A LOW COMPLEXITY OFDM MODULATOR AND DEMODULATOR BASED ON DISCRETE HARTLEY TRANSFORM

by

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LIST OF ABBREVIATIONS

ADC	Analog-to-Digital Converter
AWGN	Additive White Gaussian Noise
BER	Bit Error Rate
Bps	bits per second
BPSK	Binary Phase Shift Keying
BW	Bandwidth
CM	Coefficient Memory
CP	Cyclic Prefix
dB	decibel
DC	Direct Current
DAC	Digital to Analog Converter
DFT	Discrete Fourier Transform
DHT	Discrete Hartley Transform
DIF	Decimation In Frequency
DIT	Decimation In Time
DSL	Digital Subscriber Line
DSP	Digital Signal Processing
DVB-T	Digital Video Broadcasting-Terrestrial
FDM	Frequency Division Multiplexing
FFT	Fast Fourier Transform
FHT	Fast Hartley Transform
FIR	Finite Impulse Filter
IDFT	Inverse Discrete Fourier Transform
IDHT	Inverse Discrete Hartley Transform
IEEE	Institute of Electrical and Electronic Engineers

ICI	Intercarrier Interference
IFFT	Inverse Fast Fourier Transform
IFHT	Inverse Fast Hartley Transform
ISI	Intersymbol Interference
I/Q	In-phase/Quadrature
LAN	Local Area Network
LS	Least Square
LSB	Least Significant Bit
MCM	Multicarrier Modulation
MSB	Most Significant Bit
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiplexing Access
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
SNR	Signal to Noise Ratio
WLAN	Wireless LAN
WiMAX	Worldwide Interoperability for Multiple Accesses

SUATU SYSTEM MODULATOR DAN DEMODULATOR DENGAN KERUMITAN RENDAH BERBASIS DISCRETE HARTLEY TRANSFORM

ABSTRAK

Penyelidikan atas diskret Hartley (DHT) untuk menggantikan konvensional kompleks bernilai dan matang jelmaan Fourier diskret (DFT) sebagai modulator dan demodulator OFDM telah dijalankan dalam penyelidikan ini. Projek keseluruhan dibahagikan kepada dua bahagian seperti berikut: pertama, sistem yang dicadangkan adalah simulasi di bawah pelbagai parameter seperti BER berbanding SNR dan kualiti imej berbanding dengan nilai berkuat pasti SNR. Kedua, model simulasi telah dibangunkan menggunakan perisian yang sangat baik untuk simulasi, MATLAB. Analisis statistik telah disiasat untuk mengukur ketepatan prestasi sistem dan juga tingkat kerumitan sistem. Hasil daripada simulasi menunjukkan bahawa kerumitan sistem dikurangkan dalam hal jumlah proses darab dan prose penjumlahan. Untuk jumlah bilangan subcarriers, N = 64, 52% daripada pendaraban dan 28% daripada nombor penjumlahan telahpun dapat dikurangkan. Prestasi sistem diukur dari segi graf yang diplot daripada BER berbanding SNR dan kualiti imej yang diterima berbanding SNR, di mana nilai BER adalah 10^{-3} dan kualiti imej adalah sama dengan imej asal apabila nilai tertentu SNR dalam kisaran = 30 dB.

A LOW COMPLEXITY
OFDM MODULATOR AND DEMODULATOR
BASED ON DISCRETE HARTLEY TRANSFORM

ABSTRACT

The investigation upon to discrete Hartley transform (DHT) to replace the conventional complex-valued and mature discrete Fourier transform (DFT) as the OFDM modulator and demodulator was carried out in this research. The overall project is divided into two parts as follows: firstly, the proposed system is simulated under various parameters such as BER versus SNR and the quality of image versus given value of SNR. Secondly, the simulation model has been developed using excellent software for simulation, MATLAB. Statistically analysis has been investigated to measure the accuracy of the system performance and also the complexity of the system. Simulation results show that the system complexity is reduced in term of multiplication and addition number. For number of subcarriers, N = 64, 52 % of multiplication and 28 % of addition numbers are reduced. The system performance is measured in term of plotted graph of BER versus SNR and quality of received image versus SNR, where the BER value is 10^{-3} and quality of image is similar with the original image when the given value of SNR = 30 dB.

CHAPTER ONE

INTRODUCTION

1.1 Research Background

The rapid growth of Internet traffic has been placed the tremendous strain of conventional communication networks. This gains up is resulted by some new emerging applications, such as Internet video to TV and video communications. As the effect, the need of bandwidth becomes further increase up to triple the bandwidth demand by 2011. It does not appear that the growth of Internet traffic will slow in the foreseeable future as depicted by (Shieh & Djordjevic, 2010) in Figure 1.1. This phenomenal rise brings the changes of information infrastructure at every level, from core to metro and access networks. Therefore, the much more robustness broadband communication systems for supporting high data rate transmission are needed. Several technologies are proposed to cope with these challenges. One of the most promising technologies is orthogonal frequency division multiplexing (OFDM).

OFDM has emerged as the leading modulation/demodulation technique in the wired and wireless communication systems, because it can overcome the multipath fading effect and scale well even when the increase of data results in more severe intersymbol interference (ISI) (Tianhua Chen, 2010). As the special case of multicarrier modulation (MCM), OFDM is dedicated for supporting high speed data transmission.

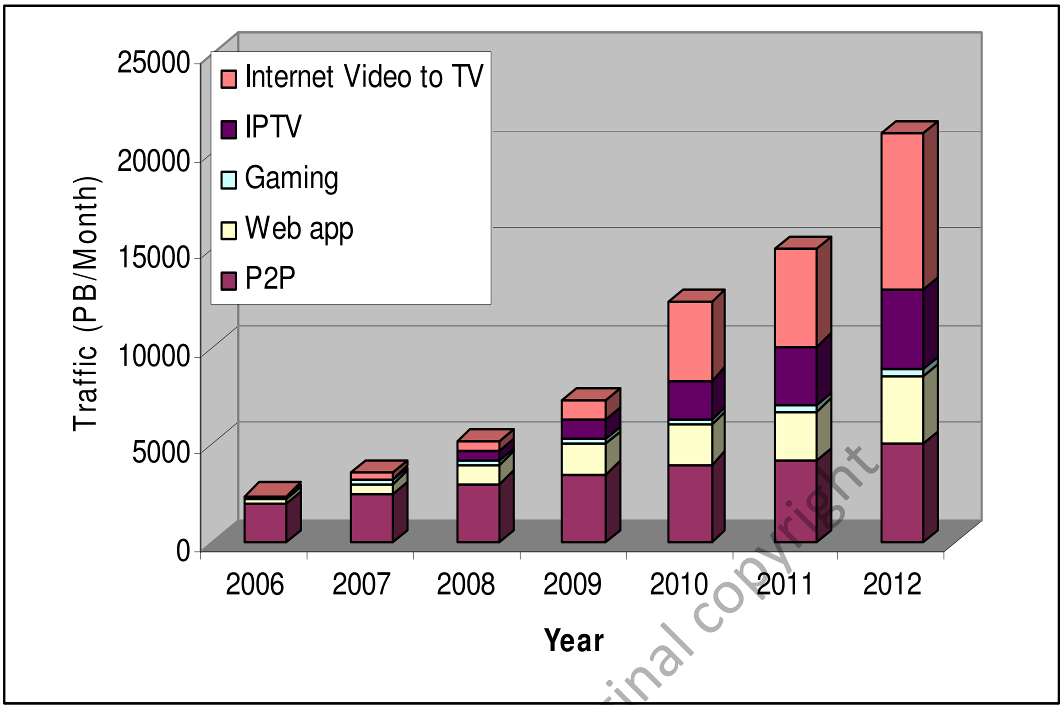

Figure 1.1: Internet traffic growth projected to 2011. (Modified from Cisco, Inc).

Moreover, this system is still capable to handle more services. This high capability is resulted from the allocating subcarriers overlapped one to another but there is no interference among them due to its orthogonality one to another. These features are then distinguished OFDM from the conventional frequency division multiplexing (FDM).

Most of OFDM transceiver employs inverse DFT (IDFT) and DFT to perform modulation and demodulation in transmitter and receiver, respectively. The system is then denoted as DFT-OFDM system. To improve the system performances, even further a fast computation algorithm, IFFT/FFT can be used. However, IFFT/FFT requires arithmetic complex-valued computations and complex multiplier in FFT core needs long-time and high complexity hardware design operational to enable high performance with stringent cost and power budget (Xilinx, 2010).

For the current DFT-based OFDM transceivers, the modulator needs to compute a long-length inverse discrete Fourier transform (IDFT), and the demodulator needs to compute a long-length DFT, where the transform length is up to 512 or more. For such long-length IDFT/DFT computations, a huge numbers of complex multiplications are required and each of them basically involves four real multiplications and two real additions. Technically and economically, the larger number of arithmetic calculations, the higher cost, time and power consuming in it.

The complexity of a DFT-based OFDM transceiver will be reduced if corresponding modulator/demodulator is implemented using purely real-valued transformation. Therefore in this research, the design of OFDM modulator and demodulator are carried out to achieve the new system which has a lower complexity both in arithmetic calculation and hardware implementation. Moreover, with using real-valued signal, not only the number of arithmetic calculation can be reduced but also the applications of this new system is expected would be extended. One of the very suitable supporting applications is optical communication system as explained by (Armstrong, 2009) and (Shieh & Djordjevic, 2010).

1.2 Problem Statement

The focus of future fourth-generation (4G) mobile systems is to support high data rate services and to ensure seamless provisioning of services across a multitude of wireless systems and networks, from indoor to outdoor, from one air interface to another, and from private to public network infrastructure (Hara & Prasad, 2003). Moreover, OFDM hasbeen proposed to combine with optical communication system for supporting the high speed data communication system (Armstrong, 2009), (Shieh & Djordjevic, 2010).