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A Comprehensive Analysis on Error Detection schemes over OFDM Signal

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ABSTRACT

In this paper, the author have analysed of different error detection schemes over the high speed OFDM networks so that the error rate can be reduced. In this work, some efficient schemes are suggested to reduce the error rate over the OFDM signal while transferring the video data. A High speed communication is the basic requirement for any network. But such kind of networks always suffers from the problem noise and the internal interference. These problems can destroy or alter the communication data. The data reliability is the main concentration in such communication network. To get the integrity and reliability in such high speed network number of error detection and correction approaches are present. The effect of these approaches also change according to the capacity and the SNR ratio.

Keywords: OFDM, error detection, BER, SNR, network.

1. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is a transmission method that can achieve high data rates by multicarrier modulation. The principles of orthogonal frequency division multiplexing modulation have been in existence for several decades. The techniques are employed in data delivery systems over the phone line, digital radio and television, and wireless networking systems. Furthermore, OFDM exhibits much better bandwidth efficiency than classical frequency division multiplexing (FDM) provided that the orthogonality of the carriers is preserved. A very important aspect in OFDM is time and frequency synchronization. In particular, frequency synchronization is the basis of the orthogonality between frequencies. Loss in frequency synchronization is caused by a number of issues. It can be caused by Doppler shift due to relative motion between the transmitter and the receiver. This is particularly severe when each OFDM frame has a large number of frequencies closely spaced next to each other.

In OFDM systems based standard, the Doppler effects are negligible when compared to the frequency spacing of more than 300 kHz. What is more important in this situation is the frequency error caused by imperfections in oscillators at the modulator and the demodulator. These frequency errors cause a frequency offset comparable to the frequency spacing, thus lowering the overall SNR. The main goals of this thesis is to understand the effects of frequency offset on OFDM systems and to present frequency offset estimation techniques so that we can correct for their effects. The performance of each technique is compared under various conditions.

Orthogonal frequency division multiplexing (OFDM) is a multicarrier modulation MCM) technique which seems to be an attractive candidate for fourth generation (4G) wireless communication systems. OFDM offer high spectral efficiency, immune to the multipath elay, low inter-symbol interference (ISI), immunity to frequency selective fading and high power efficiency. Due to these merits OFDM is chosen as high data rate communication systems such as Digital Video Broadcasting (DVB) and based mobile worldwide interoperability for microwave access (mobile Wi-MAX). However OFDM system suffers from serious problem of high PAPR. In OFDM system output is superposition of multiple sub-carriers. In this case some instantaneous power output might increase greatly and become far higher than the mean power of system. To transmit signals with such high PAPR, it requires power amplifiers with very high power scope. These kinds of amplifiers are very expensive and have low efficiency-cost. If the peak power is too high, it could be out of the scope of the linear power amplifier.

This gives rise to non-linear distortion which changes the superposition of the signal spectrum resulting in performance gradation. If no measure is taken to reduce the high PAPR, MIMO-OFDM system could face serious restriction for practical applications. PAPR can be described by its complementary cumulative distribution function (CCDF). In this probabilistic approach certain schemes have been proposed by researchers. These include clipping, coding and signal scrambling techniques. Under the heading of signal scrambling techniques there are two schemes included.

The OFDM has many advantages such as high bandwidth efficiency, robustness to the selective fading problem, use of small guard interval, and its ability to combat the ISI problem. So, simple channel equalization is needed instead of complex adaptive channel equalization. Apart from various advantages of OFDM, there are certain disadvantages also. The frequency offset of the subcarriers and the high PAPR are the major drawbacks of OFDM.

LITERATURE REVIEW

A number of CFO estimation algorithms have been presented in the literature. Some of them are quite simple, while some of them are more computationally demanding. In 1994 Moose proposed a frequency domain ML CFO estimator that uses two repeated, identical, symbols. This is in practice a form of training symbol and hence lowers the capacity of the communication scheme. Moose et al. analytically evaluated the effects of the carrier frequency offset and carrier phase noise on the SNR degradation for an AWGN channel. The results derived in these papers are used for many of the studies on frequency errors.

In 1997, Van de Beek et al. Proposed a blind maximum likelihood (ML) estimation algorithm that uses the redundancy introduced in the cyclic prefix to estimate the CFO. However, the algorithm is derived for an AWGN channel. In a multipath environment the cyclic prefix is more or less destroyed which reduces the performance of the algorithm. Still, it is one of the most widely used CFO estimation algorithms. In 2001 Chen and Wang also presented a blind CFO estimation algorithm based on two-fold oversampling.

In 2001 Choi et al. Proposed an ML estimation algorithm that assumed that the OFDM symbol is a Gaussian distributed signal, which is asymptotically true for circularly modulated OFDM symbols. However, it also assumes perfect second order knowledge of the channel statistics. In 1998 and 2000 Liu and Tureli presented algorithms that use virtual or non used subcarriers and techniques similar to the spectral analysis techniques used in algorithms such as MUSIC and ESPRIT. However, they require multiple OFDM symbols to achieve good performance and use singular value decomposition (SVD) which is computationally demanding.

Sutanu ghosh et.al provides a comparative analysis on the basis of this bit error rate. The author concluded the BER of different subcarriers of BPSK modulation. During this he will reach at lowest level of BER of BPSK modulation. There are 2048 number of subcaririers .

Dixit dutt bohra and Avinash bohra et.al concluded the Bit Error Rate (BER), for different modulation techniques such as Binary Shift Keying (BPSK) and Quadrature Phase Shift Keying (QPSK) .In this different modulation techniques compared on the basis of BER and best modulation technique determined, which can help to choose appropriate technique which suit the channel quality. Mr. Sivanagaraju and Dr. Siddaiah. et. al concluded that there is lot of stress in power limitation and quality of service provided by OFDM system in mobile networks. To improve OFDM system performance BER and SNR plays very vital role. for this different modulation techniques used.

Mr. Sumit Dalal and Mr Pulkit Berwal et.al concluded the BER performance over Rayleigh fading channel by using MMSE (minimum mean square error equalization) and MLSE (maximum- likelihood sequence estimation) equalization techniques with BPSK, QPSK, 4 and 16-QAM. BER for all modulations using CP (cyclic prefix) is calculated to reduce Inter symbol Interference (ISI), therefore to reduce the effect of ISI equalization is done at receiver, but it cannot be diminished completely in MMSE and MLSE equalizer and results are calculated with equalization and without equalization. Results obtained are average value of BER of around 0.4 in BPSK QPSK, 4-QAM, 16-QAM without and BER reduced by using MLSE equalization and become constant at value of 0.0015 in BPSK and 0.02 in QPSK, 0.12 in 16QAM, 0.0003 in 4QAM.

M. Divya et.al concluded the performance of BPSK with OFDM over AWGN and Rayleigh fading. The results show the improved results in BPSK over Rayleigh fading channel compared over AWGN channel. It is analyzed that the graphical results of simulated BER of BPSK is same as theoretical BER of BPSK and can further reduced by using channel estimation. The results are calculated over input parameters are number of subcarriers are 52 with sampling frequency of 20 MHz. The CP used is of 0.8us with symbol duration of 4us. FFT and IFFT window size is 64.

BASIC SYSTEM ANALYSIS

DESIGN OF OFDM SYSTEM

Occupied bandwidth is of course directly related to the data rate to transmit. However, the question is, what is the minimum bandwidth to take in order to obtain enough diversity and avoid the loss off all the signal in frequency selective fading environments. On the other hand much band width means also much transmitting power. There is a tradeoff between bandwidth and transmitted power. That optimal bandwidth is found by channel simulations and field test trials. In DAB, for example, a bandwidth of 1,5 Mhz is a good compromise for the type of propagation conditions that apply.

NUMBER OF CARRIERS

We have seen that the greater the number of carriers, the greater the symbol period on each carrier and soles equalization is needed and the greater the diversity offered by the system. However, with differential modulation, it is important that the channel not vary too much during one symbol period. This is not the case when the receiver is moving because of dopler effect and short term fading. Then a great number of carrier will limit the moving speed. This is another tradeoff of OFDM. Another problem is the complexity in the implementation increase when carrier number increases because large FFT are needed.

To continue with the DAB example, 1536 carriers has been found to be a good compromise. That lead to a carrier spacing of 1kHz and a symbol period of 1ms. Moving speed of mobiles shouldn't get over 160 km per hour.

GUARD INTERVAL

The tradeoff of guard interval is to set it large enough to avoid inter symbol interference depending on the memory of channel and transmitter position spacing in a single frequency network. On the other hand, we want it to be as small as possible as it carries no information and can be seen as a spoil of bandwidth.

In wireless systems, a guard interval of 25% of symbol period is often met and seems to be a good compromise. That is the value taken for DAB, it allows a maximum distance of about 80 kilometers between transmitters.

MODULATION

The modulation scheme used on each carrier depends on the BER needs. In DAB, QPSK is used but for higher order systems 16, 64 or 256 QAM is used.

CODING

Channel coding is very important in OFDM systems. When we speak of diversity, that is possible because information is redundant among the carriers.

Coding associated with frequency (among carriers) and time interleaving make the system very robust in frequency selective fading.

SYSTEM DESIGN

Multi-carrier modulation is an attractive alternative to single-carrier broadband modulation on channels with frequency-selective distortion. Research in the area of underwater acoustic communications over the past several years has resulted in demonstrating a different type of bandwidth-efficient modulation and detection method, which uses multiple carriers instead of a single carrier. In its basic form, this method is known as Orthogonal Frequency Division Multiplexing (OFDM). Rectangular pulse shaping combined with multi-carrier modulation and detection can be easily implemented using the Fast Fourier transform, which enables easy channel equalization in the frequency domain, thereby eliminating the need for potentially complex time-domain equalization of a single-carrier system. For this reason OFDM has found application in a number of systems, including the wire-line digital subscriber loops (DSL), wireless digital audio and video broadcast (DAB, DVB) systems, and wireless LAN. It is also considered for the fourth generation cellular systems and ultra-wideband (UWB) wireless communications in general.

Basic OFDM Principle

The primary motive of transmitting the data on multiple carriers is to reduce inter symbol interference and, thus, eliminate the performance degradation that occurs in single carrier modulation. Multicarrier modulation is an approach to design a bandwidth efficient digital communication system in the presence of channel distortion, by sub-dividing the available channel bandwidth into a number of sub-channels, such that each channel is nearly ideal. Dividing the available channel bandwidth into sub-bands of relatively narrow width would result in the channel transfer function being constant inside each sub-band, eliminating the need for complex time-domain channel equalization. OFDM is a frequency-division multiplexing scheme utilized as a digital multi-carrier modulation method. A large number of closely-spaced orthogonal subcarriers are used to carry data. The data is divided into several parallel data streams or channels, one for each subcarrier. Each subcarrier is modulated with a conventional modulation scheme (such as Quadrature Amplitude Modulation -QAM- or Phase Shift Keying -PSK-) at a low symbol rate, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth. Figure 1 shows the utilization of the available bandwidth for a 7 sub-carrier OFDM signal.

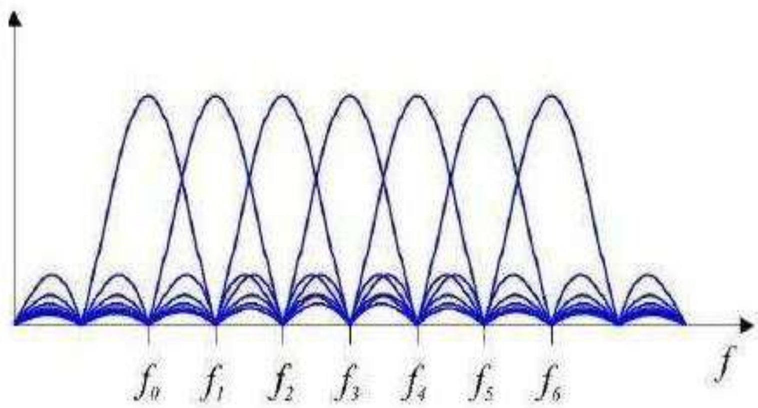

Figure 1: Bandwidth utilization of OFDM.

GUARD TIME

One key principle of OFDM is that since low symbol rate modulation schemes (i.e., where the symbols are relatively long compared to the channel time characteristics) suffer less from intersymbol interference caused by multipath propagation, it is advantageous to transmit a number of low-rate streams in parallel instead of a single high-rate stream. Since the duration of each symbol is long, it is feasible to insert a guard interval between the OFDM symbols, thus eliminating the intersymbol interference. The guard interval also eliminates the need for a pulse-shaping filter, and it reduces the sensitivity to time synchronization problems. In a cyclic prefix OFDM, the guard interval consists of the end of the OFDM symbol copied into the guard interval. The reason that the guard interval consists of a copy of the end of the OFDM symbol is because it allows the linear convolution of a frequency selective multipath channel to be modeled as a circular convolution which in turn may be transferred to the frequency domain using a discrete Fourier transform. Figure 2.

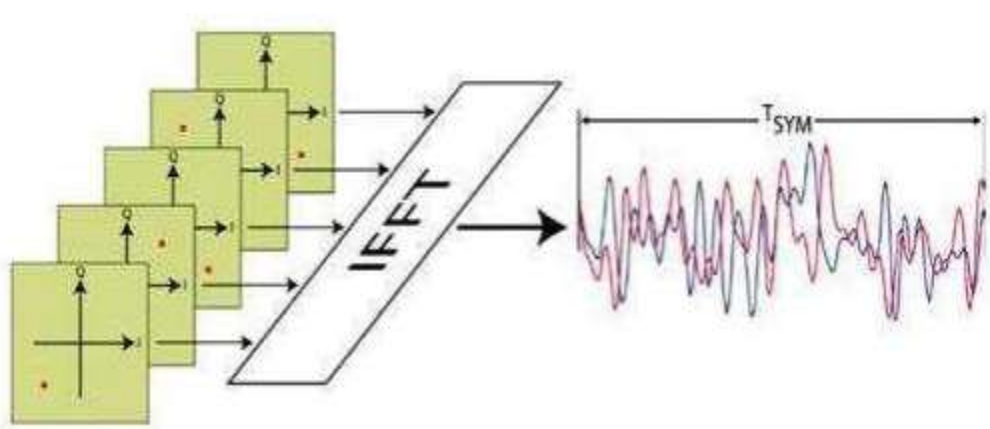

Figure 2: Transmitter implementation using IFFT

PROPOSED EXPERIMENTAL PROBLEM

In a wireless digital communication system, the channel effects can heavily degrade the system performance since the wireless link is time varying and may experience multipath fading and interference. Channel effects like deep fades might be hard to avoid, so channel estimation plays an important role when seeking to minimize the degradation due to channel effects, since many receiver methods for handling channel effects require knowledge of the channel.

NEED OF CHANNEL ESTIMATION

Space-time block codes and indeed many other space-time techniques including STTCs are designed for coherent detection where channel estimation is necessary. There is a substantial literature addressing the channel estimation issue for MIMO systems, ranging from standard training based techniques that rely on pilot symbols in the data stream to blind which does not require pilot sequences and semi-blind estimation where observations corresponding to data and pilot are used jointly. Other authors have considered non-coherent detection schemes based on differential encoding which do not require channel state information Although these methods avoid the need for channel estimation, they often suffer from problems such as error propagation.

CHANNEL ESTIMATION METHOD

There are three types of channel estimation are present. These are explained as:

Rained Channel Estimation

It is a type of coherent channel estimation in which CSI is present. In this a sequence of data known at both ends of the transmission link that is used to estimate the channel response at a specific time called training sequence. The transmission channel distorts the signal being transmitted, leading to Interference. The receiver needs to identify this channel distortion and equalize it, so transmission of a training sequence is necessary. Furthermore, trained channel estimation techniques are generally not well suited for fast fading channels since the coherence time might not be large enough to allow accurate channel estimation.

Blind Channel Estimation

It is a type of non coherent estimation and does not rely on the knowledge of any training sequence. Only the received signal is available for the estimation of the channel. In rapidly time-varying channels, training is not efficient. Training requires synchronization, which may not be feasible in multi-user scenarios. Severe multipath fading during the training period can lead to poor channel estimates. So Contrary to trained estimation, blind estimation techniques exploit the structure of the channel and the properties of the input signals in order to perform the estimation.

ERROR DETECTION SCHEMES

In general, any hash function may be used to compute the redundancy. However, some functions are of particularly widespread use, due to their simplicity, or their suitability of detecting certain kinds of errors, such as the cyclic redundancy check's performance in detecting burst errors.

Other mechanisms of adding redundancy are repetition schemes and error-correcting codes. Repetition schemes are rather inefficient but very simple to implement. Error correcting codes can provide strict guarantees on the number of errors that can be detected.

A) Repetition schemes

Variations on this scheme exist. Given a stream of data that is to be sent, the data is broken up into blocks of bits, and in sending, each block is sent some predetermined number of times. For example, if we want to send "1011", we may repeat this block three times each. Suppose we send "1011 1011 1011", and this is received as "1010 1011 1011".

As one group is not the same as the other two, we can determine that an error has occurred. This scheme is not very efficient, and can be susceptible to problems if the error occurs in exactly the same place for each group (e.g. "1010 1010 1010" in the example above will be detected as correct in this scheme).

The scheme however is extremely simple, and is in fact used in some transmissions of numbers stations.

B) Parity schemes

A simple parity bit is an error detection mechanism that can only detect an odd number of errors. The stream of data is broken up into blocks of bits, and the number of 1 bits is counted. Then, a "parity bit" is set (or cleared) if the number of one bits is odd (or even). (This scheme is called even parity; odd parity can also be used.)

If the tested blocks overlap, then the parity bits can be used to isolate the error, and even correct it if the error affects a single bit: this is the principle behind the Hamming code. There is a limitation to parity schemes. A parity bit is only guaranteed to detect an odd number of bit errors (one, three, five, and so on).

If an even number of bits (two, four, six and so on) are flipped, the parity bit appears to be correct, even though the data is corrupt. Extension and variations on the parity bit mechanism are horizontal redundancy checks, vertical redundancy checks and "double", "dual" or "diagonal" parity (used in RAIDDP).

C) Checksums

A checksum of a message is a modular arithmetic sum of message code words of a fixed word length (e.g., byte values). The sum is often negated by means of a one's complement prior to transmission as the redundancy information in order to detect errors resulting in all-zero messages. Checksum schemes include parity bits, check digits, and longitudinal redundancy check. Some checksum schemes, such as the Luhn algorithm and the Verhoeff algorithm, are specifically designed to detect errors commonly introduced by humans in writing down or remembering identification numbers.

D) Cyclic redundancy checks

The cyclic redundancy check (CRC) considers a block of data as the coefficients to a polynomial over a finite field, and then divides by a fixed, predetermined polynomial. The remainder of the division serves as the redundancy for the message. CRCs have favorable properties in that they are specifically suited for detecting burst errors. They are easily implemented in hardware, and are widely used in various protocols.

PROPOSED SOLUTION

Orthogonal frequency division multiplexing (OFDM) is a transmission method that can achieve high data rates by multicarrier modulation. The principles of orthogonal frequency division multiplexing modulation have been in existence for several decades. The techniques are employed in data delivery systems over the phone line, digital radio and television, and wireless networking systems. Furthermore, OFDM exhibits much better bandwidth efficiency than classical frequency division multiplexing (FDM) provided that the orthogonality of the carriers is preserved. A very important aspect in OFDM is time and frequency synchronization. In particular, frequency synchronization is the basis of the orthogonality between frequencies.

Frequency Errors

The orthogonality of the sub-carriers can be ensured only if the receiver and the transmitter have the same reference frequency. Any deviation from this reference frequency may cause ICI and loss of orthogonality. Another frequency error factor is phase noise, which is caused by random jitter of the phase of the steady sinusoidal waveform generated by the oscillators. Typically frequency errors are generated by the fact that the oscillators in the modulator and demodulator do not have exactly the same frequency. For single-carrier systems, the effect of phase noise and frequency offset appear only as degradation in the received SNR, rather than ISI or ICI. Nevertheless, many efficient techniques to minimize the effects of this drawback have been proposed in the literature. Other reasons for frequency errors include Doppler shift caused by the relative movement between the receiver and the transmitter, and phase noise introduced by nonlinear channels. Figure 3 shows the front end of an OFDM receiver where most of the frequency errors occur, i.e., the local oscillators and the sample clock at the analog to digital (A/D) converter. The A/D converter causes errors when the receiver does not have the same sample clock frequency as at the transmitter.

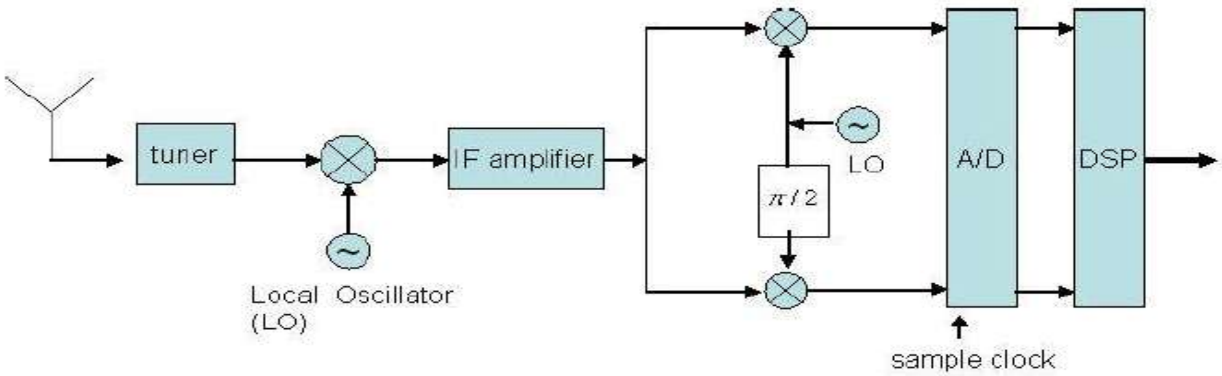

Figure 5.1 OFDM Receiver Front End

The frequency offset and the phase noise cause a phase rotation of the received symbols. Coherent OFDM systems need a phase tracking device to obtain the phase of the incoming symbols for correct demodulation. Typically, three types of algorithms are used to estimate the frequency offsets, i.e., to track the phase, in coherent OFDM systems.

CONCLUSION

This paper concludes the effects of frequency offset in OFDM demodulation and how we can estimate it so that we can compensate for its effects. The objective of this paper was to analyze the various error detection techniques over OFDM signals. CFO estimation can be performed either in the time or the frequency domain. For CFO estimation in the time domain, cyclic prefix (CP) or training symbol is used. For CFO estimation in the frequency domain, pilot tones are inserted in the frequency domain an transmitted in every OFDM symbol for CFO tracking. OFDM is seen as the future technology for communications in high data rate applications. The main disadvantages of OFDM are sensitivity to Intersymbol Interference (ISI) and Intercarrier Interference (ICI). One of the main reasons for ICI is loss of synchronization caused by frequency offset between oscillators at the transmitter and the receiver. This causes the carriers to lose orthogonality, so they cannot be completely separated at the receiver. As a consequence, ICI lowers the signal-to-noise ratio (SNR) and increases the error probability.

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