Channel Estimation with Different Diversity and 16-PSK Modulation with ML Detection

Aamir Mohd. Khan[1], Priyanka Shivhare[2], Dr. P. Mishra[3]
[1]Research Scholar, [2]Research Guide, [3]Principal
IASSCOM Fortune Institute of Technology, Bhopal, M. P.

Abstract - The estimation of channel in the wireless communication system is the need of modern research to provide best service and reliability to users. The quality of service highly depends on the channel behavior because the channel encounters with the environmental temperature, moisture, light, different microwave signals obstacles, random nature, scattering of signals and fading etc. To overcome such problems we have proposed a channel estimation methodology with utilization of different diversities with m-ary PSK modulation and maximum likelihood (ML) scheme. The error rate analysis of the proposed system is found better than the previously defined system or methodologies. The optimum value of BER is 5 x 10^{-4}.

Keywords - Channel Estimation, PSK, ML, Diversity.

I. INTRODUCTION

Wireless communication has become one of the fastest growing industries during the last few decades. Over two billion users are involved and make it one of largest research and business fields. With the development of mobile devices, many technical challenges have arisen such as video streaming, online-gaming and real-time video meeting. Hence, the 3rd and 4th generations of cellular systems such as WiMAX, LTE, and LTE Advanced have been deeply studied and deployed in many developing and developed countries. However, a higher quality of service is required for the current systems, that is, higher data rate, higher spectral efficiency and more reliable link. These features must be provided with lower cost (reduced size of equipment and less energy consumption.

A tradeoff between complexity and performance may be required in the sense that the suboptimal detection methods have lower complexity at the expense of poorer performance compared to ML receivers. In addition, hundreds of subcarriers have been exploited in such system, which makes the receiver design more complicated than narrow-band MIMO systems. Also, the wireless channels results in the distortion and superposition of the transmitted signals from multiple transmit antennas. Hence, lower-complexity and more robust channel estimation and detection techniques are critical to wireless communication systems.

Maximum likelihood

The method of maximum likelihood corresponding to many well-known estimation methods in statistics. For example, one may be interested in the heights of adult female penguins, but be unable to measure the height of every single penguin in a population due to cost or time constraints. Assuming that the heights are normally distributed with some unknown mean and variance, the mean and variance can be estimated with MLE while only knowing the heights of some sample of the overall population. MLE would accomplish this by taking the mean and variance as parameters and finding particular parametric values that make the observed results the most probable given the model.

In general, for a fixed set of data and underlying statistical model, the method of maximum likelihood selects the set of values of the model parameters that maximizes the likelihood function. Intuitively, this maximizes the "agreement" of the selected model with the observed data, and for discrete random variables it indeed maximizes the probability of the observed data under the resulting distribution. Maximum-likelihood estimation gives a unified approach to estimation, which is well-defined in the case of the normal distribution and many other problems.

Properties of Maximum likelihood

Like other estimation methods, maximum-likelihood estimation possesses a number of attractive limiting properties: As the sample size increases to infinity, sequences of maximum-likelihood estimators have these properties:

- Consistency: the sequence of MLEs converges in probability to the value being estimated.
- Asymptotic normality: as the sample size increases, the distribution of the MLE tends to the Gaussian distribution with mean and covariance matrix equal to the inverse of the Fisher information matrix.
- Efficiency, i.e., it achieves the lower bound when the sample size tends to infinity. This means that no consistent estimator has lower asymptotic mean

squared error than the MLE (or other estimators attaining this bound).

- Second-order efficiency after correction for bias.

Applications

Maximum likelihood estimation is used for a wide range of statistical models, including:

- Linear models and generalized linear models.
- Exploratory and confirmatory factor analysis.
- Structural equation modelling.
- Many situations in the context of hypothesis testing and confidence intervals.
- Discrete choice models.

Signal detection (filtering).

II. SYSTEM MODEL

For high data rate systems, the transmission of wideband signals is necessary, which creates challenges for the receiver due to channel induced inter-symbol interference (ISI). For wideband transmissions, the received signal is a super position of a number of cyclically shifted and attenuated replicas of the transmitted signal. Delayed replicas of earlier symbols will therefore interfere with the current symbol, creating ISI. As the transmission bandwidth increases, the number of interfering symbols can grow large. This adds significantly to the complexity of equalizer, which needs to handle the ISI. A popular technology to handle ISI channels, and to reduce the equalizer complexity, is OFDM. The main idea behind OFDM is to divide a frequency selective channel into a set of narrowband subchannels. Over these subchannels, or subcarriers, orthogonal narrowband signals are transmitted in parallel. Since each of these signals experiences flat fading, simple scalar channel equalization can be performed. Furthermore, since the subcarriers are orthogonal there is essentially no cross talk between signals (for a well designed system), which simplifies the detection process.

In Fig. 1 a discrete time baseband model of an OFDM system is shown. Starting with the transmitter at the left of the figure, M complex symbols x[m]

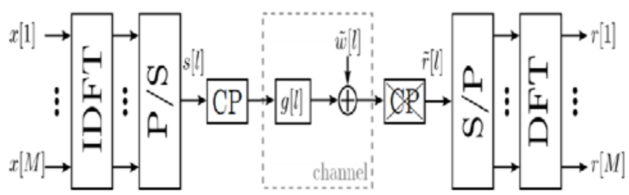

Fig. 1: Baseband OFDM system model

are fed to the M-point inverse discrete Fourier transform (IDFT) block. The IDFT performs the OFDM modulation, where each column of the underlying IDFT matrix corresponds to one of the subcarriers of the OFDM symbol. After a parallel to serial conversion, the time domain signal yields

$$s[l] = \frac{1}{\sqrt{M}} \sum_{m=0}^{M-1} x[m] e^{j2\pi\frac{lm}{M}} \qquad 2.1$$

for l = 0, . . . , M − 1. As can be seen, this is nothing but a sum of complex exponentials, i.e., sine and cosine functions. The structure of an OFDM symbol is exemplified in Fig 1, where a continuous OFDM signal is shown in time and frequency. The time domain signal also contains the CP. Note that all the signal components are orthogonal over an interval T.

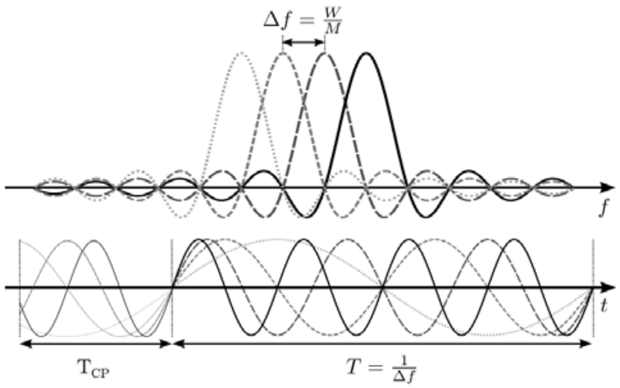

Fig 2: Frequency and Time Representation of OFDM signal

After the addition of a cyclic prefix (CP), the signal is transmitted over a time dispersive channel with impulse response g[l], which is assumed to be no longer than the CP. Then, white Gaussian noise (WGN) is added. At the receiver, assuming accurate synchronization and after the removal of the CP, the received time domain signal r̃[l] contains a superposition of delayed replicas of the transmitted OFDM symbol. In a time dispersive channel, the CP is needed in order to preserve the orthogonality between the subcarriers. The requirement for orthogonality is that all delayed replicas of a transmitted OFDM symbol overlap in an observation interval of length M (or T in continuous time). This is achieved through an addition of a CP. Orthogonality is required for a discrete Fourier transform (DFT) to perfectly separate the different signal components of the OFDM symbol at the receiver. Without the CP, replacing it with an empty guard interval, the delayed signals would partly fall outside the observation interval, and orthogonality between subcarriers would be lost. It should be noted that this orthogonality problem can be solved through post-processing at the receiver [7].

III. PROPOSED METHODOLOGY

The channel estimation system is proposed in this paper shown in the block diagram below.

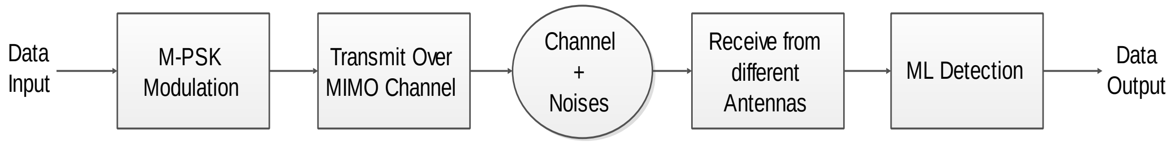

Fig. 3 Block Diagram of Proposed Methodology

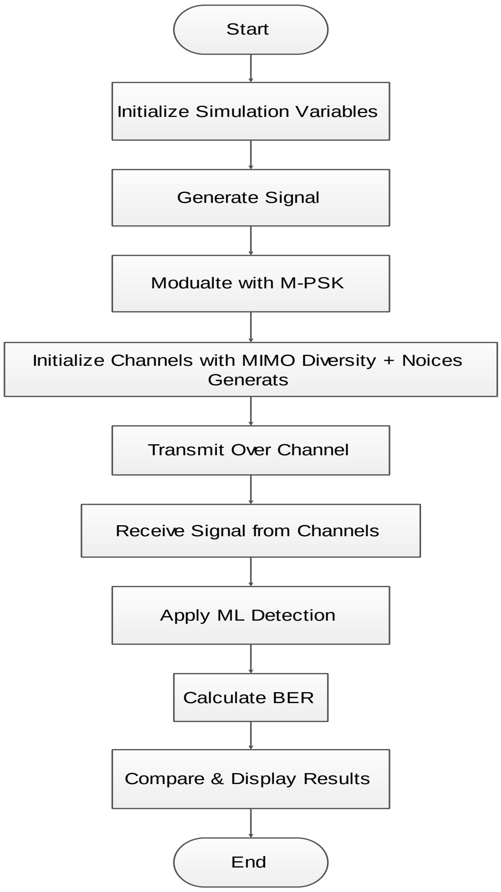

Fig. 4 Flow Chart of Proposed Methodology

The main blocks are modulation of signal with m-PSK scheme. Spatial diversity block to define MIMO channels. The channel block to define and compute the noises introduces in the signal which cause errors. The reception of signal from different antennas at the receiver and recover information using maximum likelihood detection scheme. In Fig. 4 the flow chart of the proposed methodology is shown. Flow chart shows the step by step execution of computer algorithm to simulate the proposed model to achieve the results.

IV. SIMULATION RESULTS

The simulation model simulated on the MATLAB tool and the simulation outcomes got after simulation process is shown in below figures.

The simulations are done on parameters like different antenna configurations like multiple transmitter and multiple receiver antennas. The modulation schemes is 16-PSK which maintains the higher data rate but also increases the complexity up to certain extent and definitely causes to increase error rate. And last but not least detection scheme which is maximum likelihood(ML).

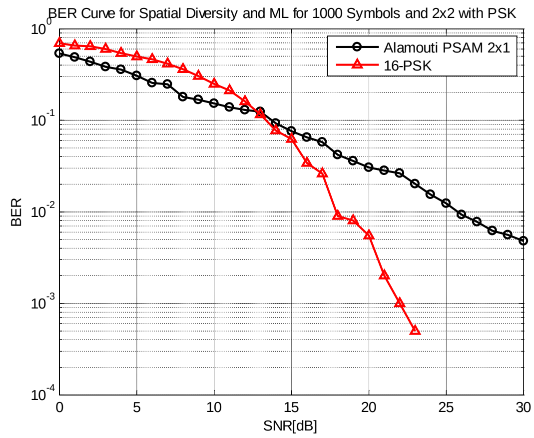

Fig. 4.1 Channel Estimation BER Curve using Spatial Diversity and ML with 2x2 Configuration

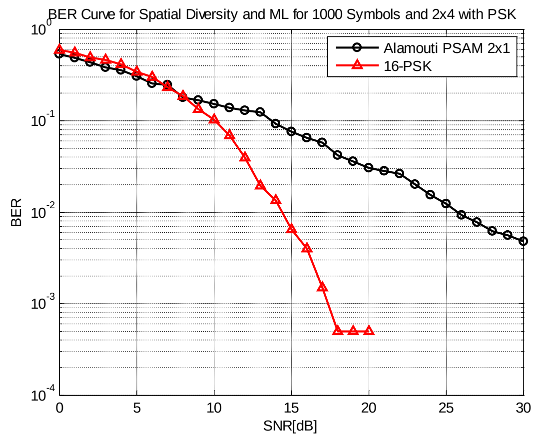

Fig. 4.2 Channel Estimation BER Curve using Spatial Diversity and ML with 2x4 Configuration

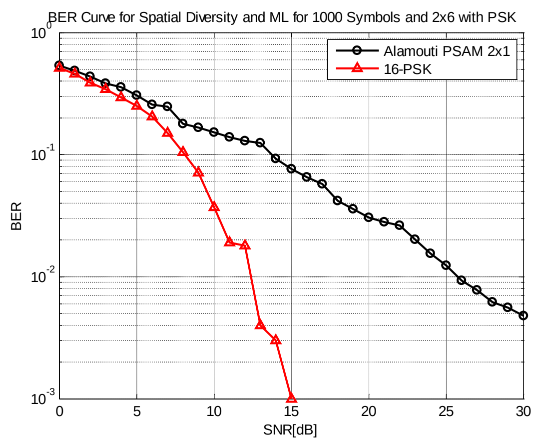

Fig. 4.3 Channel Estimation BER Curve using Spatial Diversity and ML with 2x6 Configuration

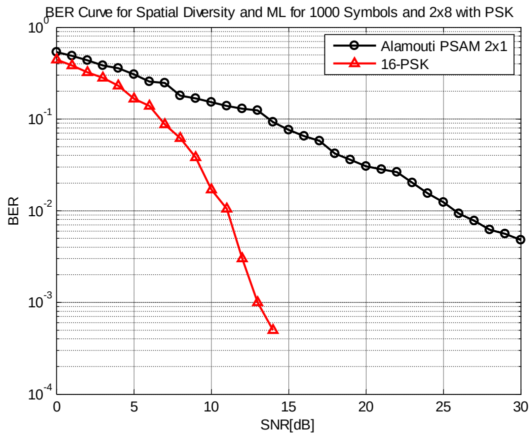

Fig. 4.4 Channel Estimation BER Curve using Spatial Diversity and ML with 2x8 Configuration

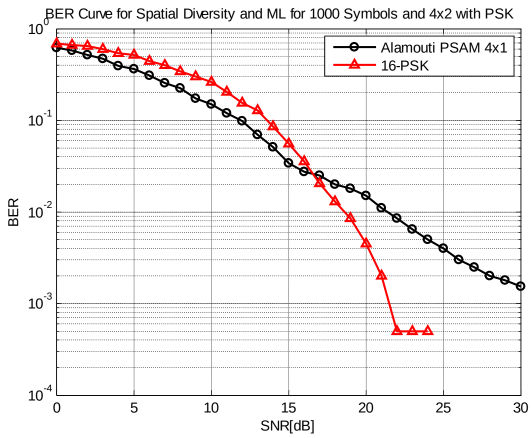

Fig. 4.5 Channel Estimation BER Curve using Spatial Diversity and ML with 4x2 Configuration

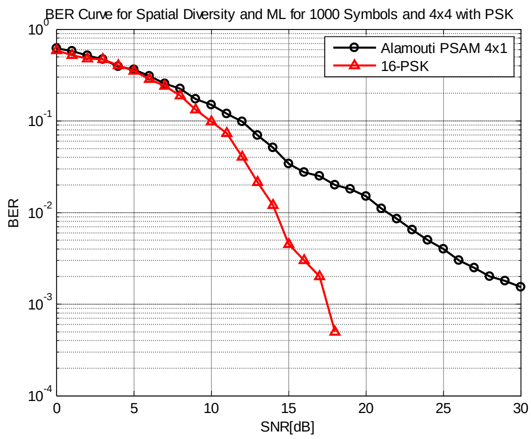

Fig. 4.6 Channel Estimation BER Curve using Spatial Diversity and ML with 4x4 Configuration

V. CONCLUSION AND FUTURE SCOPE

The proposed channel estimation of wireless system has been simulated and the outcomes have been found out in terms of BER. The BER achieved is $5x10^{-4}$ better than the existing work. The values of BER are varying with the changes in spatial diversity configurations with ML detection scheme and PSK modulation scheme. The proposed wireless channel estimation system outperform, the error rate is better than the previous techniques. As the number of antenna increases the system also start performing better and better but more than certain numbers system getting costlier. Now there are several scopes for improvements in the wireless communication channel estimation system work towards making this system better and better with the utilization of the other detection methodologies at the receiver side. The detection methods are better shield against the interferences and noises introduced during transmission.

REFERENCES

[1] E. Ben Slimane, S. Jarboui, Z. Ben Mabrouk and A. Bouallègue, "Pilot assisted channel estimation in MIMO-STBC systems over time-varying fading channels," Modeling and Optimization in Mobile, Ad Hoc, and Wireless Networks (WiOpt), 2014 12th International Symposium on, Hammamet, 2014, pp. 119-124.

[2] S. M. Alamouti, "A simple transmit diversity technique for wireless communications," in IEEE Journal on Selected Areas in Communications, vol. 16, no. 8, pp. 1451-1458, Oct 1998.

[3] V. Tarokh, H. Jafarkhani and A. R. Calderbank, "Space-time block codes from orthogonal designs," in IEEE Transactions on Information Theory, vol. 45, no. 5, pp. 1456-1467, Jul 1999.

[4] M. Biguesh and A. B. Gershman, "Training-based MIMO channel estimation: a study of estimator tradeoffs and optimal training signals," in IEEE Transactions on Signal Processing, vol. 54, no. 3, pp. 884-893, March 2006.

[5] J. K. Cavers, "An analysis of pilot symbol assisted modulation for Rayleigh fading channels [mobile radio]," in IEEE Transactions on Vehicular Technology, vol. 40, no. 4, pp. 686-693, Nov 1991.

[6] K. Yu, 1. Evans, and 1. Collings, "Performance analysis of pilot symbol aided QAM for Rayleigh fading channels," in Proc. IEEE ICC,New York,NY,pp. 1731-1735,May 2002.

[7] S.S. Ikki, S. AI-Dharrab and M. Uysal, "Error Probability of OF Relaying with Pilot-Assisted Channel Estimation over Time-Varying Fading Channels," IEEE Transactions on Vehicular Technology,vol. 61,no. I,393 - 397,2012.

[8] Wenyu Li, Yunfei Chen and Norman C. Beaulieu,"BER Optimization of Pilot Symbol Assisted MRC PSI for Slow Fading Channels " IEEE Communications Letters,vol. 13,no. 12,December 2009.

[9] Eiji Okamoto,Huan-Bang Li,and Tetsushi Ikegami,"A Pilot Symbol Assisted Compensation Scheme of Fading an Frequency Offset for 16QAM," IEEE International Conference on Universal Personal Communications (ICUPC),vol. 2,pp. 921 - 924,1998.

[10] Xiaodong Cai an Georgios B. Giannaks, "Adaptive PSAM Accounting for Channel Estimation and Prediction Errors," IEEE Transactions on Wireless Communications, vol. 4, no. 1, Janary 2005.

[11] Amine Maaref an Sonia Alssa,"Optimized Rate-Adaptive PSAM for MIMO MRC Systems with Transmit and Receive CSI Imperfections," IEEE Transactions on Communications,vol. 57,no. 3,March 2009.

[12] Wenyu Li and Norman C. Beaulieu, "Effects of Channel-Estimation Errors on Receiver Selection-Combining Schemes for Alamouti MIMO Systems With BPSI(" IEEE Transactions on Communications,vol. 54,no. I,January 2006.

[13] Jie Wu and Gary J. Saulnier, "Orthogonal Space-Time Block Code Over Time-Varying Flat-Fading Channels: Chanel Estimation, Detection, and Performance Analysis," IEEE Transactions on Communications,vol. 55,no. 5,May 2007.

[14] Duo Zhang,Guo Wei,Jinkang Zhu an Zhi Tian,"On the Bounds of Feedback Rates for Pilot-Assisted MIMO Systems," IEEE Transactions on Vehicular Technology,vol. 56,vo. 4,July 2007.