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Performance of a SISO-SAGE Based Receiver for Coded CDMA

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***Abstract*— In this extended abstract we present the performance of a soft-input soft-output (SISO)- space alternating generalized expectation maximization (SAGE) based DS/CDMA receiver. This receiver performs joint channel estimation and soft successive interference cancellation and SISO single-user decoding. Monte Carlo simulations in flat Rayleigh fading channel show that this receiver is robust against channel estimation errors and can support high system loads.**

The optimal multiuser estimator exhibits a complexity exponential in the number of users K and channel memory size. Alexander *et al.* propose an iterative process where a low-complex interference cancellation (IC) device and a bank of single-user (SU) decoders exchange soft information [1]. In [2] a soft-input channel estimator is also included in the iterative process. A crucial issue in the design of iterative receivers is the kind of soft information, i.e. extrinsic (EXT) values or a posteriori probability (APP) values, exchanged among the channel estimator, the IC device and the SU decoders.

To obtain soft estimates on the code symbols, Chiavaccini *et al.* propose in [3] to assume that the code symbols are the nuisance parameters, while the channel weights are the parameters of interest in the context of the EM framework. This approach leads, however, to an E-step that returns the soft code symbols at exponential complexity in K. We propose in [4] a SISO-SAGE based receiver which is a modification of the SAGE-JDE scheme in [5]. In the proposed receiver, a joint soft-input channel estimation and successive IC device is combined with the SU decoders exchanging soft information of the code symbols. This approach still conceptually keeps the code symbols as parameters of interest and the channel weights as nuisance parameters. A performance comparison for the SISO-SAGE based receiver is carried out by means of Monte Carlo simulations.

Fig. 1 shows the average BER performance of the proposed receiver for different initialization and soft-input information for the channel estimation and the IC. All users employ the same rate R=$\frac{1}{3}$ Turbo code $(1, \frac{5}{7}, \frac{5}{7})$ and the same interleaver size 3000. Each burst consists of 150 code symbols and 6 pilot symbols. Random signature waveforms of length N_c=8 are assigned to different users. The system load is defined as β=$\frac{KR}{N_c}$. All users' signals are received with the same average signal-to-noise ratio $\bar{\gamma}_\mathrm{b}$. The labels $\mathrm{SI_c/SI_i}$ indicate that the soft information $\mathrm{SI_c}$ and $\mathrm{SI_i}$ is input to respectively the channel estimator and the soft IC device. For a medium system load, e.g. β=0.66 (K=16), it can be seen that for a fixed $\mathrm{SI_i}$, the iterative receiver with $\mathrm{SI_c}$=EXT outperforms the one with $\mathrm{SI_c}$=APP over the entire range of $\bar{\gamma}_\mathrm{b}$. For given $\mathrm{SI_c}$, in contrast, the performance of the iterative receiver is roughly independent of $\mathrm{SI_i}$ in the high $\bar{\gamma}_\mathrm{b}$ region. The performance of the iterative receiver with RAKE-initialization (Init I) is only slightly better than that with MMSE-initialization (Init II) in a medium loaded system. It can also be seen that best performance is achieved with $\mathrm{EXT/APP}$ feedback. The iterative receiver can support a maximum load of β_max=1.4 for "Init I" and β_max=1.3 for "Init II" with $\mathrm{APP/APP}$ feedback.

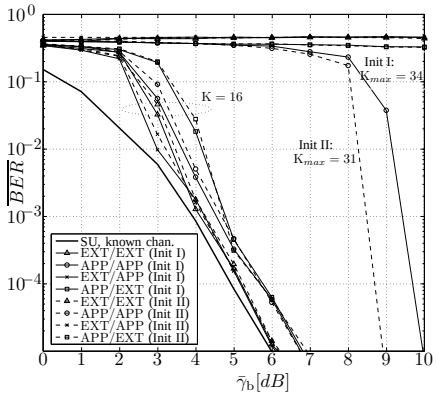

Fig. 1. BER performance of the iterative receiver in quasi-static flat Rayleigh fading; "Init I": RAKE, "Init II": MMSE. APP: a posteriori, EXT: extrinsic.

In summary, Monte Carlo simulations show that the iterative receiver is robust against channel estimation error. The performance depends on the kind of initialization and type of soft information fed back to the channel estimator. For a medium system load, the best performance is achieved with $\mathrm{EXT/APP}$ feedback, while the receiver with $\mathrm{APP/APP}$ feedback can support higher system loads.

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