T-DMB 시스템에서 WOFDM과 COFDM의 성능비교에 관한 연구

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A Study on the Performance Comparison of WOFDM and COFDM in T-DMB System

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Abstract

As the demand of the high-speed transmission between fast moving mobile objects is increasing, more ideas are coming out to improve the channel distortion for such cases. WOFDM (Wavelet-based Orthogonal Frequency Division Multiplexing) is the most brilliant one among them, which combines the advantages of wavelet transform technique and OFDM technique, and it has been implemented into the PLC (Power Line communication) system. In this paper, we are trying to describe a comparative study on COFDM (Fourier-base OFDM) and WOFDM in the conventional T-DMB system. From the simulation results, we can see that the performances of COFDM and WOFDM are nearly same under the AWGN channel. However, WOFDM outperforms COFDM under the time-invariant Rayleigh fading channel.

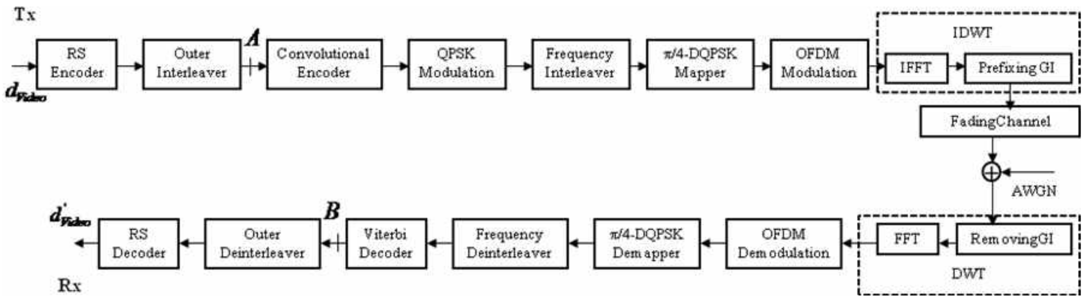
I. INTRODUCTION

As well know that, OFDM system is the typical one of multi-carrier system, where signals are allowed to be transmitted simultaneously in parallel at different frequencies called subcarriers, and each subcarrier is orthogonal to any other subcarrier over one OFDM symbol bandwidth. In T-DMB system [1], the Fourier-based OFDM has been adopted, and all solid-line blocks, in figure 1, form the T-DMB system. In this figure, OFDM modulation/demodulation, IFFT/FFT, prefixing GI (Guard Interval)/removing GI form the COFDM system, in which GI is used to improve the ISI (Inter-Symbol Interference) by consuming a certain bandwidth [2]. Up to now, lots of researches have been done, where they replaced COFDM with WOFDM. In our paper, we implemented the WOFDM instead of COFDM in T-DMB system, which means the blocks in two dashed-line blocks would be replaced with IDWT/DWT, respectively, and compared the simulation results of them under AWGN channel and time-invariant Rayleigh channel.

This paragraph is the organization of our paper. In section 2, there is an overview of T-DMB system. In section 3, we will introduce the WOFDM model briefly. And we'll mention some necessary parameters of our simulation in section 4. Section 5 depicts the simulation results. The last section is the conclusion.

II. Overview of T-DMB System

T-DMB (Terrestrial Digital Multimedia Broadcasting) system is derived from DAB (Digital Audio Broadcasting) system [6], which was developed as a research project for the European Union, and it works at the transmission mode 1 of [6] with the sampling time 1/2048000 seconds. By the end of 2006, South Korea started to deploy it as a digital radio transmission



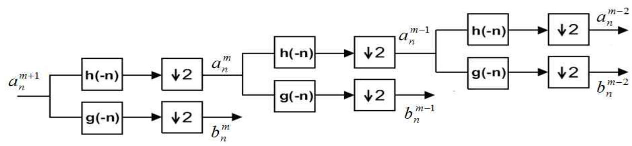
[Fig. 1] OFDM Transceiver in T-DMB System

technology. The standards [1] and [6] show that, on the physical layer of the OSI model, T-DMB system could be composed of Fourier Transform technique, OFDM technique, DQSK Modulation technique, Convolutional Codec technique, Interleaving technique, and RS (Reed Solomon) Codec technique, all of which are shown in figure 1. When we look at the frame structure of T-DMB, it could be split into 3 segments: SC (Synchronization Channel), FIC (Fast Information Channel), and MSC (Main Service Channel) which includes the multimedia data. And in this paper, transmission performance of video data has been considered.

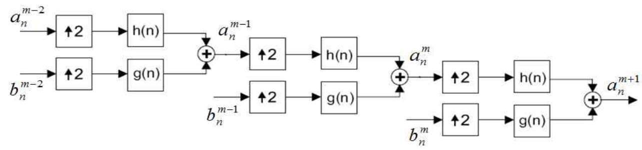
III. Brief Description of WOFDM Model

Since Fourier-based OFDM has already been implemented in T-DMB [1], we are going to explain WOFDM only in this section.

According to wavelet theory [3], in the WOFDM system, wavelet function is used to carry data at each subcarrier instead of sinusoidal function which is used in COFDM system. Because wavelet function has a property that it is orthogonal to its translation and its dilation [4], it is easy to be combined with OFDM technique. Also, because the wavelet waveform in time-domain has a good overlapping nature, WOFDM does not need GI, which promotes the bandwidth efficiency. Based on the former, to implement the WOFDM into T-DMB system, we only need to replace the IFFT and FFT with IDWT and DWT at the transmitter and receiver, respectively and eliminate the GI blocks in fig 1.



[Fig. 2-1] Filter Bank Structure of DWT



[Fig. 2-2] Filter Bank Structure of IDWT

From [5], we can consider DWT as a signal decomposition, and IDWT as a signal reconstruction. Figure 2 explains the DWT and the IDWT directly. Equ1 and Equ2 represent the DWT and the IDWT respectively,

$$a_n^m = \sum_p h(p-2n) a_n^{m+1} \qquad (Equ1-1)$$

$$b_n^m = \sum_p g(p-2n) a_n^{m+1} \qquad (Equ1-2)$$

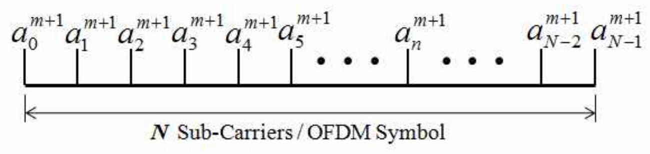
$$a_n^{m+1} = \sum_p h(2p-n) a_n^m + \sum_p g(2p-n) b_n^m \qquad (Equ2)$$

where *h(n)* and *g(n)* are QMF (Quadrature Mirror Filterpair) express low-pass filters and high-pass filters. And their characteristicsstick to the following two equations:

$$\sum_n h(n) h(n-2k) = \delta(k) \qquad (Equ3)$$

$$g(n) = (-1)^n h(N-n) \qquad (Equ4)$$

At the output of IDWT, the subcarrier allocation of OFDM symbol should comply with the one shown in figure 3.



[Fig. 3] Subcarrier Allocation of WOFDM Symbol

IV. Simulation Parameters

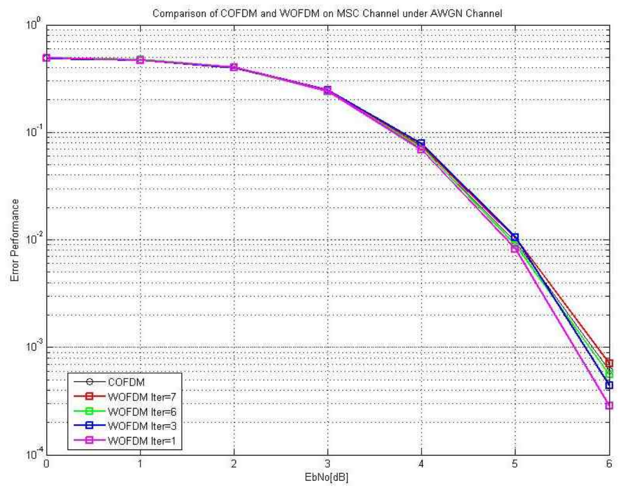
Our simulation exactly follows the blocks shown in figure1, and we only study the transmission capacity of video data in MSC channel. There is one more thing should be mentioned that RS codec is not implemented in our simulation, which means that, in this paper, we would discuss the performance between point A and point B in figure 1. Parameters of COFDM-based T-DMB system are from [1], however, parameters of WOFDM-based T-DMB system are shown in table 1. And table 2 on the last page of this paper shows PDP (Power Delay Profile) of COST207 BU (Bad Urban) fading channel, which has been used to simulate the time-invariant Rayleigh channel.

[Table 1] Parameters for WOFDM-based T-DMB

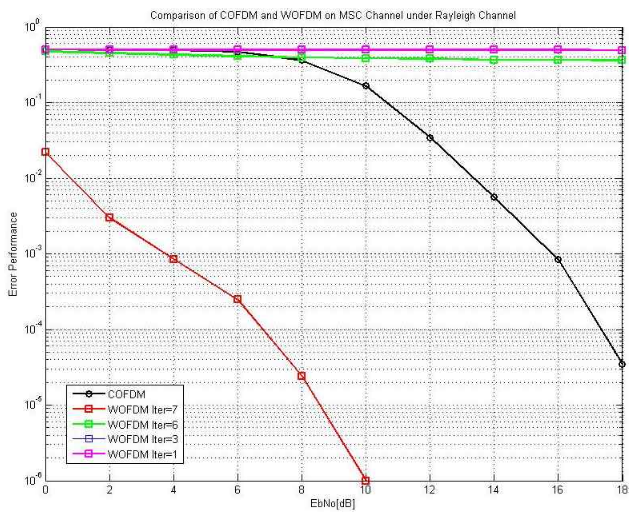
Parameters	Value
No. of Subcarriers per OFDM Symbol	2048
No. of GI Samples	0
Wavelet Types	Daubechies-2
Wavelet Transform Iteration	1, 3, 6, 7
h(0), h(1)	0.707, 0.707
g(0), g(1)	0.707, -0.707

V. Simulation Results

Performance results of COFDM and WOFDM in T-DMB system under AWGN channel are shown in figure 4, where we can see that the performances are almost same, even when the iteration of wavelet transform is different, which means the COFDM system and the WOFDM system have the same transmission capacity under AWGN channel. Figure 5 displays that, under time-invariant Rayleigh fading channel, the performances of WOFDM-based T-DMB system are varying, as the iteration level changing. Furthermore, from figure 5, we can get that, WOFDM-based T-DMB system could obtain nearly 12dB code gain more than COFDM-based T-DMB system, at BER = 10^{-3}, when the iteration is 7. In other words, the WOFDM system has a remarkable ability in overcoming the fading distortion, at a certain high iterationlevel.



[Fig. 4] Performance of COFDM and WOFDM in T-DMB System under AWGN Channel



[Fig. 5] Performance of COFDM and WOFDM in T-DMB System under Time-invariant Rayleigh Channel

[Table 2] PDP of Cost207 BU Model

No. of Taps	Relative Delay[us]	Average Power
0	0.0	0.0
1	0.488281	0.177224
2	0.976562	0.108759
3	1.464844	0.066743
4	1.953125	0.040959
5	2.441406	0.025136
6	2.929688	0.015425
7	3.417969	0.009466
8	3.906250	0.005809
9	4.394531	0.003565
10	4.882813	0.002188
11	5.371094	0.099629
12	5.859375	0.061140
13	6.347656	0.037521
14	6.835938	0.023026
15	7.324282	0.014130
16	7.812500	0.008672
17	8.300781	0.005322
18	8.789063	0.003266
19	9.277344	0.002004
20	9.765625	0.001230

VI. Conclusions

According to the simulations and simulation results, we can find that: firstly, WOFDM can save a certain bandwidth, and remain the performance under AWGN channel in no differences with COFDM. Secondly, when we vary the iteration level of WOFDM under a fading channel, the performances are different. The higher the iteration level is implemented, the better the performance result turns out. Thirdly, as we select a certain high iteration level, the performance of WOFDM under the fading channel is prominently outperform COFDM under the same channel.

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