IMPROVING THE PERFORMANCE OF ORTHOGONAL MULTIPLEXING FREQUENCY DIVISION USING EFFICIENT CHANNEL ESTIMATION MODEL

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ABSTRACT

Multiple input and multiple output – Orthogonal Multiplexing Frequency Division (MIMO-OFDM) has been a trivial focus and is now a potential to use high-rate and robust data technology in wireless systems. High spectral efficiency and output over fast fading channels are difficult to achieve simultaneously. Fading is a phenomenon that results in differences in the duration of the channel intensity due to small effects of the multipath. The use of a single transmitter to that of a common receiver may cause these interferences. Orthogonal Frequency Division Multiplexing is the digital modeling technology used for multi-carrier. Unlike wireless channels, it plays a significant role in the transfer of signals in broadband wireless networking. The multi-way channel is where OFDM really shines. With OFDM, a parallel channel is created out of a selective frequency channel. The waveform's orthogonal area maintains the frequency separation of the various carrier frequencies, which utilize the sub channels. The goal of channel estimation, an optimization issue, is to find the optimal value of the channel's estimated coefficient while minimising the gap between the two. The channel allotment plays a key role in avoiding interference with node-to-node communications in sensor networks, typically involving centralised coordination. Increasing numbers of devices or terminals and the complex network environment will place a significant burden on wireless networks for computing and information interchange during the centralised delivery of the channel. The proposed model introduced a Dynamic Channel Estimation Model (DCEM) for accurate channel estimation and allocation for improving the network performance. The key goal of research is to learn how to solve these problems in order to increase the performance of a communication system by proper channel estimation and channel allocation. Compared to conventional approaches, the model proposed and its findings show that the performance of the model proposed is higher.

Keywords: *Channel Estimation, Orthogonal Multiplexing Frequency Division, Multi-Way Channel, Optimization, Fading, Collision Reduction.*

1. INTRODUCTION

Wireless technology has flourished over the past few years. This growth has opened up the future of wireless communications with the ultimate aim of providing universal personal and multimedia connectivity with high rates of data, regardless of accessibility or location [1]. In order to achieve this goal, a broad range of services, including high quality audio, data, replica, still images and streaming video, would need to be supported by the next generation of personal communication networks [2]. These future services would likely include applications requiring multiple Megabits per second of high transmission speeds (Mbps). Data transfer is important for many services, including video, high-quality audio and mobile integrated digital services, in current and future mobile communications systems [3] [5]. The channel pulse response can extend over several symbol times, leading up to inter symbol interference, when high bitrates of the data are transferred through Mobile Radio Channels (MRC) [6]. The bandwidth in an Orthogonal Frequency Division (OFDM) signal is divided into several small, concurrent sub-channels. OFDM offers an inexpensive, low complexity tool for avoiding interference with symbols for transmission over frequency selective fading channels [7]. This technique was very interested in mobile communication research, because the radio channel is generally selective in frequency and time variant. Modulation can be consistent or distinctive in the OFDM framework [8]. In order for the OFDM receiver to carry out consistent detection or combination of diversity when multiple transmissions and antennas are used, channel state information (CSI)is needed.

When it came to time-distributing channel data rates, OFDM was found to be an appropriate modulation technique [9]. Technical requirements for wireless OFDM systems include methods for accurately achieving sync and selecting the bandwidth of the subchannels utilized for transmission [10]. In order for the receiver to get good results, they need to understand how the channel works. The challenge is in the most effective way to extract this data. Common practice dictates multiplexing known symbols into the data stream for channel evaluation. Based on these symbols, all channel attenuations using an interpolation filter are computed.

There is a wealth of experience and knowledge around the estimation of channels in systems of single carrier communication. Many of the methods for estimating channels in single-carrier systems can also be used to multi-carrier systems [12]. New methods for multi-carrier channel estimate systems can be developed with the help of the extra insights provided by the special characteristics of multi-carrier transmission [13]. Data on the orthogonal frequency carriers are modulated on the OFDM based systems. These frequency subchannel answers can be calculated and removed from the frequency samples for consistent detection of the transmitted data [14]. The carrier spacing of OFDM is indicated in Figure 1.

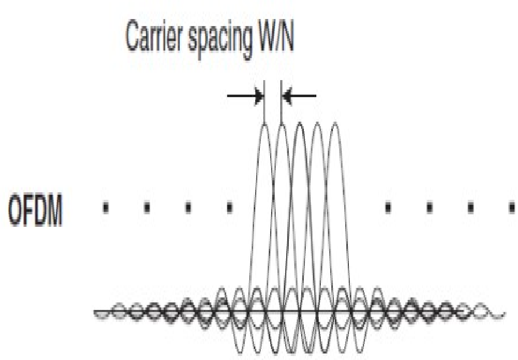

Fig 1: Carrier Spacing in OFDM

The time domain channel can also be modelled as a FIR filter in single carrier systems. Time domain samples of received signal that can be converted into a frequency field in order to achieve a frequency responsiveness can estimate delays and coefficients [15]. The radio channel may also be evaluated using the known or detected data on the sub-channels of the frequency domain [16]. Channel estimation approaches can be divided into two principal groups for OFDM-based systems: blind and dynamic [17]. The methods of blind channel estimation use the statistical comportment of the signal obtained and involve a high volume of data [18]. Therefore, in fast fading channels, they suffer severe performance harm. The receiver that will be used for channel estimation, on the other hand, is available in the dynamic channel calculation approaches based on information from previous channel estimates or some portions of the transmitted signals. The OFDM system model is represented in Figure 2.

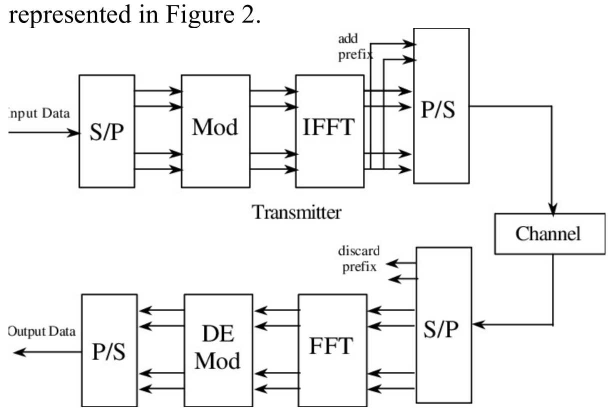

Fig 2: OFDM Model

Consider 'N' as the total sub-carrier in the OFDM symbol which needs two log M multiplications by data symbol on the transmitter and receiver in order to calculate the estimation coefficients in the channel. Since N is proportional to the channel response length, it is highly predicted [19]. The OFDM is considered to be a better transmission for broad multipath spread than traditional modulation of singles with time domain equal treatment. There are generally three forms of channel estimation methodology: pilot, dynamic and blind. The principle of "train before transmission" is based on pilot-based transmission technology [21]. The channel answers are calculated with this estimation method by sending known pilot sequences. This approach works when there are no major time fluctuations in the channel. This method is not useful for rapidly variable networks, because training needs to be done quickly and this decreases the performance quality [22]. When information

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signals are transmitted, the estimate is carried out on the blind tube. This approach has the greatest benefit of improving the use of bandwidth over time different channels [24]. The technique for estimating the dynamic channel depends on pilot to blind channel that has more advantages than the available models [26].

The channel is said to be decaying slowly when a channel's response to the pulse that is used to represent channel behaviour, which means the symbol life is lower than the channel coherence period [28]. On the same basis, a channel whose features shift quickly relative to the signal transmitted is known as a rapid decline [29]. The length of the symbol here is longer than the time of channel consistency [30]. Little scale-up can be controlled by the contact context and the quality of the signal sent. Bandwidth, channel parameter, and symbol length are the factors determining the type of channel.

The calculation of the channel using pilot symbols creates overhead. Therefore, it is noteworthy to keep the number of pilot symbols to a minimum level. The number of pilots has been shown to be significantly reduced with partly-linear interpolation, rather than partly-continuous interpolation.The difficulty in MIMO-OFDM systems is to acquire safe information to detect the message symbols in a consistent manner. This dynamic assessment has no overhead and is only understood to the receiver in trainings symbols [31]. These symbols are multiplied by the channel estimation data stream. In the case of an estimate of the dynamic channel, it is a hybrid combination of the estimate of the blind channel and the instruction by pilot carriers. Such pilot sequences are the unmodulated data transmitting data, and pilots are used to estimate and synchronise a channel [32]. More pilots are calculated efficiently and can increase the channel capacity. However, the rise in the pilot raises the overhead too.

Temporary frequency domains are the channel estimates in the proposed scheme. This training sequence is employed in the time domain to estimate the channel path delay and the frequency domain pilot coefficients [33] [35]. The OFDM data block is random and unknown for an ideal estimation of the channel. This estimation problem is separated into the antennas. But the correlation between multiple antennas is considered for improved training-based technology [36]. This does not signify that such improved training approaches are not used or used to provide antennas for a new technique when the output is not comparable to those of smaller subgroups.

2. LITERATURE SURVEY

For different channel estimations, the wireless channel model was created by Renzo et al. [1]. These estimations are intended to detect major differences in the time and in terms of statistics of multipath components between wireless networks. The communications system of Wuet al. [2] can be used as any communication system with an instant spectral occupancy exceeding 500 MHz or a fractional bandwidth of more than 20 percent.

One popular approach to high-speed wireless transmission was covered by Wu et al. [3] in relation to orthogonal frequency division multiplexing. To maximize diversity gain, OFDM is used in conjunction with antenna arrays, which include both transmitters and receivers. This leads to a setup with many outputs and boosts the system's capacity as well. Also covered are the basics of orthogonal frequency division multiplexing (OFDM) and its physical layer as they pertain to MIMO-OFDM subsystem design.

One typical approach to a high wireless transmission rate is the orthogonal frequency multiplexing division. This was discussed by Lyuet al. [4]. Antenna arrays serve as both transmitter and receiver in the OFDM system, which is used to enhance diversity gain. A configuration with numerous inputs is also the result of this, which boosts the system's power. As for the physical layer of MIMO-OFDM systems, it delves into the basics of OFDM as well.

The estimate of OFDM channels using parametric channel models of multipath fading channels was suggested by Nadeem et al. [5]. A model parametric channel, which uses a multipath channel to compute the response, is the basis of this approach. By utilizing the rotational invariance approach to obtain the original multipath delay and cancellation of the signal parameters, this algorithm estimates an interpath interference delay locked loop to monitor the multipath time delay. To estimate the channel frequency response using the knowledge about multipath delays, an MMSE estimator is derived. On sparse fading multi-track channels, the parametric channel model can efficiently decrease the channel correlation matrix signal subspace dimension, leading to improved channel estimation efficiency.

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Wang et al. [6] proposed a pilot-based channel estimation method for OFDM communication using Kalman filter. The state transition matrix is considered to be an identity matrix in the Kalman filter. Estimates of the Kalman filter state transition matrix from the signal vector were considered.If the prediction order is strong, this approach becomes more complex. The channel evaluation technics of the OFDM systems were extensively summarised by Nadeem et al. [7]. Furthermore it is studied and addressed the benefits, disadvantages and links of these estimating techniques. The combined data rates and assessment techniques of MIMO-OFDM systems are observed. In the OFDM channel estimation methods for minimising MSE, in the presence of AWGN, were analysed in their analysis in different channel estimation algorithms such as Linear Minima Mean Square Error (LMMSE).

The pilot carrier positions affecting the channel estimation are noted byGuan et al. [9]. The model examined the MSE pilot positions for the overall device efficiency of this channel assessment. The author has also suggested the identification of the pilot carrier placement to describe the MSE channel estimation by two further heuristic search algorithms: the hill climbing algorithm and the bound algorithm. Lower complexity has been achieved and the parameters do not need to be optimised.

The blind channel estimation that requires a long report for an estimation on the receiver and also for a slowly different channel, was further discussed by Kang et al. [10]. The dynamic channel estimation uses the blind-estimation method combined with the static properties of the signal received; both the receipted signal and channel coefficients have been used in the case of the deterministic approach. The channel estimate was given based on a comb-specific scheme known for low pass interpolation that performs well using channel estimation algorithms. This comb-type pilot scheme allows fast fading channels to be tracked.

A channel estimation that is semi blind to the OFDM/OQAM systems has been suggested by Yang et al. [11]. It was focused on the statistical characteristics of signals and the components obtained in the OQAM signal. In addition, the channel estimates performed further with a number of pilots with zero values. This is a good proposal if the consistency period is short and the obtained data for the estimation of the channel is small. In the simulation the advantages of the proposed approach were demonstrated. A blind noise to signal estimator, assisted by the non-data of the signal received, has been proposed by Zhenget al. [12]. For the timedomain Gaussian distributed signals such as the OFDM, this envelope dependent non-data aided estimator could be used. Interesting was that the expression showed that the proposed estimator is totally independent of the signal obtained and its composition, as well as its operation and output. The efficiency of the proposed estimator has been assessed by a medium-squared error which under different channel conditions has less complexity. The method for estimating SNR was also expanded to include various antennas. The findings demonstrate the function of this evaluator as well as the applications such as cognitive radio spectrum sharing scenarios under the low SNR conditions.

Caiet al. [15] have suggested a cost efficient channel estimation scheme for UWB communication systems based on OFDM and more specifically for low-priced, high-speed UWB based USB. Two steps are included in the proposed process. In the first step, a basic, square method and a frequency domain smoothing procedure are used to estimate the channel with the training sequence available. The second phase uses this channel estimation to detect the frame header and then to refine the channel estimation by using decision-making. The efficiency and complexity of MSE are analysed.

The channel estimation problem of UWB systems has been investigated by Liet al. [16]. The channel is historically modelled as sparse because of the wide transmission bandwidth. A new Hybrid Sparse Diffuse (HSD) channel model is proposed, Channel estimators, adapted to the HSD model, are intended for various situations that vary with the amount of side data available at the recipient. An Expectation Maximization algorithm is also designed to estimate the diffuse element's power delay profile. These approaches are compared to sparse and unstructured estimations. More realistic geometry based channel emulators are used to test the new channel estimators.

3. PROPOSED MODEL

The estimation of the channel is a problem of optimization, with a view to minimising the difference between the estimated and the appropriate channel coefficients. Like the simple method of linear programming, most conventional classical algorithms are deterministic. Any gradient

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dependent on the non-gradient can be deterministic algorithms.

Consider a MIMO system with A_T transmit antenna and A_R receive antennas. Let $Mi = [M(1), M(2) \ldots\ldots M(L)]^N$ be the transmitted symbol and $N = [N(1), N(2) \ldots\ldots N(L)]^M$ be the received data. The channel memory length is considered as L. Training symbols are transmitted to support dynamic channel estimation. The proposed model initiates dynamic channel estimation with optimization. The channel coefficients are represented as

$Ci = P^{-1}Q$

Where Ci is the channel coefficients, P and Q are Input and output matrices.

The signals received are considered as

$$\begin{cases} Sr_1^L = Ci.Ps_1^L + Cj\ .Ps_2^L + NC_1^L + Th \\ Sr_2^L = Ci\ .Ps_1^L + Cj.Ps_2^L + NC_2^L + Th \end{cases}$$

Where,

$Ps_1^L \,\&\, Ps_2^L$ are the dynamic pilot signals from the transmitted antenna 1 & 2 respectively.

$Sr_1^L \,\&\, Sr_2^L$ are the received dynamic pilot signals on the receive antenna 1 & 2 respectively.

C_{ij} is the channel from j^{th} transmit antenna to i^{th} receive antenna with i and jε {1,2}.

$NC_1^L \,\&\, NC_2^L$ are the noise components on receive antenna 1&2 respectively.

The Received Signal RS with Index I is modelled as

RS(I) = Ci(I) + Sl(I)

Here ,Ci is the channel impulse vector and Sl is the symbols list considered.Presently, Ci is required for symbolic detection and equalisation in most communications systems. It is improved by the use of a specific dynamic pilot symbols which consumes a considerable amount of electricity and a large size device/system throughput. The impulse channel identification is performed as

$$ch_{(i,j)}(I) = \eta(i,j), LOS\delta(M) + Ci_{(i,j)}$$
$$+ \min(Ni), diffuse(RS(I) - \nabla_t(j,i))$$

Here, $\eta(i,j), LOS$ represents the line of sight(LOS) elements, iand j represents Dirac Delta Function (DDF), $Ci_{(i,j)}$, is diffusion network element, $\nabla_t(j,i)$ represent delay between the diffuse and LOS signal. In the discrete time domain, the channel impulse signal c from the I to j is indicated in the equation as

$$h_{(k,i)}(n) = c_{(i,j)}(nCi_s)$$

The dynamic pilot signals received are calculated as

$X_{i,j}^{dpilot} = PM_i h_{(1,j)} + P_i Ci + Th$

Here PM is the pilot matrix, Ci is the channel impulse vector. The Th indicates the interval of the pilot samples. The input of the above equations can be solved if the two source nodes transmit training data at orthogonal frequency places. Let M1 send preamble data evenly when there are no data at odd places, and M2 send the preamble data to odd places of frequency where no data is sent to even places of frequent frequency. Let R_{even}andR_{odd}be the vector of non-zero and zero components. The estimation for the frequency response in the single and impartial sample places of s(1), g(1) is calculated as

$$s_{even}^{-(1)} = \left(M_{R,even}^{(1)h} M_{R,even}^{(Ci)}\right)^{-1} \left(M_{R,even}^{(1)Th} M_n^{(L)}\right)$$

$$g_{odd}^{-(1)} = \left(M_{R,odd}^{(L)Th} M_{R,odd}^{(Sl)}\right)^{-1} \left(M_{R,odd}^{(Si)h} M_n^{(Xi,j)}\right)$$

Here L is the channel memory, Th is the threshold value added to frequency, Sl is the dynamic symbols list considered.

The dynamic channel estimation can be obtained via a simple interpolation technique. The linear interpolation model is performed as,

$$sl^{(M)}(I) = \frac{1}{2}\left[R_{even}^{(s)}\left(\frac{I-1}{2+Xdpilot}\right) + R_{even}^{(Th)}\left(\frac{I+1}{h_{i,j}}\right)\right] + Pm_N$$

Where I is odd and $I \neq I-1$.

$$Sl^{(M)}(I) = R_{even}^{(S)}\left(\frac{I}{2}-1\right) + sl^M + Th$$

Here I is

The linear interpolation for obtaining $g^{(1)}$ is calculated as

$$g^{(N)}(I) = \frac{i}{2}\left[R_{odd}^{(M)}\left(\frac{I}{2}\right) + g_{odd}^{(Th)}\left(\frac{I}{2} + h_{i,j}\right)\right]$$

Here I is even and $I \neq 0$.

$$g^{(N)}(I) = g_{odd}^{(M)}\left(\frac{I-1}{2+Ci}\right) + g_{odd}^{(N)}\left(\frac{I-1}{Sl(i)+Ci}\right)$$

Here I is odd.

Since a subscription S to the channel frequency response is included and adaptive filter is included to denote the estimates at time ET. The structure of the immediate channel estimate is therefore is calculated as

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$$s_n^{(ci)} = \left[h(i,j)^*,....,h(n,I-1)^*\right]^{Th}$$
$$g_n^{(Ci)} = \left[g(i,j)^*,....,g(n,I-1)^*\right]^{Th}$$

The channel estimation errors are calculated as

$$CEE_{df}^{ij} = \left(g_{NL_s} + s\left\{\Omega_{ij}\Omega_{ij}^{L}\right\}\right)^{-1} Sl_{df}^{ij} - R_{ij}$$

Where g is the covariance matrix, s(Ω) is the pilot allocation matrix, R is the error code, and L is the loss levels.

The multiple channel estimations are performed as

$$MCE_{i,j}^{(Ci)} = \left(\alpha s_{n-1}^{(h)}\right)^{-1} sl_n^{(\min(M,N))} + \left(\alpha g_{n-1}^{(h)}\right)^{-1} sl_n^{\max(M,N))} + Th$$

where $s_n^{(h)} = diag\left\{s_n^{(h)}\right\}$ and $g_n^{(h)} = diag\left\{sl_n^{(h)}\right\}$.

The final channel estimation model can be calculated as

$$Icl_L^{ij} = \left(Ps_i N_L\right) + R_j^{(pilot)}$$

$$Fc_{tl}^{ij} = diag\begin{pmatrix} Ps_L\left(MCE_L^{Ci} Ps_i s_g\right)^{-1} \\ Sl_L^H\left(\alpha g_{n-1}^{(h)}\right) Ps_i R_j^{(pilot)} \end{pmatrix} + Icl_L^{ij}$$

The probability density function of the data matrix DM obtained depends on the OFDM channel ch and the symbolic matrix MS transmitted can be represented as

$$Pdf\left(MS|DM\right) = \frac{Ci + S_n + g_n}{\left(2\pi_n^2\right)^{Ni,j\times L}} + e^{-\frac{1}{2\sigma_n^2}\Sigma_{I-1}^{L}\left\|M(I)-Ci(I)\right\|^2} + g_{odd}^{(N)}\left(\frac{I-1}{Sl(i)+Ci}\right) + Th$$

For invariant channel, the maximum probability metric function for optimization is performed as

$$MPO(Sl) = \sum_{i=1}^{N_t}\left\|Ci(I) - g(h(i,j))\right\|^N + Th$$

MSE in dynamic pilot positions is calculated as

$$\left(MSE\right)_p = \frac{2\sigma_n^2}{L}\exp\left[\left(MPO_p^{Sl} * Ci + Th\right)^{-1}\right]$$

The Normalized Mean Square Error(NMSE) of the estimated channels are calculated as

$$Err(Sl) = \left\{\frac{\sum_{i=1}^{N}\left\|s_n - g_n\right\|^2}{\sum_{i=1}^{N}\left\|g_n\right\|^2}\right\} + e^{-\frac{1}{2\sigma_n^2}\Sigma_{I-1}^{L}\left\|M(I)-Ci(I)\right\|^2}$$

$$NMSE = \frac{1}{N}\frac{\sum_{i=1}^{N} E\left\{\left\|g_n - s_n\right\|^2\right\}}{\sum_{i=1}^{N} E\left\{\left\|g_n\right\|^2\right\}} + \sum_{i=1}^{N} Err\left\{\left\|g_n - s_n\right\|^2\right\}$$

4. RESULTS

Computer simulations for mobile wireless channels assess the efficiency of the proposed channel estimation model. The proposed model is implemented using NS2 simulator. Mobile radio channels are two-way channels with separate ray fading on each of them and with two different frequencies of Doppler, fd = 40 Hz and fd = 100 Hz. The Dynamic Channel Estimation Model (DCEM) is compared with the existing Blind Channel Estimation Model (BCEM). The simulated OFDM system parameters are described in Table 1.

Table 1: Parameters Used

Parameters	Specifications
FFT size	64
Coding rat,k/n	7/15
List size of KV-RSalgorithm,L_s	4
Pilot to data symbol ratio	4/15,6/15
Sampling rate	10kHz
Signal constellation	16-QAM
Normalized Doppler f_d^T	0.010,0.015
Channel Model	Rayleigh Fading, Multipath

The channel estimation model of the proposed and traditional methods is indicated in Figure 3. The

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proposed model channel estimation time levels are less when compared to existing ones.

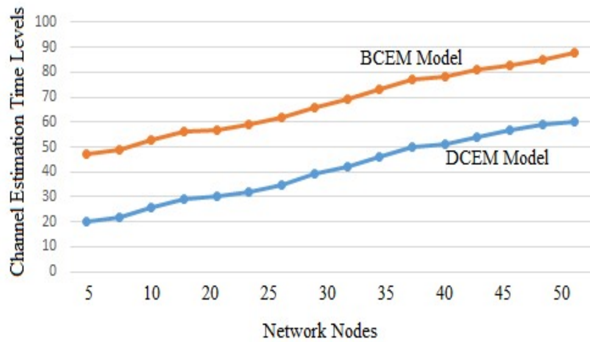

Fig 3: Channel Estimation Time Levels.

The Optimization Time Levels of the proposed and traditional models are indicated in Figure 4. The optimization levels of the proposed model are better and takes less time when contrasted with traditional model.

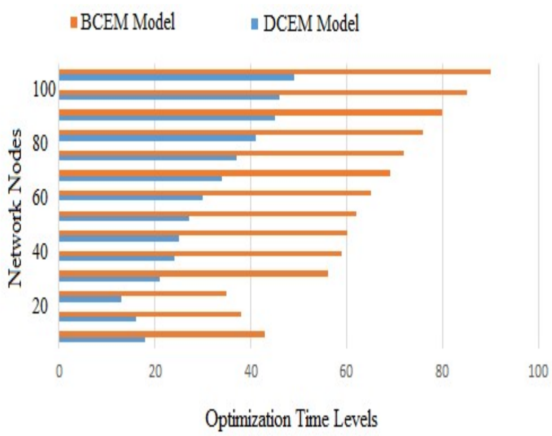

Fig 4: Optimization Time Levels

The discrete time-impulse response |h(n)| in different taps is shown in Figure 5. Figure 6 shows the mean channel estimate square error at various SNRs in dB. With SNR increasing, LSE and MMSE decrease in square error. The mean SNR vs the Symbol Error Rate is shown in Figure 7. (SER). The rate of symbol errors decreases in both cases as SNR increases. The MMSE estimator is stronger than the LSE estimator for a given SNR.

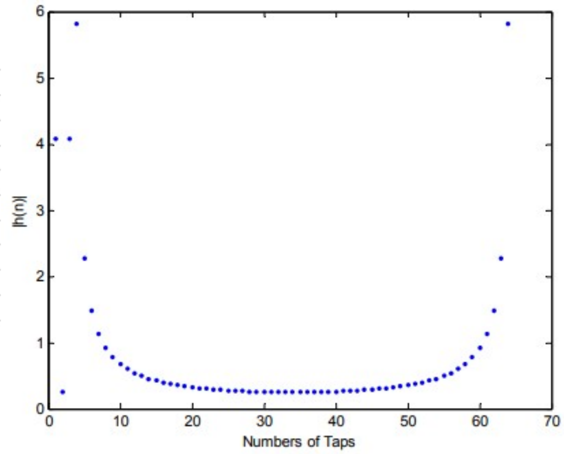

Fig 5: Channel Impulse Response |H(N)|

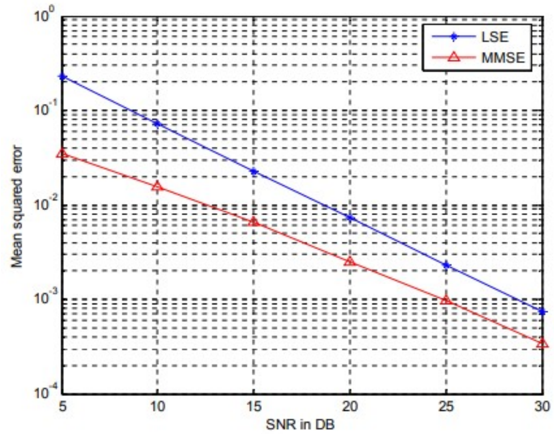

Fig 6: Mean-Square Error For LSE And MMSE Estimators At Different Snrs.

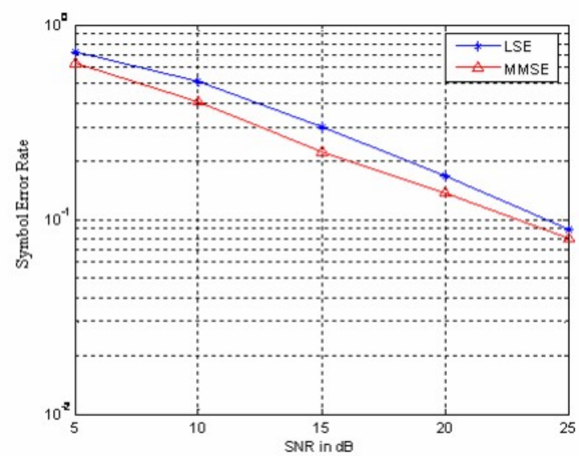

Fig 7: SER For LSE And MMSE Estimators At Different Snrs

The Overall Accuracy Levels in Channel Estimation of the proposed model is high when compared to the existing ones. The Accuracy Levels are represented in Figure 8.

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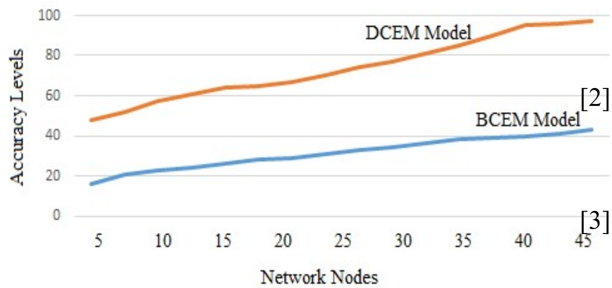

Fig 8: Accuracy Levels

5. CONCLUSION

Decomposing the optimization model over channel and data with an iterative two-level optimization loop, a new approach is proposed for dynamic channel estimation and data detection in MIMO systems. In order to detect and estimate the sent data for the unknown channel coefficient, the suggested approach is employed. In order to initialize the channel estimator using the optimization technique, the system is dynamic and has minimal pilot overhead. The suggested model in this study took into account the specifics of training in both the temporal and frequency domains. The group-pilot method achieves spectrum performance. The combined pilots use up a meager 3% of the available signal bandwidth. The estimated joint time-frequency channel uses TS to derive from the OFDM symbol's scattered pilot groups without interfering with the channel path estimation or delaying the route coefficients.The non-orthogonality of the channel estimation sequences and data symbols affects system performance, even when spectral efficiency has improved when ST is utilized in OFDM systems. A balanced overlapping technique is suggested by using the periodicity of the training sequences in the time domain and using zero insertion at some locations between data interference and the training sequences in the frequency domain.In order to provide versatility in design through the trade of complexity, performance and efficiency in bandwidth, the proposed system can also be integrated in systems with complicated equalisation mechanisms and iterative techniques for better channel estimations.

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