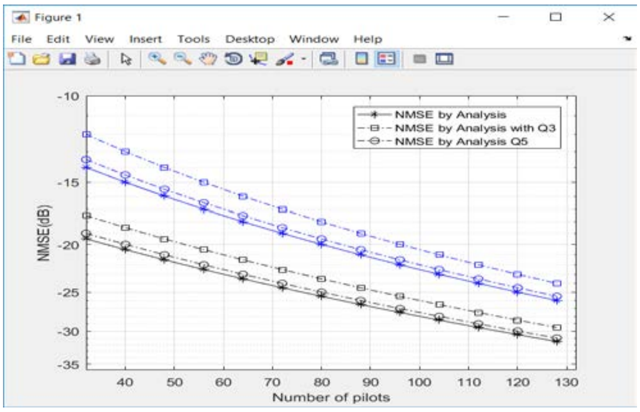


Figure 9: ROMP Q analysis for scenarios with different Np

As shown in the figure 9 the performance of Q-Analysis for the ROMP estimation method shows. Its x-axis shows the No of pilot's value and y-axis shows the NMSE rate.

5 Polynomial fitting curves using simulation results for mobile scenarios with 120km/h

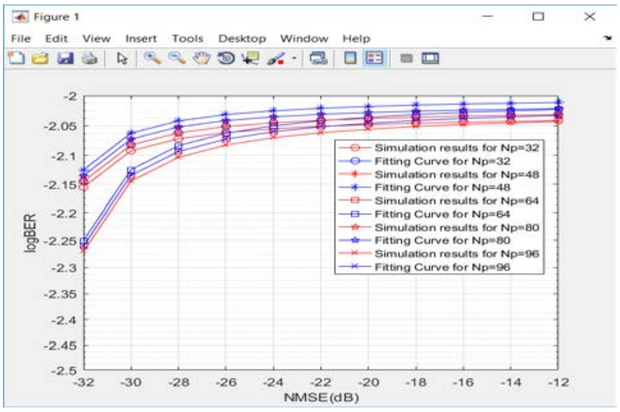


Figure 10: OMP Polynomial fitting curves using simulation results for mobile scenarios with 120km/h

As shown in the figure 10 the performance of polynomial fitting curves for the OMP estimation method shows. Its x-axis shows the NMSE value and y-axis shows the log (BER) rate.

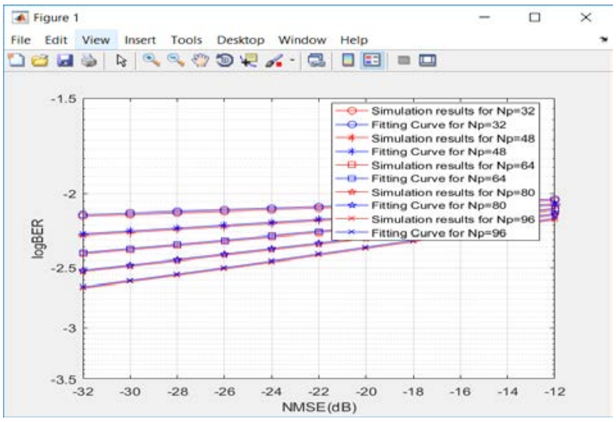


Figure 11: ROMP Polynomial fitting curves using simulation results for mobile scenarios with 120km/h

As shown in the figure 11 the performance of polynomial fitting curves for the ROMP estimation method shows. Its x-axis shows the NMSE value and y-axis shows the log (BER) rate.

6. All Channel Estimation

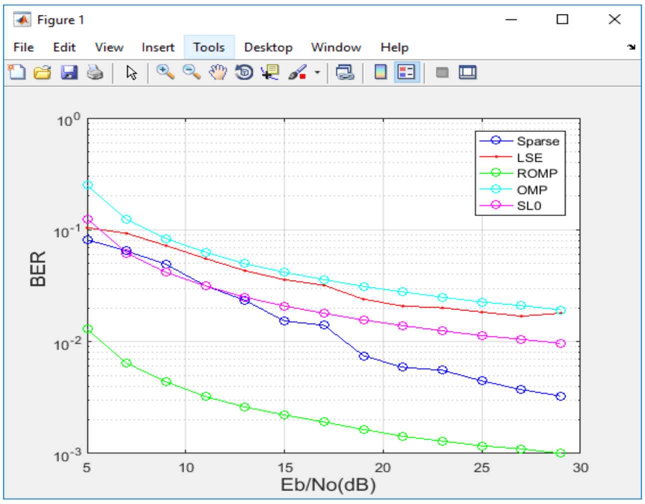


Figure 12: Different Channel Estimation Methods

As shown in the figure 12 the performance of bit error rate for the Comparative channel estimation method s its x-axis shows the SNR value and y-axis shows the BER rate.

V. CONCLUSION

Channel estimation is a method used to considerably improve the performance of the system. Different channel estimators in an OFDM system had studied for in this work. In this thesis, pilot-based channel estimation of OFDM system is discussed in detail. Focus has been placed on two types of pilot, block type and comb type. The thesis first introduces the OFDM wireless communication technology, history, basic principles, advantages, disadvantages and application prospects. Then, the wireless multipath channel effect on the OFDM system is analyzed theoretically, and the multipath fading channel model is given. After that, the focus on pilot-based channel estimation of OFDM is discussed.

OFDM is broadly applied in wireless communications systems because of its capability of high rate transmission, high bandwidth efficiency and its robustness with observe to multi-path fading and delay. The estimators are used to efficiently estimate the channel in an OFDM system given certain knowledge about channel statistics. The mathematical analysis and the simulation results show that The ROMP estimator has good performance in terms of SNR but high complexity. The OMP estimator has low complexity, but its performance is not as good as that ROMP estimator basically at low SNRs. Our Proposed System gives better results. In Proposed work NMSE is improving 10-15% and BER Performance is also improving 12-18% then existing system.

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