ADAPTIVE OFDM WIRELESS COMMUNICATION DEVELOPMENT FOR WIRELESS MEDICAL IMAGE TRANSMISSION IN DIFFERENT RESOLUTION

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ABSTRACT

Recently, a worldwide convergence has occurred for the use of Orthogonal Frequency Division Multiplexing (OFDM) as an emerging technology in high data rate communication. OFDM technology has a mean to increase dramatically in future wireless communications. Although OFDM researches have been gained considerable attention recently, but, still there is a need to analyze the full capacity of this communication technology especially for transmitting medical images. The main objective of this project is to explore the different capabilities OFDM system based on the effects on different modulation methods. Modulation scheme such as BPSK, QPSK, 16PSK and 256PSK has been simulated in MATLAB to evaluate the performance of OFDM system. The performance of the expected result was evaluated in the term of Bit Error Rate (BER) versus Signal-to-noise Ratio (SNR) which can be concluded that SNR is inversely proportional to BER. As observed, higher order of PSK, it requires larger value of SNR to minimize BER

ABSTRAK

Kebelakangan ini, dunia tertumpu kepada penggunaan *Orthogonal Frequency Division Multiplexing* (OFDM) sebagai satu teknologi baru di dalam komunikasi berkadar tinggi. Teknologi OFDM ini dikatakan akan meningkat secara mendadak di dalam komunikasi tanpa wayar. Walaupun kajian terhadap sistem OFDM telah mendapat banyak perhatian sejak kebelakangan ini, namun masih terdapat keperluan untuk menganalisis teknologi ini secara menyeluruh terutamanya untuk menghantar imej-imej perubatan. Objektif utama projek ini adalah untuk meneroka keupayaan sistem OFDM ini yang berbeza-beza berdasarkan kesan terhadap kaedah modulasi yang berbeza. Skim modulasi seperti BPSK, QPSK, 16-PSK dan 256-PSK telah disimulasikan menggunakan perisian MATLAB untuk menilai prestasi sistem OFDM ini. Hasil dapatan daripada simulasi tersebut dinilai dari segi *Bit Error Rate* (BER) melawan *Signal-To-Noise Ratio* (SNR), dimana dapat disimpulkan bahawa SNR adalah berkadar songsang dengan BER. Seperti yang dapat disimpulkan, semakin tinggi peringkat PSK yang digunakan, semakin tinggi nilai SNR yang diperlukan untuk mengurangkan kadar BER.

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LIST OF ABBREVIATIONS

OFDM	**-**	**ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING**
LTE	**-**	**LONG-TERM EVOLUTION**
DVB	**-**	**DIGITAL VIDEO BROADCASTING**
FFT	**-**	**FAST FOURIER TRANSFORM**
PSK	**-**	**PHASE-SHIFT KEYING**
IFFT	**-**	**INVERSE FAST FOURIER TRANSFORM**
FIR	**-**	**FINITE IMPULSE RESPONSE**
ADC	**-**	**ANALOG TO DIGITAL CONVERSION**
BER	**-**	**BIT ERROR RATE**
SNR	**-**	**SIGNAL-TO-NOISE RATIO**
CT	**-**	**COMPUTED TOMOGRAPHY**
QAM	**-**	**QUADRATURE AMPLITUDE MODULATION**
AWGN	**-**	**ADDICTIVE WHITE GAUSSIAN NOISE**
WIMAX	**-**	**WORLWIDE INTEROPERABILITY FOR MICROWAVE ACCESS**
WIFI	**-**	**WIRELESS FIDELITY**
UWB	**-**	**ULTRA-WIDEBAND**

QPSK	**-**	**QUADRATURE PHASE SHIFT KEYING**
BPSK	**-**	**BINARY PHASE SHIFT KEYING**
WMAN	**-**	**WIRELESS METROPOLITAN AREA NETWORK**
PRBS	**-**	**PSEUDO RANDOM BINARY SEQUENCE**
DAB	**-**	**DIGITAL AUDIO BROADCASTING**
DWT	**-**	**DISCRETE WAVELET TRANSFORM**
EZW	**-**	**EMBEDDED ZEROTREES OF WAVELET**
FYP	**-**	**FINAL YEAR PROJECT**

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CHAPTER I

INTRODUCTION

This chapter discussed about project background, objectives and scope of project, problem statement, system operation and organization of thesis.

1.1 Introduction to Adaptive Orthogonal Frequency Division Multiplexing

Recently, a worldwide convergence has occurred for the use of Orthogonal Frequency Division Multiplexing (OFDM) as an emerging technology in high data rate. Many wireless standards such as Wi-Max, LTE and DVB have adopted the OFDM technology as a mean to increase dramatically future wireless communications [11]. The OFDM is a particular form of multi-carrier transmission and is suited for frequency selective channels and high data rates. This technique transform a frequency-selective wide-band channel into a group of non-selective narrowband channels, which makes it robust against large delay spreads by preserving orthogonality in the frequency domain [19]. Moreover, the ingenious introduction of cyclic redundancy at the transmitter reduces the complexity to only FFT processing and one tap scalar equalization at the receiver.

Orthogonal frequency division multiplexing (OFDM) is a method of encoding digital data on a multiple carrier frequencies. It is a scheme used as a digital multi-carrier modulation method [18]. OFDM takes several low data rate frequency channels and then combined them into one high data rate frequency channel. This multiplexing system is developed into wideband digital communication used for both wireless and copper wires communication. The data from the OFDM are modulated into time signal. The system can be generated using Q-PSK, 16-PSK, 256-PSK, B-PSK etc. The symbols are divided into frames to modulate the data frame by frame during the OFDM data modulation [18].

A large number of closely space orthogonal sub-carrier signals are used to carry data on several parallel data streams or channels [12]. Each sub-carrier is modulated with a conventional modulation scheme at a low symbol rate, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth [19]. Orthogonality is mean having a sum of products of an integral that is zero or sometimes are under specified conditions are said to be orthogonality to each other. Multiple of two sinusoids signal with some frequencies can fulfil this condition [19].

$$\int_0^T \cos(2\pi nft)\cos(2\pi mft)\,dt = 0(n \neq m)$$

Where n and m are two unequal integers, f is fundamental frequency and t is the time period.

OFDM can easily adapt to severe channel conditions without complex time-domain equalization [20]. It also robust against narrow-band co-channel interference. OFDM also have low sensitivity to time synchronization errors and have a high spectral efficiency as compared to other double sideband modulation schemes, spread spectrum, etc [20].

The history of multi-carrier modulation began more than 30 years ago. In the beginning, only analog design based on the use of orthogonal waveforms was proposed [18]. Only recently has it been finding its way into commercial use, as the recent developments in technology have lowered the cost of the signal processing that is needed to implement OFDM system. In the frequency selective channels, we have the low-pass received signal as:

$$r(t) = \int_{-\infty}^{\infty} c(\tau)x(t-\tau)d\tau + n(t).$$

Frequency selectivity occurs whenever the transmitted signal $x(t)$ occupies an interval bandwidth$[-\frac{W}{2}, \frac{W}{2}]$ greater than the coherence bandwidth B_{coh} of the channel $c(t)$ defined as the inverse of the delay T_d. In this case, frequency components of $x(t)$ with frequency separation exceeding B_{coh} are subject to different gains. One of the main concerns in transmission schemes is to retrieve $x(t)$ from the equation. This operation is called equalization and the difficulty of extracting $x(t)$ is mostly due to the frequency selectivity behaviour of the channel. The main idea of OFDM transmission is to turn the channel convolutional effect of the equation into a multiplicative one in order to simplify the equalization task [19]. To this end, OFDM schemes add redundancy known as cyclic prefix in a clever manner in order to circularize the channel effect. Based on the fact that circular convolution can be diagonalized in an FFT basis, the multipath time domain channel is transformed into a set of parallel frequency flat fading channels. Moreover, OFDM system take benefit from the low cost implementation structure of digital FFT modulators [25].

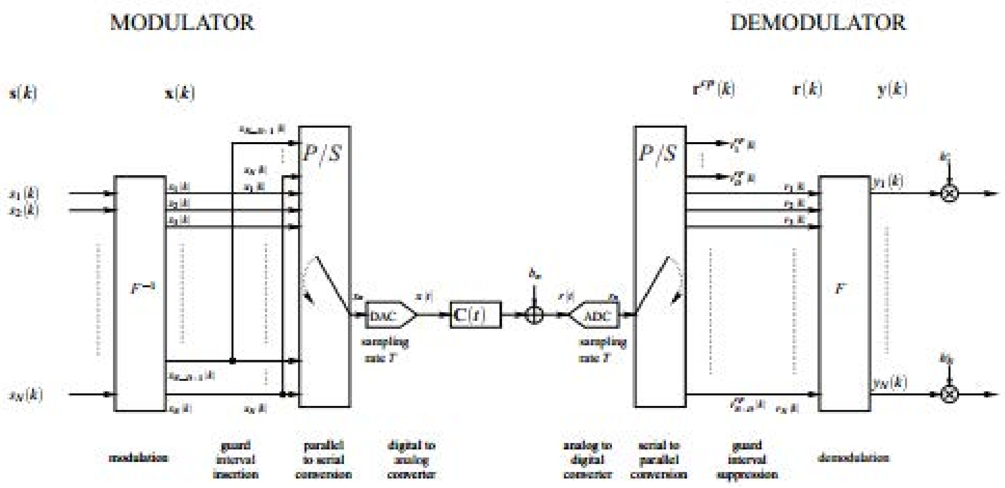


Figure 1.1.1: OFDM model

From figure 1.1.1, at the starting point, it considers the noiseless transmission case. The incoming high data rates information is split into N rate sub-carriers. The data is therefore transmitted by blocks of size N; s(k) = [s_1(k),…s_2(k),….$s_N(k)$] where the index k is the block OFDM symbol number and the subscript i is for the carrier index. The block OFDM symbol is precoded by an inverse FFT matrix $F_N^H = F_N^{-1}$ to yield the so called time domain block vector x(k) = $[x_1(k), \ldots x_i(k), \ldots . x_N(k)]$. At the output of the IFFT, a guard interval of D samples is inserted at the beginning of each block $[x_{N-D+1}(k), \ldots . x_N(k), x_1(k), \ldots x_i(k), \ldots x_N(k)]$. It consists of a cyclic extension of the time domain OFDM symbol of size larger than the channel impulse response

(D>L-1). The cyclic prefix is appended between each block in order to transform the multipath linear convolution into a circular one [18]. After Parallel to Serial and Digital to Analog Conversion, the signal is sent through a frequency-selective channel.

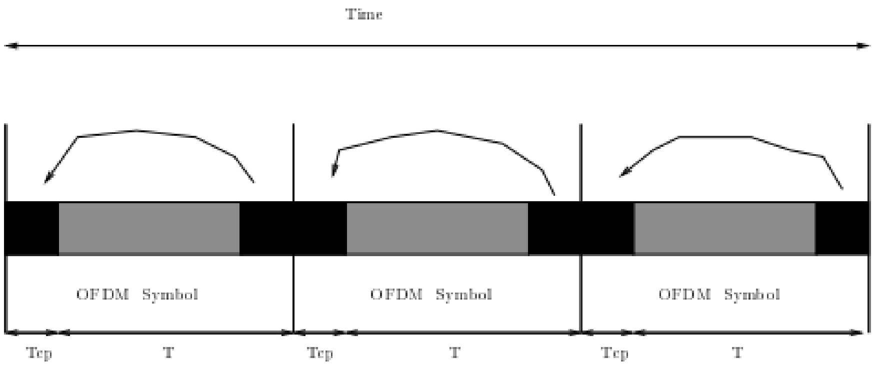


Figure 1.1.2: time representation of OFDM

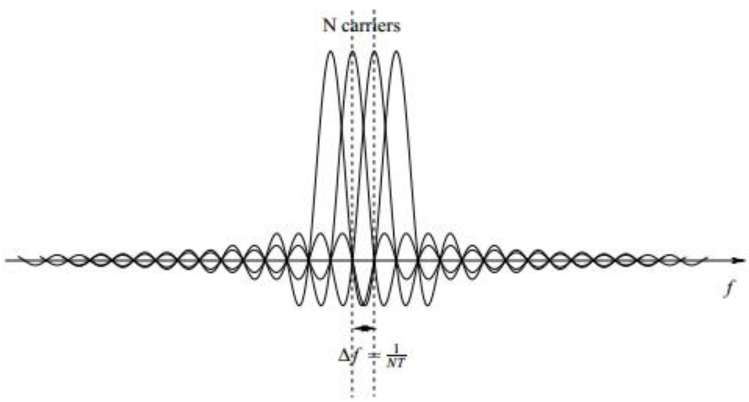


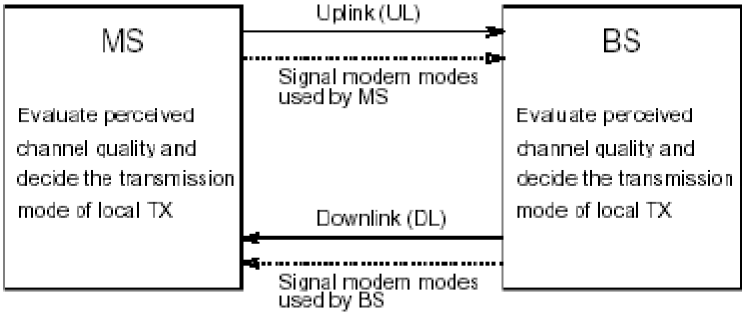
Figure 1.1.3: frequency representation of OFDM

The channel can be represented by an equivalent discrete time model and its effects can be modelled by linear FIR filtering with Channel Impulse Response $C_N = [C_1, \ldots C_{L-1}, 0, \ldots .0]$. Usually, the system is designed so that D is smaller than $N(D = \frac{N}{4})$ and greater than (L – 1). One can notice that the redundancy factor is equal to $\frac{N}{N+D}$. On the one hand, in order to avoid spectrally inefficient transmissions, N has to be chosen far greater than D. On the other hand, the FFT complexity per carrier grows with the size of N [12]. Moreover, the channel should not change inside one OFDM symbol to be able to circularize the convolution. Finally, the carrier spacing is related to the factor $\frac{1}{NT}$ and reduces as N increases: there is no gain in terms of diversity for a fixed channel by increasing N. The choice of N depends therefore on the type of channel (slow0-5 varying, fast fading, high diversity channel, impulse response length...) and the complexity cost one is able to accept. At the receiver, symmetrical operations are performed: down conversion, Analog to Digital Conversion (ADC).

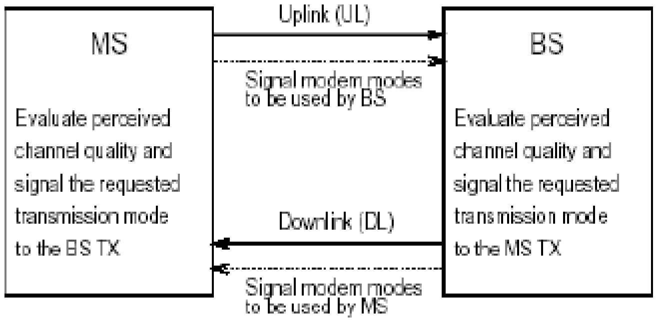
In adaptive OFDM, the bit error probability of OFDM subcarriers are transmitted in time dispersive channels depends on the frequency domain channel transfer function. If the subcarriers that will exhibit high bit error probabilities in the OFDM symbol to be transmitted can be identified and excluded from data transmission, the overall BER can be improved in exchange for a slight loss of system throughput [21]. As the frequency domain fading deteriorates the signal-to-noise ratio of certain subcarriers, but improves other subcarriers above the average SNR value, the potential loss of throughput due to the exclusion of faded subcarriers can be mitigated by employing higher order modulation modes on the subcarriers exhibiting high SNR values. In addition to excluding sets of faded subcarriers and varying the modulation modes employed, other parameters such as the coding rate of error correction coding schemes can be adapted at the transmitter according to the perceived channel transfer function. Adaptation of the transmission parameters is based on the transmitter‟s perception of the channel conditions in the forthcoming timeslot. This estimation of future channel parameters can only be obtained by extrapolation of previous channel estimations, which are acquired upon detecting each received OFDM symbol. The channel characteristics therefore have to be varying sufficiently slowly compared to the estimation interval.

Adapting the transmission technique to the channel conditions on a timeslot-by-timeslot basis for serial modems in narrowband fading channels has been shown to considerably improve the BER performance. The Doppler fading rate of the narrow-band channel has a strong effect on the achievable system performance, if the fading is rapid, then the prediction of the channel conditions for the next transmit timeslot is inaccurate, and therefore the wrong set of transmission parameters may be chosen.

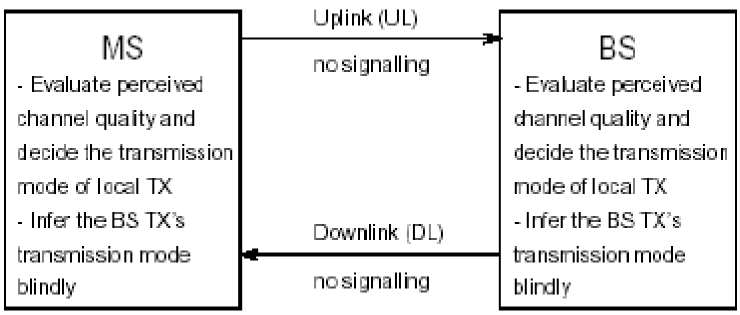
Adaptive modulation is only suitable for duplex communication between two stations, since the transmission parameters have to be adapted using some form of two-way transmission in order to allow channel measurements and signalling to take place. Transmission parameter adaptation is a response of the transmitter to time-varying channels condition. In order to efficiently react to the changes in channel quality, there are steps to be taken which are channel quality estimation, parameter adaptation and signalling the parameter.



(a) Reciprocal channel, open loop control



(b) Non-reciprocal, closed loop signalling



(c) Reciprocal channel, blind modem mode detection

Figure 1.1.4: signalling scenarios in adaptive modems

1.2 Problem Statement

Nowadays, in worldwide convergence has occurred for the use of the orthogonal frequency division multiplexing (OFDM) as an emerging technology for