[1-3]

Robust Synchronization to Frequency Selective Fading Channel in OFDM Systems

Jin-Woo Lee and Yong-Hwan Lee
School of Electrical Engineering and INMC, Seoul National University
jinu@trans.snu.ac.kr ylee@snu.ac.kr

주파수 선택적 페이딩 채널에서 강인한 OFDM 동기 기법

이진우, 이용환
서울대학교 전기컴퓨터공학부 뉴미디어 연구소

Abstract

The synchronization is one of the most important issues in the OFDM systems. Although the cyclic prefix has widely been used for symbol synchronization, it may not provide performance robust to the multi-cell environment. Therefore, the training symbol method is usually employed in multi-cell environment. Although the use of matched filter can provide best performance, it may have a problem of a large amount of computational complexity. To reduce the complexity, Cox introduced a method that utilizes a training symbol that has two repetitive patterns. However, it may not properly work in frequency selective fading channel due to the delay spread. In this paper, we propose three-step synchronization scheme robust to frequency selective fading channel. Firstly, the receiver obtains frame timing and then the symbol timing in the next step. Finally, the delay is compensated to correct residual timing offset. To facilitate the three-step operation, we design a training symbol that has four repetitions within a symbol period. Numerical results show that the proposed scheme can provide robust performance with low complexity.

I. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) has been considered as one of the most promising modulation techniques to support multimedia services in mobile radio communications [1, 2]. However, the OFDM system requires to accurately maintain symbol and frame timing synchronization.

There have been a number of researches on the synchronization method for the OFDM system. Beek proposed a symbol synchronization scheme by using correlation with the cyclic prefix (CP) [3]. A three-step cell search algorithm was proposed to find the symbol and frame timing based on the Beek's scheme [4-6]. However, these schemes may provide performance degradation in frequency selective fading channel because the CP is contaminated by multi-path delay spread. Moreover, it may not properly work in a multi-cell, multi-user environment. Since the output of correlation with the CP is directly proportional to the transmit power from the base station, the user can be synchronized to a wrong base station that has higher power than the base station nearby. As a result, the more users the base station has, the more likely new users are to be synchronized to that base station, causing severe unbalancing cellular network load.

On the other hand, the use of a special OFDM training symbol can avoid the problem involved in multi-cell environment since the transmit power of the signal can be maintained at the same level. While matched filter scheme can provide optimum performance, it is difficult to implement due to large complexity. To reduce the implementation complexity, Cox introduced a synchronization method that utilizes a training symbol that has two repetitive patterns [7]. However, since this scheme has very large uncertainty region and high ambiguity at the boundary of timing metric, it can be vulnerable to frequency selective fading channel [9].

In this paper, we propose a timing synchronization scheme that can provide robust performance and low computational complexity in frequency selective fading channel.

II. OFDM SYSTEM MODEL

Fig. 1 illustrates the discrete-time OFDM system model. The OFDM transmitter modulates X_n using N_c subcarriers by inverse discrete Fourier transform (IDFT). The last N_g samples are inserted as a CP to form the OFDM symbol s_k. The channel impulse response h_k affects the signal s_k. Thus, the received signal, r_k, is given by

$$r_k = h_k * s_k + n_k \quad (1)$$

Here * denotes convolution. The data Y_n are obtained by discarding the first N_g samples (CP) of r_k and demodulating the N_c remaining samples of each OFDM symbol by means of a

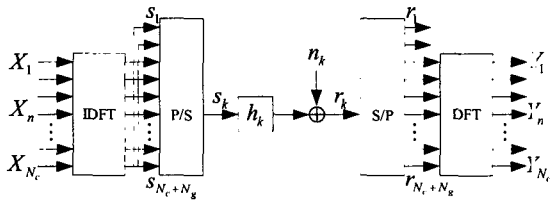

Fig. 1. OFDM system

This research was supported in part by Skypass4G project of Samsung Electronics.