

Unified Framework for Synchronization and BS Identification in Cellular OFDM Systems

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Abstract: This paper ¹ shows initial synchronization techniques including the base station identification (BS ID) for the cellular orthogonal frequency division multiplexing (OFDM) downlink systems. The novel preamble and pilot structures are proposed and simplified three-stage synchronization process is shown. The simulation results indicate that the proposed techniques work well even at low signal-to-interference-plus-noise ratio (SINR) regime.

1. Introduction

We show noticeable frame structures and initial synchronization techniques as a competitive candidate with the fourth-generation (4G) cellular OFDM-based systems such as IEEE 802.16e standard [1] in terms of the systemwise performance and computational complexity. Throughout our preamble and pilot structures, which perform the synchronization procedures, the total computational complexity of the proposed system can be reduced more efficiently in realistic cellular environments. In addition, simplified three-stage process, which can be sequentially described in Fig. 1 as 1) the joint timing and frequency synchronization, 2) the frame synchronization and preamble pattern ID, and 3) the pilot group ID, is shown.

2. Main Results

In this section, the downlink frame structure, the synchronization technique for each stage, and the simulation results are shown.

2.1 Downlink Frame Structure

The preamble structure is designed by considering the peak-to-average-power ratio (PAPR) reduction, differential encoding, and low correlation among the preamble sets. The frame synchronization and the BS ID, denoted as the preamble pattern ID, are performed using the preamble. In particular, the pseudo noise (PN) sequences are considered to design the preamble sets obtaining relatively low cross-correlation between sequences and to perform the differential encoding in the frequency-domain. The actual preamble samples are shown in Fig. 2 when the number of total subcarriers is 1024. Moreover, the preamble selection scheme is examined in a sense of minimizing the PAPR where the chosen preamble sets are allocated at each BS. In our design, the number of the selected preamble pattern

N_{pp} is given by 16. On the other hand, pilots are designed by considering a division of their groups and facility of the channel estimation. The BS ID, denoted as the pilot group ID, is performed using the pilots. Pilot subcarrier power is 2.5 dB boosted compared with that of the other data subcarriers such as that in [1]. Fig. 3 shows the example when the number of available pilot groups N_{PG} is 9.

2.2 Proposed Synchronization Procedure

For joint timing and frequency synchronization, a correlation between cyclic prefix (CP) and other data parts can be used as the first stage. The joint maximum-likelihood (ML) estimator is proposed under practical wireless environments such as time-varying frequency selective channels. Secondly, our joint frame synchronization and preamble pattern ID are based on the preamble. Since the symbol timing is already adjusted in advance, the computational complexity for the frame synchronization can be reduced more efficiently by finding the starting point of the frame, unlike [1]. The frequency-domain cross-correlation between the transmitted and received signals, which are differentially encoded, has been employed to the joint frame synchronization and preamble pattern ID technique. After preamble pattern ID, the pilot group ID for BS ID is required as the final stage. The pilot group is detected by comparing the accumulated signal power for the candidate pilot subcarriers.

2.3 Simulation Results

Simulation parameters are summarized in TABLE I. In Figs. 4(a) and 4(b), the mean square error (MSE) performance of symbol timing and frequency offset estimation has been examined through computer simulations, respectively. The false acquisition probability (FAP) of frame synchronization and BS ID has also been shown in Figs. 4(c) and 4(d), respectively. It is investigated that the proposed techniques work well even at low SINR regime below 0 dB SNR.

3. Conclusion

We refer readers to [2] for more details. The performance comparison with various schemes [1], [3], [4], and the system performance in terms of average acquisition time, which is shown in [5], as well as the extension to multiple antenna systems for the proposed techniques will be further accomplished.

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References

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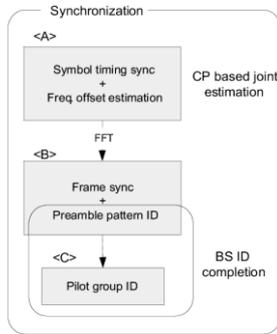


Fig. 1. The block diagram for the proposed synchronization process.

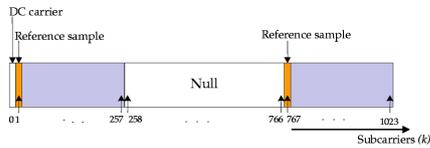


Fig. 2. The preamble structure through the differential encoding of the PN sequence.

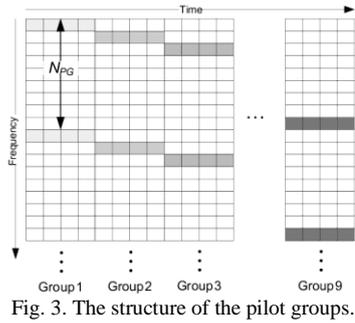
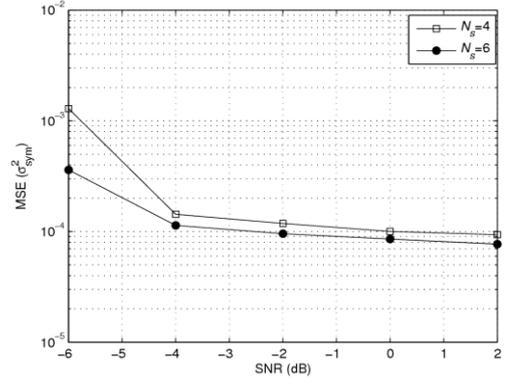


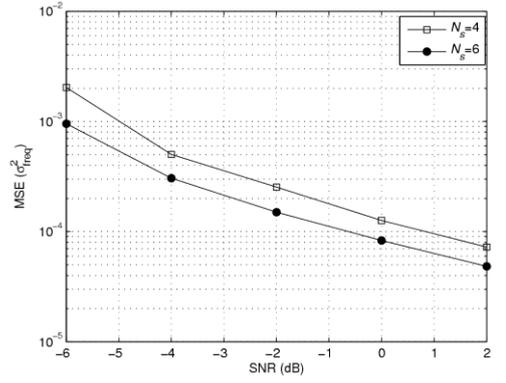
Fig. 3. The structure of the pilot groups.

TABLE I
COMPUTER SIMULATION PARAMETERS

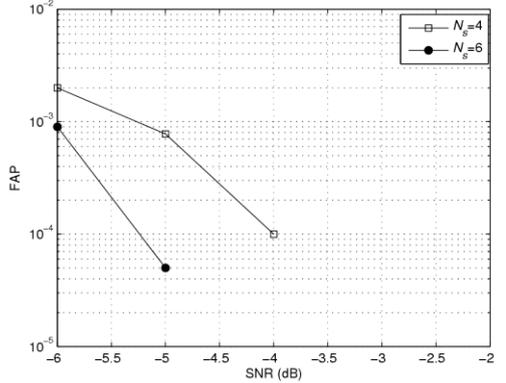
Item	Value
Carrier frequency	2.3 GHz
Modulation	QPSK
Channel bandwidth	10 MHz
FFT size (N)	1024
Cyclic prefix length (N_{cp})	128
Channel tap (L)	96
Factors of BS ID ($N_{pp}N_{pg}$)	144 (=16×9)
Vehicle speed (Jake's model)	60 km/h
# of observation symbols (N_s)	4 or 6



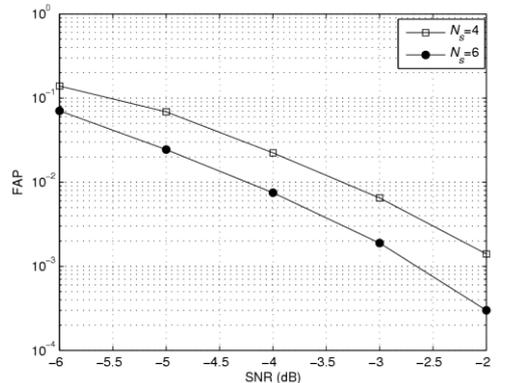
(a)



(b)



(c)



(d)

Fig. 4. The system performance through the computer simulation (a) Symbol timing estimate. (b) Frequency offset estimate. (c) Frame synchronization. (d) BS ID.