MUD Based on Hidden Training Sequence for UWB Communication System

Sung-Yoon Jung and Dong-Jo Park
Department of Electrical Engineering and Computer Science
Korea Advanced Institute of Science and Technology (KAIST)
373-1 Guseong-dong, Yuseong-gu, Daejeon, Republic of Korea 305-701
E-mail: syjung@kaist.ac.kr and djpark@ee.kaist.ac.kr

Abstract—**In this paper, we propose a multi-user detection scheme using a hidden training sequence. The hidden training sequence, which uses a fraction of the informative sequence's transmitting power as a training sequence, was utilized for the receiver adaptation. The proposed detection scheme is applied to the DS-CDMA UWB system considered strongly as a physical solution for the IEEE 802.15.3a standard and we analyzed the performance of the proposed scheme in the view point of output signal-to-interference and noise-ratio (SINR). From simulation results using the IEEE 802.15.3a NLOS UWB channel model, we verify that the proposed scheme shows reasonably good BER performance and near-far resistance in single and multiuser environment.**

I. Introduction

The ultra-wideband (UWB) technology has recently attracted considerable interest. Especially, it is thought as a candidate solution for High Data Rate Wireless Personal Area Networks (HDR W-PAN). In early days, most existing approaches are based on impulse radio (IR) systems with time-hopping multiple access (TH-MA) employing correlators to correlate received signals with a template signal [4]. This technique is simple and powerful, but not so satisfactory in a multipath and multiple access channel. Therefore, both unknown multiple access interference (MAI) and multipath distortion need to be mitigated. Recently, the multi-user detection schemes for the UWB system based on time-hopping or direct-sequence (DS) multiple-access (MA) are proposed [5]-[7]. As an early work, the multi-user detection scheme with a perfect channel is investigated just for performance evaluation [5]. The adaptive multi-user detection scheme based on a training sequence with unknown channel information is also suggested in home environment [6]. As a next step, to make up for the inefficient bandwidth utilization of the trained detection scheme, the blind multi-user detection scheme which does not need channel information is also considered [7].

In this paper, we propose an adaptive multi-user detection scheme using a hidden training sequence. The hidden training sequence, which uses a fraction of the informative sequence's transmitting power as a training sequence, was utilized for the receiver adaptation [1]-[3]. By sacrificing a portion of the transmitting power for training, the proposed scheme offered increased bandwidth efficiency (no period just for training) and showed performance similar to the perfectly trained multi-user detection scheme, for example, the trained minimum mean square error (MMSE) scheme. The proposed detection scheme is applied to the DS-CDMA UWB system considered strongly as a physical solution for the IEEE 802.15.3a standard and we analyzed the performance of the proposed scheme in the view point of output signal-to-interference and noise-ratio (SINR). From simulation results with the IEEE 802.15.3a NLOS channel model [10], we verify that the proposed scheme shows reasonably good BER performance and near-far resistance in single and multiuser environment.

II. System Description

We consider detecting user 1's symbols in a K-user asynchronous DS-CDMA system through multipath UWB channels, where each user employs BPSK direct-sequence spread-spectrum (DS-SS) modulation. The overall block diagram of the proposed system is illustrated in Fig. 1.

The transmitter side is shown in Fig. 1(a). As seen in [1]-[3], the mth transmitting symbol can be generated as follows:

$$b_k(m) = \sqrt{\alpha_k}\, b_{I_k}(m) + \sqrt{\beta_k}\, b_{P_k}(m) \tag{1}$$

where b_{I_k} is the kth user's informative sequence to be marked; b_{P_k} is the kth user's marking sequence that, for our purpose, we indicate it as the hidden training sequence. Here α_k and β_k are the transmitting power of the informative sequence and that of the hidden training sequence, respectively. If the system's total transmitting power is restricted to be E_s, $\alpha_k+\beta_k$ should be E_s. It is assumed that b_{I_k} and b_{P_k} are i.i.d., random binary sequences with zero mean and unit variance. Then, it is spreaded by the spreading waveform, $c_k(t)$. After the UWB pulse shaping, the transmitted signal generated by the kth user is given by

$$x_k(t) = \sum_{m=-\infty}^{\infty} b_k(m) \cdot c_k(t - mT_s) \tag{2}$$

where T_s is symbol duration. The spreading waveform $c_k(t)$