New Channel Estimation Scheme Exploiting Reliable Decision Feedback Symbols for OFDM Systems†

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Abstract — The conventional pilot-aided channel estimation schemes use the fixed number of pilots to estimate the channel. In this paper, the channel estimator exploits reliable decision feedback symbols as quasi-pilots. This new channel estimation scheme is commercially attractive without additional hardware in the receiver using DSP chips for the OFDM systems.

I. INTRODUCTION

The orthogonal frequency division multiplexing (OFDM) systems have been adopted in several wireless standards such as digital audio broadcasting (DAB), terrestrial digital video broadcasting (DVB-T), the IEEE 802.11a/g wireless local area network (WLAN) standard, IEEE 802.16a and HiperLAN/2. Undoubtedly, the OFDM scheme is one of the potential air interface candidates for the next generation mobile wireless systems [1]-[3].

For the coherent modulation schemes in the OFDM systems, channel state information (CSI) is required to compensate channel distortion. Among the various channel estimation schemes, the pilot-aided schemes show good performances. The conventional pilot-aided OFDM systems use the fixed number of pilots to estimate the CSI [4]. The more number of pilots are employed, the more correctly estimated CSI is obtained. However, the increased number of pilot tones decreases the number of data to transmit, resulting in the low bandwidth efficiency.

The double maximum likelihood (ML) channel estimation is proposed in [5] to enhance the bandwidth efficiency. First, the CSI is estimated based on the ML estimation scheme by the original pilot symbols, and this CSI compensates the channel distortion. Next, the quasi-pilots are extracted from the decision symbols located in the midpoint position between the original pilot locations. The quasi-pilot means the decision symbols that will be employed as the pilots but not always correct (in fact, the term, “quasi-pilot” is not used in [5]). Finally, the double ML method applies both quasi-pilots and pilots to refine the channel estimate based on the ML estimation scheme. Hence, the channel estimation error of the double ML channel estimation (MLCE) scheme is lower than that of the conventional ML channel estimation scheme. However, these quasi-pilots are not reliable. Therefore, the channel estimation can be deterred by unreliable quasi-pilot symbols. To overcome this problem, we propose new channel estimation scheme exploiting reliable quasi-pilot symbols for the OFDM systems.

II. PROPOSED SCHEME

The reliability of the decision feedback symbols depends on their error rate. In other words, the reliable symbol has a low symbol error rate.

As shown in Fig. 1, the symbol error rate is inversely proportional to the channel gain. Hence, the reliable quasi-pilots can be extracted in the subcarrier region whose channel gain is greater than the certain threshold. For example, the threshold can be defined as channel gain where symbol error rate is 0.05 at the threshold channel gain. The symbol error rate of reliable quasi-pilots is smaller than 0.05 because the reliable quasi-pilots are extracted based on their channel gain whose magnitude is greater than the threshold.

To estimate the channel, the following process is required. In the first place, the CSI is estimated employing the MLCE scheme by the pilot symbols, and this CSI compensates the channel distortion. Next, the detection process for the transmitted symbols is operated. From the decision symbols, the quasi-pilots are extracted based on their reliability using the estimated channel gain. Both the quasi-pilots and the original pilots are exploited to estimate the CSI again using the MLCE method. This proposed method gives more accurate estimated channel and lower bit error rate (BER) than the conventional methods. The block diagram of the proposed

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scheme is illustrated in Fig. 2, where \( x \) is the transmitted symbol and \( y \) is the received symbol.

![Diagram](image)

**Fig. 2.** The proposed channel estimation systems.

### III. SIMULATION RESULTS

![Graph](image)

**Fig. 3.** MSE of the estimated channel.

![Graph](image)

**Fig. 4.** BER of the various channel estimation schemes

The HiperLan/2 channel model B is used to generate the channel with its length 16. The total number of subcarriers is 1024 and the number of pilot tones is 16. Each symbol employs QPSK modulation scheme. The threshold to extract the reliable quasi-pilots is defined as the channel gain where 0.05 symbol error rate occurs at that threshold channel gain. Hence, the symbol error rate of reliable quasi-pilots is below 0.05.

Fig. 3 shows the mean square error (MSE) of the estimated channel of various methods. All pilot case means that all symbols are considered as pilots. The proposed scheme outperforms the conventional MLCE and the double MLCE methods. In the high SNR region (above the 25 dB), the proposed scheme approaches to the all pilot case, i.e., ideal estimated channel. Fig. 4 shows BER curves with several channel estimation schemes. The proposed scheme shows better results than the ML and double ML schemes.

### IV. DISCUSSION AND CONCLUSION

In this paper, we propose a new channel estimation scheme exploiting reliable decision feedback symbols in the OFDM systems over the frequency selective fading channel. The reliability of the decision feedback symbols depends on its error rate. In other words, the reliable symbol has a low symbol error rate.

The proposed scheme employs more number of (quasi-)pilot symbols than the conventional MLCE scheme. Differently from the double MLCE method, the reliable quasi-pilot symbols have low error rate with the certain threshold. These two factors improve the channel estimation performance. The simulation results show that the MSE of the estimated channel is better than that of existing methods, and BER of our scheme is lower than that of conventional schemes.

The proposed method can be implemented on the DSP chip in the receiver without additional hardware. Hence, it is commercially attractive to any coherent OFDM systems to improve the channel estimation performance with low cost. This compatibility is another benefit of the proposed scheme.

### REFERENCES


