Pilot Structure and Channel Estimation for Multicarrier-based Uplink Cellular Systems

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Abstract—We have proposed Frequency Hopping Spread Spectrum OFDMA (FH/SS-OFDMA) [1] as a novel solution for uplink multiple access scheme. In this paper, it is shown that FH/SS-OFDMA has good features to have efficient pilot structure especially on uplink OFDMA systems. Hop-based pilot structure for FH/SS-OFDMA is designed and channel estimation is successfully performed with 2D-LMMSE estimator. We also propose specific pilot patterns for asynchronous cellular environment where intercell interference severely degrades channel estimation performance. The performance of the system is evaluated in our multicell simulator generating all interferers individually, which gives more reliable results than previous works. ¹

I. INTRODUCTION

Various multiple access schemes that combine OFDM with spreading and hopping techniques such as FH-OFDMA [2], MC-CDMA [3] and SS-MC-MA [4] have been proposed for multicell environment. Each multiple access scheme can be a good solution in downlink. However, those systems are not practically available in uplink considering pilot structure and pilot overhead. We assume FH/SS-OFDMA which has a good feature for pilot structure as our multiple access scheme in this paper. It is illustrated in Fig. 1.

Grouping: Each user is allocated with a group of adjacent subcarriers. Because of the differentiation of users in frequency domain, there is no intracell interference among users.

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II. HOP-BASED PILOT STRUCTURE

In cellular systems, intercell interference makes it impossible to estimate channel perfectly from pilot observations with ideal pilot spacing as calculated in [5]. We use the coherent bandwidth and the coherent time instead with the correlation 0.5 for practical pilot spacing in cellular environment [6]. Fig. 2 illustrates the hop-based pilot structure. We define the term hop as a basic unit of uplink resource that consists of 17 subcarriers for 4 OFDM symbols. According to the criterion above, four pilot symbols are evenly distributed in hop structure, which means that at least one pilot symbol exists both within the coherent bandwidth and the coherent time. At each position in hop, channel is estimated with the pilot observations using 2D-LMMSE estimator.
III. PILOT PATTERN DESIGN FOR MULTICELL SYSTEM

If pilot symbols are corrupted, data fail to be demodulated irrespective of correcting processes such as despreading and decoding. Pilot power boost-up does not help in this case because SIR remains the same. The solution is to make the pilots from different cells not to collide each other because pilot symbols are relatively stronger than spread data symbols except full cell loading case. The channel estimation performance is improved by reducing the number of pilot symbol collisions. If each base station select one of the pilot patterns in Fig. 3, the number of pilot symbol collisions is at most one even in asynchronous system, still maintaining pilot spacing properly.

![Proposed Pilot Patterns for Cellular System](image)

Fig. 3. Proposed Pilot Patterns for Cellular System

IV. SIMULATION RESULTS

We assume 7-cell structure, ITU-R channel models, 2GHz carrier frequency, 10MHz bandwidth, 1024 subcarriers and 1/3 convolutional code. In our multicell simulator, we generate all users in neighboring cell individually as interferers without Gaussian approximation of interference. In spite of huge computational complexity, multicell simulation is indispensable to evaluate the effect of pilot pattern and pilot collision. BER performance with uniformly-distributed pilot pattern is shown in Fig. 4. There is a performance improvement when we boost up the pilot power in the noise-limited region. This improvement, however, goes zero in the cell boundary because SINR do not increase in the interference-limited region. Using the proposed pilot patterns, BER performance is improved especially in the interference-limited region as in Fig. 5. Although relatively strong pilot symbols act as interferers to data symbols in the neighboring cells, the performance improvement due to better channel estimations is larger than that due to more reliable data symbols.

![Channel Estimation Performance](image)

Fig. 4. Channel Estimation Performance

![Channel Estimation Performance with Proposed Pilot Patterns](image)

Fig. 5. Channel Estimation Performance with Proposed Pilot Patterns

V. CONCLUSIONS

The contribution of this paper is as follows. Firstly, the hop-based pilot structure for FH/SS-OFDMA is designed and the BER performance is evaluated in our multicell simulator which makes the simulation results more reliable than those of previous works especially when cell loading is low. Secondly, we also design collision-avoiding pilot patterns for asynchronous cellular system and evaluate the improvements.

REFERENCES