Performance of Blind Turbo Equalizer in Indoor Channels

Mohamed Lassaad Ammari

Abstract—**In this paper, we consider the transmission of turbo coded symbols in the indoor radio environment. The system is affected by the intersymbol interference (ISI) caused by the multipath time-delay spread of the transmission medium. To reduce the channel effect, we propose to use a blind turbo equalizer combining channel estimation, equalization and turbo decoding. The equalizer consists of an interference canceller (IC) and a MAP-BCJR decoder. To improve system performances, we redefine the channel reliability factor used by the MAP-BCJR decoding algorithm. We propose a new metric that takes into account the statistics of the signal at the equalizer output. The channel coefficient estimation is performed using a recursive least squares (RLS) algorithm. A blind receiver initialization technique is proposed. This technique is based on a soft decision-directed least mean square algorithm (soft DD-LMS). For the proposed turbo detector, the ISI cancellation, channel estimation and decoding are jointly performed through an iterative process where modules exchange a soft information.**

Index Terms—**Indoor channel, MAP decoder, turbo processing, channel reliability, RLS channel estimation.**

I. Introduction

Digital communications in building environments have been widely studied in recent years [1]–[4]. They provide users the possibility to exchange information and many application files in a local area. To ensure the compatibility of wireless transmission with cabled local area networks (LAN) and to support multimedia applications, data rates on the order of 10 Mbps and more are needed [5]. It has been shown in [5], [6] that it is possible to increase considerably the transmission rate by using a DFE equalizer at the receiver. These cited articles consider M-QAM/DFE systems with uncoded symbols. In this paper, we suppose that the transmitted symbols are turbo coded and QPSK modulated. We analyze the behavior of the turbo equalization and we compare the performance of the proposed turbo detector with that of the DFE equalizer and the turbo equalizer given in [7].

Turbo codes introduced in [8] can achieve performance close to the Shannon capacity limit in both the additive white Gaussian noise channel (AWGN) and the Rayleigh flat-fading channel with perfect knowledge of the channel statistics. The iterative decoding process with extrinsic information exchange, called "turbo principle", is considered as the most important development in channel coding theory. The good performances given by turbo decoders are attributed to this turbo principle which has been used recently in several applications. In 1995, Douillard *et al*. [9] presented, for the first time, turbo equalization as an iterative process inspired from the turbo decoding principles. In fact, for turbo equalization, the ISI cancellation and decoding are jointly performed through an iterative process where each module uses the soft extrinsic information provided by the other. This technique allows for the use of all available information [10] and improves the system performance. The turbo detector proposed in [9] uses the iterative MAP algorithm for both equalization and decoding. This scheme achieves a good performance but it suffers from high complexity [10], [11]. Many researchers have proposed turbo equalizer architectures [7], [9]–[12], using different algorithms in order to reduce the computational complexity.

In this paper, we use a turbo equalizer having the same structure proposed in [7]. So, the turbo detector consists of an intersymbol interference canceller (IC) and a MAP-BCJR decoder. The IC needs the knowledge of the channel coefficients. The authors in [7] have assumed that the channel is perfectly known at the receiver. Thus, for the first iteration of the turbo equalizer, the IC is fed by zero since the symbol estimation is not available. In this paper, we consider a blind equalization and we assume that the channel state information in unknown which is a more realistic constraint. So, we have introduced a channel estimation module in our turbo detector. Thereby, we propose to use a blind equalizer at the first iteration in order to provide the symbol estimation to both the IC and the channel estimator.

Furthermore, unlike [7] where data are convolutionally coded, we use in this paper a turbo encoder. Thus, we have to redefine the channel reliability factor used by the MAP-BCJR decoding algorithm. We propose a new metric that takes into account the statistics of the signal at the IC equalizer output. The MAP decoder is also modified as in [13] in order to compute the log likelihood ratio (LLR) of both systematic and coded symbols.

The outline of this paper is as follows. In section II, the system and channel models are described. Section III presents the turbo detection principle and proposes a blind turbo detector. We also describe, in this section, the evaluation of the channel reliability factor used by the MAP-BCJR decoder. Section IV discusses the channel estimation procedure. In section V, we present simulation results for different scenarios and we compare the proposed detector with the DFE equalizer and the turbo equalizer of [7]. Finally, a conclusion is given in section VI.

Manuscript received August 16, 2010; revised February 18, and April 27, 2011.

M. L. Ammari is with 6'Tel Research Unit, School of Communications of Tunis, University of Carthage, Tunisia, (email: mlammari@ele.etsmtl.ca).