International Journal on Emerging Technologies **5**(1): 28-32(2014)

ISSN No. (Online) : 2249-3255

Channel Estimation in OFDM Systems Using (UMTS) Third Generation Technology

Mandar Joshi*, Tarun Metta** and Prof. Pushpraj Singh Tanwar*

Department of Electronics and Communication Engineering, RITS, Bhopal, (MP)
***Department of Electronics and Telecommunications Engineering, Amity University, Noida India*

(Corresponding author Mandar Joshi)

(Received 15 January, 2014 Accepted 03 February, 2014)

ABSTRACT: Orthogonal frequency division multiplexing (OFDM) provides an effective and low complexity means of eliminating intersymbol interference for transmission over frequency selective fading channels. This technique has received a lot of interest in mobile communication research as the radio channel is usually frequency selective and time variant. In OFDM system, modulation maybe coherent or differential. Channel state information (CSI) is required for the OFDM receiver to perform coherent detection or diversity combining, if multiple transmit and receive antennas are deployed. In practice, CSI can be reliably estimated at the receiver by transmitting pilots along with data symbols [1]. Pilot symbol assisted channel estimation is especially attractive for wireless links, where the channel is time-varying. When using differential modulation there is no need for a channel estimate but its performance is inferior to coherent system .In this thesis we investigate and compare various efficient pilot based channel estimation schemes for OFDM systems. The channel estimation can be performed by either inserting pilot tones into all sub carriers of OFDM symbols with a specific period or inserting pilot tones into each OFDM symbol.

Keywords: channel estimation, Pilot symbol,

I. INTRODUCTION

Multiple-antenna technology is a rich area of research. Whether for future military wireless networks, soldier radios, autonomous sensors, or robotics, the demand for improved performance may be met with multiple-antenna communication links and the advanced technology making those links effective. Lincoln Laboratory is investigating multiple-input multiple-output (MIMO) techniques to improve the robustness and performance of wireless links. Here, the term multiple-input multiple-output refers to the use of an array of antennas for both transmitting and receiving. MIMO approaches show promise of enabling better wireless communications because they mitigate problems inherent in ground-to-ground links, which are the most common links used by wireless devices, including cell phones and WiFi.Typically ground-to-ground links are not line of sight.

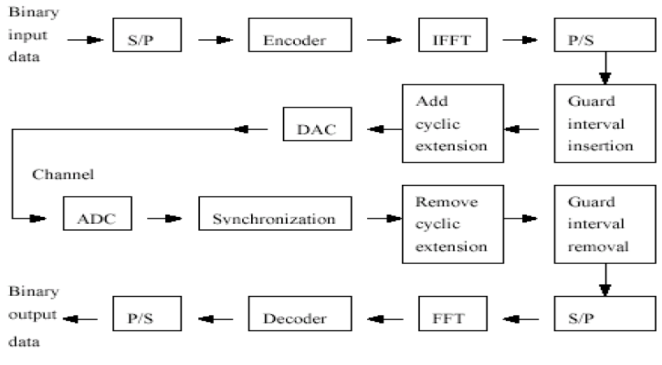

Fig. 1: A block diagram of an MCM transceiver.

The electromagnetic waves transmitted from the antennas bounce around the environment in a complicated fashion and end up at the receiver coming from multiple directions and with varying delays. The effect produced by the direction/delay interactions is referred to as multi path, a condition that must be accommodated by ground-to-ground systems. With the use of MIMO communication techniques [1], multi path need not be a hindrance and can be exploited to increase potential data rates and simultaneously improve the robustness of the links (Figure 1).Increased military and commercial dependence on wireless communication has intensified the need for more robust links. For example, the lack of adequately robust, reliable links has limited the usefulness of remotely controlled robots in military environments. More is also being asked of the links in terms of flexibility of use and higher data rates. Furthermore, ad hoc wireless networks, which are inevitably becoming integrated into military and commercial applications, require more robust, flexible, and higher-data-rate links. Lincoln Laboratory is pushing the limits of MIMO technology, developing record-setting space-time codes. Space-time codes describe what is transmitted by the array of transmitters in a MIMO communication link [2]. These codes employ advanced coding concepts along with sophisticated iterative receivers. The Laboratory-developed codes, which are allowing the largest data rates for a given transmit power; have been demonstrated theoretically and experimentally. These training sequences can be structured in two ways: a preamble structure or a pilot structure. In the preamble structure, the first OFDM symbol sent is composed strictly of pilot symbols while in the pilot structure, the first OFDM symbol sent is composed of both training and information data 1.

The advantage of using the preamble structure over the pilot structure is that the larger number of sub carriers in the preamble structure dedicated to pilot symbols results in better [4] channel estimates. The pilot structure however, allows for tracking of a fast moving channel. Using the preamble and pilot structure described above, we also simulated the performance of this channel estimation method for a MIMO system with the same channel characteristics as previously described. The frequency response using the pilot structure estimated response while the dotted curve is the actual frequency response. It is easy to see that the estimated channel closely approximates the actual channel response.

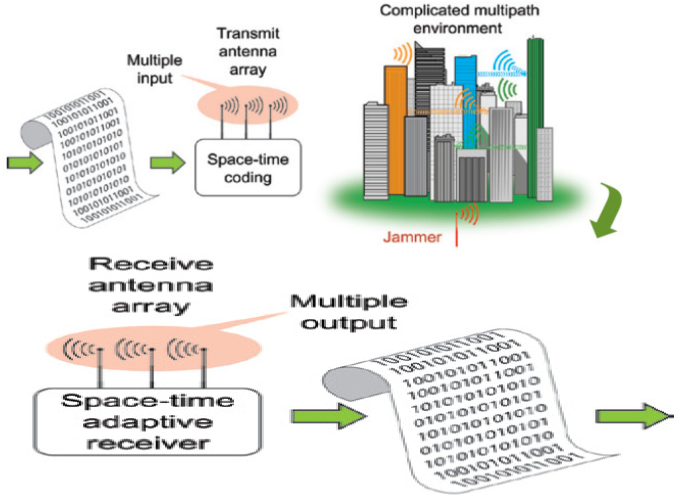

Fig. 2. MIMO communication links enable accurate data to be received despite a complicated multi path environment with jamming.

Developed and demonstrated advanced receiver techniques that enable communication in the presence of interference and jamming without significant degradation in link performance [3]. The diversity provided by multiple transmitting antennas allows the system to avoid signal interference, and the multiple receiving antennas allow the system to mitigate the effects of interference. Mitigation is achieved by subtracting the jamming and interference components of the signal seen at one receiving antenna from signals received at other antennas. While the idea of using multiple antennas to null or mitigate without using multiple-antenna mitigation techniques, a typical communication link would simply fail or at best be forced to reduce its data rate by factors of thousands to millions, making the links effectively useless. Advanced mitigation techniques such as STAP make the loss in performance essentially [5] negligible. With the use of MIMO communication techniques, multi path need not be a hindrance and can be exploited to increase potential data rates and simultaneously improve the robustness of wireless links. Jammers is not new, the Laboratory has pushed these approaches significantly and achieved remarkable mitigation performance in a variety of applications (communications, geolocation, GPS). Space-time adaptive processing (STAP) is a class of techniques used to improve mitigation performance. In this context, "space" refers to the multiple antennas and "time" refers to delay variations caused by multi path. The STAP approaches, which allow for improved matching of the signals seen at the receiving antennas, enable the subtraction to work better; therefore, jammer mitigation is improved. Joint Transmit/Receive Arrays The Laboratory is also extending its MIMO research to include the adaptive use of joint transmitting and receiving antenna arrays. In order to do this, the transmitter must have an estimate of the channel, i.e., the environment between the transmitting antenna array and the receiving antenna array. Given this estimate of the channel, the transmitter can make intelligent decisions that improve performance of the intended link while simultaneously reducing interference to other communication links. Extreme examples of this joint transmitter and receiver adaptation have been demonstrated theoretically and experimentally [4]. In one example, a node with separate transmitting and receiving antenna arrays optimizes the space-time coding.

II. WIRELESS CHANNEL CHARACTERISTICS

Development of high-speed wireless LANs (WLANs) has changed the philosophy for potential bandwidth demanding multimedia applications. They no longer need to rely on an access to the high-speed wired networks but can he easily accessed in locations where every user having a compatible wireless modem can use the network. An example of such a scenario can be a lecture theatre, where not only the teaching material is distributed to student's notebook PCs via wireless network but also their class test solutions are submitted via the same way. A popular type of the high-speed W LANs currently being deployed is one complying with IEEE 802.11a [l] (or HYPERLANZ [Z]) standard. In contrary to their predecessors, these W LANs operate in the 5 GHz band and use OFDM signaling. Small scale fading is a term that is used to describe the rapid fluctuations in amplitude and phase of a radio signal over a short period of time or travel distance. Fading is caused by interference between two of more versions of transmitted signal, which arrive at the receiver at slightly different times. The results of fading in radio propagation can be loss of signal temporarily, or incorrect signals being interpreted at the receiver end. In the case of data transmission, it can severely reduce throughput if packets that suffer fading have to be constantly retransmitted. Several techniques to help to reduce these problems have been devised, including using multiple receive transmit antennas, or application of special modulation schemes.

Some research has been done into fading in both the 2.4 GHz and 5 GHz bands It has been found that the Rician distribution is a suitable approximation for the results obtained in practice [3, 4]. The aim of the reported study was to measure the main characteristics of fading, e.g. the Rician k-factor, the level crossing rate and the average fade duration in typical operational environments where 802.1 1 a networks are being deployed. The chosen locations were a small size clattered laboratory room, a hallway, a large lecture theatre, and a stairwell. At each of these locations we measured the temporal variations in the received signal strength with three people moving around the receive antenna. The results were stored for future processing to calculate characteristics of fades. Apart from fading parameters, the delay profile characteristics were measured at the same locations. The results of those measurements, when there is a dominant stationary signal component, such as a line-of-sight propagation path, the small-scale fading envelope distribution are Rician. In such a situation, random multi path components arriving at different angles are superimposed on a stationary dominant signal. At the output of an envelope detector, this has the effect of adding a dc component to the random multi path. The effect of a dominant signal arriving with many weaker multi path signals gives rise to the Rician distribution. As the dominant signal becomes weaker, the composite signal resembles a noise signal, which has an envelope that is described by Rayleigh distribution. Thus, the Rician distribution degenerates to a Rayleigh distribution when the dominant component fades away. Detailed performance assessment of space-time coding algorithms in realistic channels is critically dependent upon accurate knowledge of the wireless channel spatial characteristics. We present an experimental measurement platform capable of providing the channel transfer matrix for indoor and outdoor wireless communications scenarios. The system allows direct measurement of key multiple inputs multiple output parameters for 16 transmit and 16 receive antennas. The basic hardware blocks are outlined, and the data post-processing algorithms are presented. Representative data showing channel capacity and spatial correlation for several indoor sites are provided. The increasing demand for capacity in wireless systems has motivated considerable research aimed at achieving higher throughput on a given bandwidth. One The process uses adaptive step size selection and shortened codes to expedite the search process. Additionally, the procedure searches over every combination of receive channel and codeword, ensuring accurate code synchronization even in situations where a fraction of the signals undergo severe attenuation. The IF estimated during the code search process is refined using a subplex optimization loop that maximizes the magnitude of the Discrete Time Fourier Transform (DTFT) of the dispread signal.

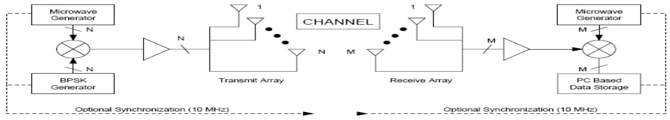

Fig. 3. High level system diagram of the narrowband wireless MIMO measurement system.

III. DIVERSITY TECHNIQUES

Fading problem is a major impairment of the wireless communication channel. In this paper we consider different techniques to mitigate the fading problem in wireless channel. The trivial solution for the fading problem would be to add a fading margin at the transmitter. However, this is not an efficient solution at all. One alternate solution is to take advantage of the statistical behavior of the fading channel. Here comes the basic concept of diversity; where two or more inputs at the receiver are used to get uncorrelated signals. wireless communication channel suffers from many impairments such as the thermal noise often modeled as Additive White Gaussian Noise (AWGN), the path loss in power as the radio signal propagates, the shadowing due to the presence of fixed obstacles in the radio path, and the fading which combines the effect of multiple propagation paths, and the rapid movement of mobile units reflectors.

Upon the signal transmission, different signal copies undergo different attenuation, distortion, delays and phase shifts. Due to this problem, the overall system performance can be severely degraded. In a typical wireless communication environment, multiple propagation paths often exist.

IV. CLASSIFICATION OF FADING CHANNELS

Based on the parameters of the channels and the characteristics of the signal to be transmitted, time-varying fading channels can be classified as: Frequency non-selective versus frequency selective. If the bandwidth of the transmitted signal is small compared with then all frequency components of the signal would roughly undergo the same degree of fading. The channel is then classified as frequency non-selective (also called flat fading). We notice that because of the reciprocal relationship between and the one between bandwidth and symbol duration, in a frequency non-selective channel, the symbol duration is large compared with In this case, delays between different paths are relatively small with respect to the symbol duration. We can assume that we would receive only one copy of the signal, whose gain and phase are actually determined by the superposition of all those copies that come within.

On the other hand, if the bandwidth of the transmitted signal is large compared with then different frequency components of the signal (that differ by more than would undergo different degrees of fading. The channel is then classified as frequency selective. Due to the reciprocal relationships, the symbol duration is small compared with Delays between different paths can be relatively large with respect to the symbol duration. We then assume that we would receive multiple copies of the signal.

V. SLOW FADING VERSUS FAST FADING

If the symbol duration is small compared with then the channel is classified as slow fading. Slow fading channels are very often modeled as time-invariant channels over a number of symbol intervals. Moreover, the channel parameters, which are slow varying, may be estimated with different estimation techniques. On the other hand, if is close to or smaller than the symbol duration, the channel is considered to be fast fading (also known as time selective fading). In general, it is difficult to estimate the channel parameters in a fast fading channel. We notice that the above classification of a fading channel depends on the properties of the transmitted signal. The two ways of classification give rise to four different types of channel:

- Frequency non-selective slow fading
- Frequency selective slow fading
- Frequency non-selective fast fading
- Frequency selective fast fading

Diversity techniques can be used to improve system performance in fading channels. Instead of transmitting and receiving the desired signal through one channel, we obtain L copies of the desired signal through M different channels. The idea is that while some copies may undergo deep fades, others may not. We might still be able to obtain enough energy to make the correct decision on the transmitted symbol. There are several different kinds of diversity which are commonly employed in wireless communication systems

VI. SIMULATION RESULT

For comb type pilot arrangement we consider an OFDM system with N = 1024 sub carriers. The frequency selective Rayleigh channel has L = 40 zero-mean uncorrelated complex Gaussian random taps.

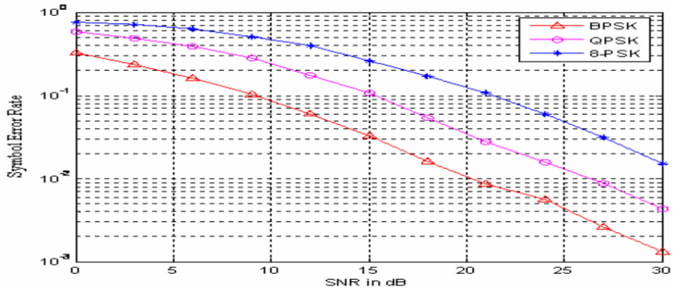

Fig. 4. SER (MMSE channel Estimation) for M-PSK modulation for different SNRs.

The spacing between pilots are taken as 4. So the number of pilots are 256 and number of information symbols are 768. In the simulation we consider BPSK, QPSK and 8-PSK. Fig. 4 and Fig. 5 demonstrate Symbol Error Rate (SER) performance (SNR versus SER) for different modulations in MMSE and LSE estimators respectively. It shows that as SNR increases the Symbol error rate decreases and also by going higher order modulation Symbol Error Rate increases which is coming true as we expected.

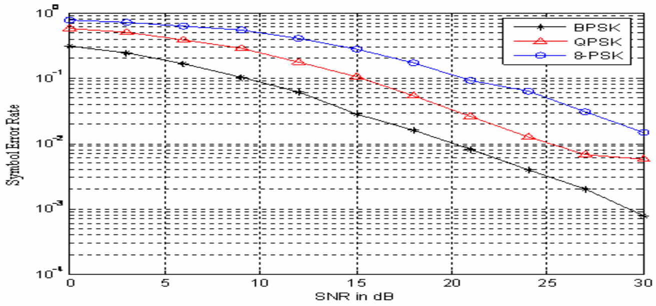

Fig. 5. Bit Error rate versus SNR (LSE channel Estimation) for M-PSK modulation.

VII. CONCLUSION

In this work, we have studied LSE and MMSE estimators for both block type and comb type pilot arrangement. The estimators in this study can be used to efficiently estimate the channel in an OFDM system given a certain knowledge about channel statistics. The MMSE estimators assume a priori knowledge of noise variance and channel covariance. Moreover, its complexity is large compare to the LSE estimator. For high SNRs the LSE estimator is both simple and adequate. The MMSE estimator has good performance but high complexity. The LSE estimator has low complexity, but its performance is not as good as that MMSE estimator basically at low SNRs. In comparison between block and comb type pilot arrangement, block type of pilot arrangement is suitable to use for slow fading channel where channel impulse response is not changing very fast. So that the channel estimated, in one block of OFDM symbols through pilot carriers can be used in next block for recovery the data which are degraded by the channel. In our simulation of block type pilot arrangement we used two ray static channel for 16-QAM modulation. Here 64 numbers of carriers are used in one OFDM block. We So comb type of pilot arrangement can not be used in this case. We used both data and pilot carriers in one block of OFDM symbols. Pilot carriers are used to estimate the channel impulse response. The estimated channel can be used to get back the data sent by transmitter certainly with some error.

In the simulation we used 1024 number of carriers in one OFDM block. In which one fourth are used for pilot carriers and rest are of data carriers. We calculated BER for different SNR conditions for M-PSK signaling. We also have compared performance of LSE with MMSE estimator. It is found that higher order interpolation technique (spline) is giving better performance than lower order interpolation technique (linear). In simulation we have also calculated MSE for estimation of channel with number of pilot arrangement. MSE decreases when number of pilots increase. But we have to limit the number pilots when mean square error comes constant.

REFERENCES

[1]. H. Sari, G. Karam, and I. Jeanclaude, "Transmission techniques for digital terrestrial TV broadcasting," *IEEE Commun. Mag.*, vol. **33**, pp. 100–109, Feb. 1995.

[2]. P. Hoeher, S. Kaiser, and I. Robertson, "Two-dimensional pilot-symbol-aided channel estimation by wiener filtering," in *Proc. ICASSP'97*, 1997, pp. 1845–1848.

[3]. M. Speth, S. Fechtel, G. Fock, and H. Meyr, "Broadband transmission using OFDM: System performance and receiver complexity," in *Proc. Int. Zurich Seminar on Broadband Communications*, 1998, pp. 99–104.

[4]. O. Edfors, M. Sandell, J. J. van de Beek, S.. Wilson, and P.O. Börjesson,"OFDM channel estimation by singular valudecomposition," *IEEE Trans. Commun.*, vol. **46**, pp. 931–939, July 1998.

[5]. Y. Li, L. J. Cimini, and N. R. Sollenberger, "Robust channel estimationfor OFDM systems with rapid dispersive fading channels," *IEEE Trans.Commun.*, vol. **46**, pp. 902–915, July 1998.

[6]. J. T. Chen, A. Paulraj, and U. Reddy, "Multichannel maximum-likelihood sequence estimation (MLSE) equalizer for GSM using a parametric channel model," *IEEE Trans. Commun.*, vol. **47**, pp. 53–63, Jan. 1999.