OFDM Modulation for 4G LTE Mobile

EEEE3087 Mobile technologies—Coursework1

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March 25, 2023

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Abstract

My abstract

Part I
Introduction and Background Research

1 Introduction

Orthogonal Frequency Division Multiplexing (OFDM) is one of the most powerful modulation technique. It is designed for high-data-rate transmission. In general, it will convert a high-rate data stream into several low-rate data streams which can be transmitted in parallel [1]. These streams or sub-carriers are orthogonal to each other, which means they don't interfere with each other, allowing multiple sub-carriers to be transmitted simultaneously over the same channel without causing interference.

2 A Brief Implementation of OFDM

At the transmitter, it is required to apply a series-parallel (SP) conversion, i.e., from a single point to N points. Then use *Inverse Fast Fourier Transform* (IFFT) to create the time-domain OFDM signal from the modulated signal. In the end, add a *digital-to-analogue converter* (DAC) to from the signal which can be transmitted in the channel.

At the receiver, the OFDM signal is first demodulated to recover the sub-carriers. Then, each sub-carrier is processed individually to recover the raw data. A parallel-serial converter is then used to convert the low-speed data stream to a high-speed data stream for use by the terminal.

Overall, the principle of OFDM allows for high-speed data transmission over limited bandwidth channels, with robustness against interference and distortion caused by multi-path propagation.

3 Role in Mobile Networks

OFDM plays an important role in both 4G and 5G LTE (Long-term Evolution) mobile networks.

- Strong anti-interference capability:When the signal is transmitted in the air, it is very likely to be interfered and distorted by multi-path propagation which is shown in Figure 1. Hence, people are considering to transmit multiple non-interference sub-carriers which can be recovered easily by their orthogonality.

- High data rates: As OFDM owns several channels to transmit data, it can gain a higher rates. That is, it can be considered as a MIMO system.

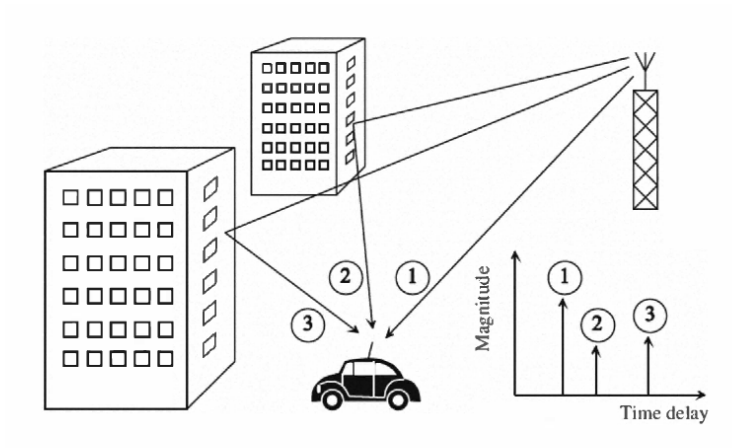

Figure 1: The multi-path propagation

- High spectrum utilization: OFDM can be used to transmit multiple sub-carriers simultaneously over the same channel, which can be used to increase the spectral efficiency of the system.

OFDM is used in many different communication systems, including digital television, Wi-Fi, 4G and 5G LTE mobile networks, and *Digital Subscriber Line* (DSL) modems over copper-based telephone access lines. Due to its excellent performance, OFDM has been standardized by IEEE into standards such as 802.11g and 802.11a. The *asynchronous digital subscriber line* (ADSL) and *high-bit-rate digital subscriber line* (HDSL) technologies use OFDM for fixed-wire applications. [1, 2].

4 Implementations of OFDM Based on QAM

In order to make there sub-carriers orthogonal to each other or not overlap each other in the frequency domain, the inner product of any two sub-carriers is zero. That is, in the time domain, the cross-correlation of any two sub-carriers is zero. As shown in the following Equation 1,

$$(f \star g) \triangleq \int_{-\infty}^{\infty} sub - carrier_1(t) \cdot sub - carrier_2(t) dt = 0 \tag{1}$$

Before mapping each low-rate date to sub-carriers, we first need to use a serial to parallel converter. The IFFT can be performed only after the series-parallel (SP) conversion, i.e., from a single point to N points. At the same time, this operation corresponds to an N-fold increase in the duration of each symbol, increasing the system's immunity to interference.

Secondly, it's common to use the *Inverse Discrete Fourier Transform* (IDFT) technique to map to sub-carriers. We usually us the *Inverse Fast Fourier trans-*

form (IFFT) technique to complete that as it will perform a more efficient way to compute. The process of generating an OFDM signal using IFFT involves taking the data to be transmitted and mapping it onto the sub-carriers. The sub-carrier signals are then modulated using the appropriate phase and amplitude information, and then combined using the IFFT to create the time-domain OFDM signal.

At the receiver, the process is reversed. When the signal passes through the channel, it is first sampled. Then, a PS converter is used to feed the FFT with sub-carriers. After that, write a block of N symbols into a vector which is SP converter

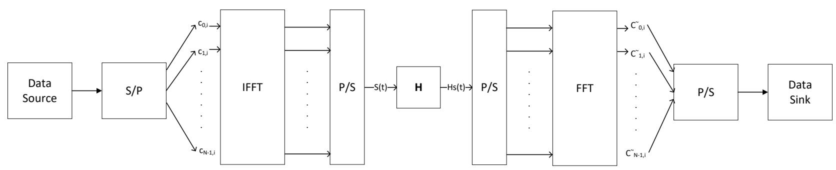

Figure 2: Transceiver structure of OFDM

Part II
BER Analysis

Part III
Conclusion

Conclusion

Part IV
[Appendices]

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References

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[2] L. Hanzo, "Ofdm and mc-cdma a primer / l. hanzo, t. keller," 2015, (Thomas) Includes bibliographical references (p. [363]-394) and indexes.