Performance Analysis of Coded Cooperation over Time-Variant Channels

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***Abstract*—We contribute to the evaluation of the performance of a relaying technique called coded cooperation. This cooperation scheme involves two or more mobile stations (MS) that reciprocally transmit portions of their codewords through independent fading channels so as to achieve diversity. Performance analysis in the literature considers two extreme cases of temporal variability for the fading channel: the block fading (BF) model for channels that remain constant during the transmission of the whole codeword and the fast fading (FF) one for independent identically distributed channel gains over the time. In this paper we extend the analysis to more realistic propagation scenarios where the channel response varies over the time with a correlation function that depends on the MSs' velocity. We derive analytical bounds on the average bit error probability and we validate the results by numerical simulations for a varying degree of channel correlation, ranging from the BF to the FF case. Numerical results show that the performance gain provided by the cooperation with respect to the non-cooperative case decreases as the MSs move faster.**

I. Introduction

In this paper we investigate the performance of coded cooperation over flat-fading channels that exhibit time variance due to terminal mobility. Forward error correcting (FEC) codes are used by two or more mobile stations (MS), which cooperate by transmitting to the base station (BS) incremental redundancy for the partners, in order to increase the transmit diversity. The first analysis of coded cooperation, presented in [1], has focused on two extreme cases of temporal variability of the channel, i.e. the block-fading (BF) and the fast-fading (FF) models. Impressive power savings have been highlighted in the case of BF due to the increased diversity. However, coded cooperation is no longer beneficial in the case of FF, i.e. for independent identically distributed (i.i.d.) channel coefficients along the codeword, when the MSs uplink channels have the same average SNR. A study of the effects of the user mobility on coded cooperation has been recently presented in [2]. In that work the outage probability has been evaluated only numerically by simulating different mobility scenarios and, subsequently, a method for the dynamic selection of the cooperating partner has been proposed. An analytical upperbound on the BER performance has been derived in [3] for BF orthogonal frequency division multiplexing (OFDM) channels, based on the Chernoff bound.

To the best of our knowledges, every successive analytical study about the different aspects concerning the applicability and the performance of coded cooperation in various contexts and systems examines only the BF channel model. Nevertheless, MSs moving at vehicular speed communicate over wireless channels affected by a multipath fading that is not constant within the frame time interval, but it is instead correlated due to the Doppler effect. In this case, the system can already exploit the temporal diversity [4] by means of channel coding and bit-interleaving techniques. A question arises spontaneously: how much beneficial is to generate transmit space diversity through coded cooperation in a system that already takes advantage of a certain level of temporal diversity? In order to answer this question, the first aim of our work is to offer an analytical model for the performance evaluation of coded cooperation in terms of average bit error rate (BER) at the decoder output. We adapt and extend the method used in [5], [6] for the performance evaluation in single/multiple antenna OFDM systems. The BER depends on the signal-to-noise ratio (SNR) at the decision variable [7], here referred to as *effective SNR*. We derive the statistical distribution of the effective SNR based on the knowledge of the fading channel autocorrelation over the transmitted data block, here modeled according to the modified Jakes' model in [8], [9]. We then use this analytical tool to evaluate the performance gain provided by coded cooperation with respect to a non-cooperative system for varying degree of user mobility and for different channel state conditions.

To summarize, the original contributions provided by the present work are as follows:

- we apply and extend the analytical methodology presented in [5], [6] for evaluating the average BER of coded cooperation over time-variant channels, and verify the bounds by numerical simulations;
- we use the methodology to identify the practical conditions under which coded cooperation provides significant gains over a comparable non-cooperative system, by comparing the two systems for varying MSs' velocities, in the case of both symmetric and asymmetric uplink channel conditions.

The paper is organized as follows. In Section II we give a brief description of the system and the channel model; Section III presents the derivation of the analytical upperbound on the BER; Section IV contains both numerical and analytical results, for the validation of the analytical BER and the investigation of the MSs' mobility effects on coded cooperation; finally, in Section V we discuss our conclusions.

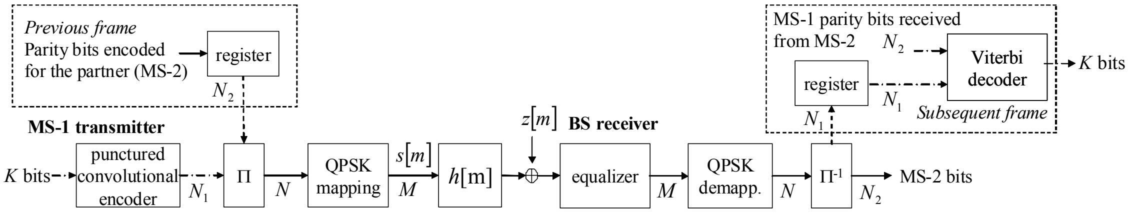

Fig. 1. Uplink system model for MS-1 successfully cooperating with MS-2.

II. System model

We consider the transmission of rate-R coded data from two mobile users, MS-1 and MS-2, towards a common BS through two orthogonal channels by frequency division multiple access (FDMA). The two channels are assumed to be subject to *independent* time-selective (due to user mobility) frequency-flat fading. Coded cooperation is carried out according to the scheme introduced in [1], by sending portions of each user data over the two independent channels so that a diversity gain is provided, as briefly summarized below.

Each MS encodes its data block of K information bits by means of a rate-compatible punctured convolutional (RCPC) code [10] that yields an overall codeword of $N = K/R$ bits. This codeword is divided through puncturing into two sub-codewords of length N_1 and N_2, with $N = N_1 + N_2$: the first subset is the punctured codeword of rate $R_1 = K/N_1$, the second one is the set of removed parity bits. The sub-codewords are then transmitted into two subsequent time frames. In the first frame each MS broadcasts the first sub-codeword, that is received by the cooperating partner and the BS. If the partner successfully decodes the first sub-codeword (this is determined by a cyclic redundancy check (CRC) code), then it will compute and transmit the N_2 additional parity bits in the second frame. At the BS this incremental redundancy is used for de-puncturing the rate-R_1 codeword received in the first frame, thus obtaining the initial rate-R codeword. If the partner cannot successfully decode the MS' first-frame data, it will transmit its own N_2 code bits during the second frame. The level of cooperation is quantified by $\alpha = \frac{N_2}{N}$.

To simplify the analysis, in this paper we focus on the performance of coded cooperation for ideal inter-MSs channel, i.e. we assume that the cooperation is always successful and thus the CRC is not needed (which is almost true if the two MSs are relatively close to each other, as for two vehicles running in the same direction). A methodology that allows to deal with BER computation in the case of imperfect inter-MSs channels can be inferred from [1] and is not considered here due to space limitations.

The complete system model for each MS-BS link is depicted in Fig. 1. Bit-interleaved quadrature phase shift keying (QPSK) modulation is assumed [11] with symbol rate $1/T_\mathrm{S}$. The baseband-equivalent discrete-time signal transmitted by MS-i, with $i \in \{1, 2\}$, is $s_i[m] = \sqrt{E_\mathrm{S}} q_i[m]$, $m = 1, \ldots, M$, where $M = N/2$ is the number of symbols per frame, E_S is the transmitted energy per symbol, and $q_i[m] = (\pm 1 \pm j)/\sqrt{2}$ is the QPSK symbol at time mT_S. The corresponding signal received at the BS is then

$$y_i[m] = h_i[m]s_i[m] + z[m], \tag{1}$$

where $z[m] \sim \mathcal{CN}(0, \sigma_n^2)$ denotes the complex additive white Gaussian noise (AWGN) at the receiver, with variance σ_n^2. The time-variant Rayleigh-fading channel for the link between MS-i and the BS is $h_i[m] \sim \mathcal{CN}(0, \Omega_i)$ with variance Ω_i. The fading process is assumed to be wide-sense stationary (up to the second-order statistics) with Jakes' auto-correlation function given by [7]

$$R_i[k] = \mathrm{E}\{h_i[m]h_i^*[m + k]\} = \Omega_i J_0(2\pi k \nu_{\mathrm{D}i}), \tag{2}$$

where J_0 is the zeroth-order Bessel function of the first kind, $\nu_{\mathrm{D}i}$ is the one-sided normalized Doppler bandwidth $\nu_{\mathrm{D}i} = \frac{v_i f_\mathrm{C}}{c_0} T_\mathrm{S}$, v_i is the MS-i velocity, f_C the carrier frequency and c_0 the speed of light. The parameter $\nu_{\mathrm{D}i}$ is a measure of the temporal variability of the channel. A more meaningful parameter for coded transmissions is the time-bandwidth product, here defined as $\mathrm{TBP}_i = 2M\nu_{\mathrm{D}i}$, where $2M$ is the temporal duration of the codeword expressed in symbol times (two frames), i.e. the time interval in which the interleaved code can exploit the temporal diversity. The time-bandwidth product is the velocity of the MS in terms of number of wavelengths per two frame.

According to the Rayleigh fading assumption, the instantaneous SNR, defined as

$$\gamma_i[m] = |h_i[m]|^2 \frac{E_\mathrm{S}}{\sigma_n^2}, \tag{3}$$

exhibits an exponential distribution with mean $\overline{\gamma_i} = \Omega_i \frac{E_\mathrm{S}}{\sigma_n^2}$ [7].

At the receiver, coherent equalization is carried out using perfect knowledge for the channel $h_i[m]$, followed by demapping, deinterleaving and decoding, as illustrated in Fig. 1.

III. Performance analysis

According to the union bound approach [11], the average bit error probability P_b at the Viterbi decoder output is:

$$P_b \leq \frac{1}{k} \sum_{d \geq d_\mathrm{free}} \sum_{\mathbf{c} \in \mathcal{E}(d)} \beta(\mathbf{c}) P(\mathbf{c}), \tag{4}$$

where k is the number of input bits for each branch of the convolutional code trellis, d_free is the free distance, $\mathcal{E}(d)$ is the set of error events $\mathbf{c}$ at a certain Hamming distance d, $\beta(\mathbf{c})$ is the Hamming weight of the input sequence corresponding to $\mathbf{c}$ and $P(\mathbf{c})$ is the average pairwise error probability (PEP). The average PEP $P(\mathbf{c})$ is the probability of detecting the codeword $\mathbf{c}$ instead of the transmitted all-zero codeword.

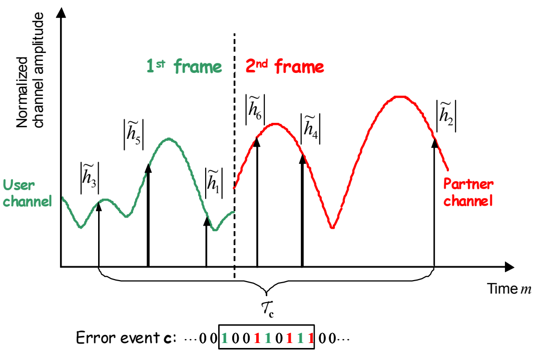

Fig. 2. Example of the correlated fading observed along the error event.

Let $\mathcal{T}_{\mathbf{c}} = \{\tau_{\mathbf{c},1}, \ldots, \tau_{\mathbf{c},d}\}$ be the set of time instants associated with the d error bits in $\mathbf{c}$, and $\tilde{\mathbf{h}} = \sqrt{E_{\text{s}}}\left[h(\tau_{\mathbf{c},1}) \cdots h(\tau_{\mathbf{c},d})\right]^{\text{T}}/\sigma_{\text{n}}$ be the vector that gathers the corresponding channel gains scaled by $\sqrt{E_{\text{s}}}/\sigma_{\text{n}}$. The average PEP $P(\mathbf{c})$ can be calculated as [4]:

$$P(\mathbf{c}) = \int_0^{\infty} Q\left(\sqrt{2\gamma_{\text{eff}}}\right) p\left(\gamma_{\text{eff}}\right) d\gamma_{\text{eff}}, \tag{5}$$

where γ_{eff} (effective SNR) is the sum of the SNR variates that are experienced over the time instants $\mathcal{T}_{\mathbf{c}}$ [5], or, equivalently, the sum of the squared magnitudes of the vector $\tilde{\mathbf{h}}$'s entries:

$$\gamma_{\text{eff}} = \sum_{k \in \mathcal{T}_{\mathbf{c}}} \gamma(k) = \left\|\tilde{\mathbf{h}}\right\|^2. \tag{6}$$

Its probability density function (pdf), $p\left(\gamma_{\text{eff}}\right)$, clearly depends on the correlation of the channel gains contained in $\tilde{\mathbf{h}}$. We observe that $\tilde{\mathbf{h}}$ is a zero-mean complex Gaussian random vector, $\tilde{\mathbf{h}} \sim \mathcal{CN}(\mathbf{0}, \mathbf{R}_{\mathbf{c}})$, with covariance $\mathbf{R}_{\mathbf{c}} = \mathrm{E}[\tilde{\mathbf{h}} \cdot \tilde{\mathbf{h}}^{\text{H}}]$ whose entries are samples of the auto-correlation function (2). The distribution of the effective SNR is here derived based on the knowledge of the correlation matrix $\mathbf{R}_{\mathbf{c}}$, by extending the approach in [6] to the cooperative scenario with time-selective fading channels.

Recalling that the codeword is partitioned into two frames due to the coded cooperation scheme, it should be observed that the d error bits in $\mathbf{c}$ are split into two groups of bits coming from the MS's and the partner's uplink channels (see Fig. 2). Let us consider for instance the codeword of user MS-1, the time instants associated with the first and the second groups are here indicated as $\mathcal{T}_{\mathbf{c};1}$ (d_1 elements) and $\mathcal{T}_{\mathbf{c};2}$ (d_2 elements), respectively, with $\mathcal{T}_{\mathbf{c}} = \mathcal{T}_{\mathbf{c};1} \bigcup \mathcal{T}_{\mathbf{c};2}$. Accordingly, the channel vector is $\tilde{\mathbf{h}} = [\tilde{\mathbf{h}}_1^{\text{T}}, \tilde{\mathbf{h}}_2^{\text{T}}]^{\text{T}}$, where $\tilde{\mathbf{h}}_1 = \sqrt{E_{\text{s}}}\left[h_1(\tau_{\mathbf{c},1}) \cdots h_1(\tau_{\mathbf{c},d_1})\right]^{\text{T}}/\sigma_{\text{n}}$ and $\tilde{\mathbf{h}}_2 = \sqrt{E_{\text{s}}}\left[h_2(\tau_{\mathbf{c},d_1+1}) \cdots h_2(\tau_{\mathbf{c},d_1+d_2})\right]^{\text{T}}/\sigma_{\text{n}}$ gather the channel coefficients for, respectively, the MS-1 and MS-2 uplink channels, at time instants $\mathcal{T}_{\mathbf{c};1}$ and $\mathcal{T}_{\mathbf{c};2}$. In order to derive the effective SNR's statistical distribution, we introduce the eigenvalue decomposition (EVD) of the covariance matrices of the two channel vectors:

$$\begin{aligned} \mathbf{R}_{\mathbf{c},1} &= \mathrm{E}[\tilde{\mathbf{h}}_1 \cdot \tilde{\mathbf{h}}_1^{\text{H}}] = \mathbf{U}_1 \mathbf{\Lambda}_1 \mathbf{U}_1^{\text{H}}, \\ \mathbf{R}_{\mathbf{c},2} &= \mathrm{E}[\tilde{\mathbf{h}}_2 \cdot \tilde{\mathbf{h}}_2^{\text{H}}] = \mathbf{U}_2 \mathbf{\Lambda}_2 \mathbf{U}_2^{\text{H}}. \end{aligned} \tag{7}$$

$\mathbf{\Lambda}_1 = \mathrm{diag}\left[\lambda_{1,1}, \ldots, \lambda_{1,r_1}\right]$ and $\mathbf{\Lambda}_2 = \mathrm{diag}\left[\lambda_{1,1}, \ldots, \lambda_{1,r_2}\right]$ are the matrices of non-zero eigenvalues, with $r_1 = \mathrm{rank}[\mathbf{R}_{\mathbf{c},1}] \leq d_1$ and $r_2 = \mathrm{rank}[\mathbf{R}_{\mathbf{c},2}] \leq d_2$. $\mathbf{U}_1$ and $\mathbf{U}_2$ gather the corresponding eigevectors. We recall that the two MSs' channels are assumed to be independent, hence it is $\mathrm{E}[\tilde{\mathbf{h}}_1 \cdot \tilde{\mathbf{h}}_2^{\text{H}}] = \mathbf{0}$ and the correlation matrix $\mathbf{R}_{\mathbf{c}}$ can be written as

$$\mathbf{R}_{\mathbf{c}} = \begin{bmatrix} \mathbf{R}_{\mathbf{c},1} & \mathbf{0} \\ \mathbf{0} & \mathbf{R}_{\mathbf{c},2} \end{bmatrix} = \underbrace{\begin{bmatrix} \mathbf{U}_1 & \mathbf{0} \\ \mathbf{0} & \mathbf{U}_2 \end{bmatrix}}_{\mathbf{U}} \underbrace{\begin{bmatrix} \mathbf{\Lambda}_1 & \mathbf{0} \\ \mathbf{0} & \mathbf{\Lambda}_2 \end{bmatrix}}_{\mathbf{\Lambda}} \underbrace{\begin{bmatrix} \mathbf{U}_1 & \mathbf{0} \\ \mathbf{0} & \mathbf{U}_2 \end{bmatrix}^{\text{H}}}_{\mathbf{U}^{\text{H}}}, \tag{8}$$

where $\mathbf{\Lambda} = \mathrm{diag}\left[\lambda_{1,1}, \ldots, \lambda_{1,r_1}, \lambda_{1,1}, \ldots, \lambda_{1,r_2}\right]$ collects the eigenvalues of $\mathbf{R}_{\mathbf{c}}$ and $\mathbf{U}$ the corresponding eigenvectors. Notice that it is $r = \mathrm{rank}[\mathbf{R}_{\mathbf{c}}] = r_1 + r_2$.

Using the EVD (8), the effective SNR can now be rewritten as $\gamma_{\text{eff}} = \|\mathbf{b}\|^2 = \sum_{i=1}^{r} b_i^2$, in terms of the projection of the channel onto the r-dimensional column-space of $\mathbf{R}_{\mathbf{c}}$: $\mathbf{b} = \mathbf{U}^{\text{H}}\tilde{\mathbf{h}} = [b_1 \cdots b_r]^{\text{T}}$. Notice that $\mathbf{b} \sim \mathcal{CN}(\mathbf{0}, \mathbf{\Lambda})$, thus the effective SNR is the sum of r independent exponentially distributed variates having as mean values the eigenvalues of $\mathbf{R}_{\mathbf{c}}$. It follows that the pdf of γ_{eff} exhibits the moment-generating function (MGF) [7], [13] :

$$\mathbf{M}_{\gamma_{\text{eff}}}(s) = \prod_{i=1}^{r_1} \frac{1}{1 - \lambda_{1,i}s} \prod_{j=1}^{r_2} \frac{1}{1 - \lambda_{2,j}s}. \tag{9}$$

The integral over γ_{eff} in (5) can now be derived using the alternate integral form of the Q-function [12] and the well known MGF method [13]. We get the average PEP

$$\begin{aligned} P(\mathbf{c}) &= \frac{1}{\pi} \int_0^{\frac{\pi}{2}} \prod_{i=1}^{r_1} \left(1 + \frac{\lambda_{1,i}}{\sin^2 \vartheta}\right)^{-1} \prod_{j=1}^{r_2} \left(1 + \frac{\lambda_{2,j}}{\sin^2 \vartheta}\right)^{-1} d\vartheta \quad (10) \\ &\leq \frac{1}{2} \prod_{i=1}^{r_1} \frac{1}{1 + \lambda_{1,i}} \prod_{j=1}^{r_2} \frac{1}{1 + \lambda_{2,j}}, \quad (11) \end{aligned}$$

upperbounded in (11) using $\sin^2 \vartheta \leq 1$.

We observe that each MS interleaves its own bits and the parity bits computed for the other MS before mapping them into symbols. It follows that the $d = d_1 + d_2$ non-zero bits of the error event $\mathbf{c}$ can appear within the two time frames in several possible configurations, each corresponding to a different shift of $\mathbf{c}$ at the input of the Viterbi decoder. To get an upperbound, we will select for each error event $\mathbf{c}$ the most probable configuration among all these possible shifts by finding the one that maximizes (10).

IV. Simulation Results

We employ a rate $R = 1/4$ RCPC mother-code [10], with octal generators (23, 35, 27, 33) and free distance $d_{\text{free}} = 15$. The mother-code is punctured, obtaining a rate $R_1 = 1/2$ sub-codeword for the first frame transmission ($\alpha = 50\%$). A soft-input hard-output Viterbi decoder is implemented at the receiver-side [11] and the error events $\mathbf{c}$ are found via computer-enumeration. The coded-block length is $N = 512$ bits, resulting in $M = 256$ QPSK symbols. Before symbol

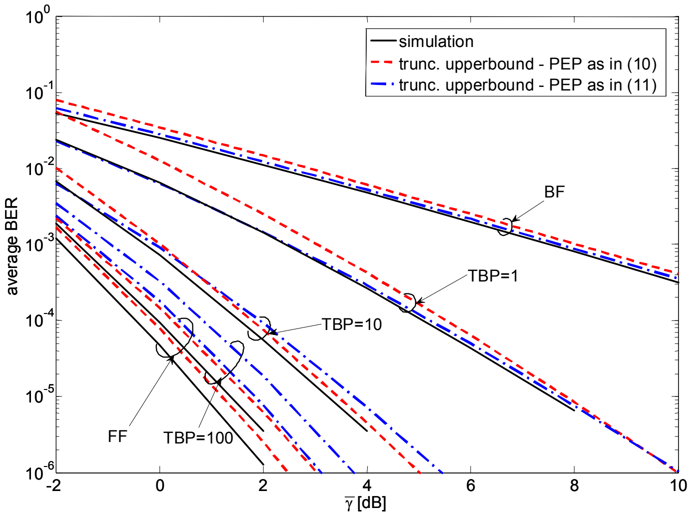

Fig. 3. Performance of coded cooperation.

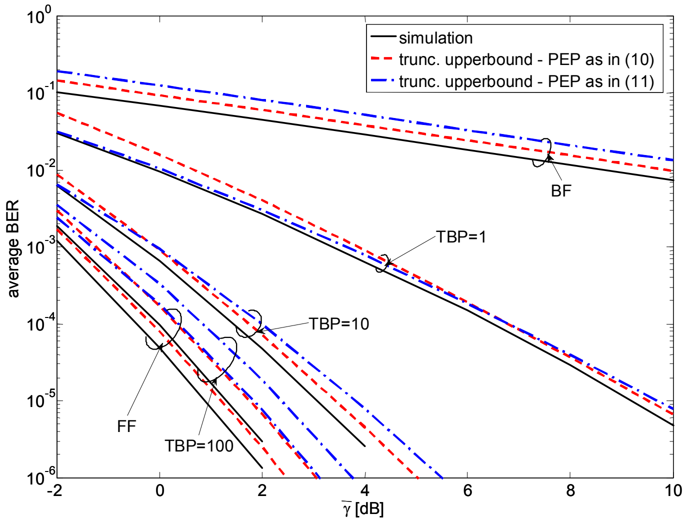

Fig. 4. Performance of no-cooperation.

mapping, the coded bits are interleaved by a block bit-interleaver, which writes the input codeword row by row in a (128×4) matrix, and then reads it column by column. The input codeword at the interleaver is composed of two adjacent sub-codewords: the first $N_1 = N/2$ bits belong to the MS; the remaining $N_2 = N/2$ are the parity bits computed for the partner (cooperation), or the MS's parity bits punctured in the previous frame (no-cooperation). Since the code and the bit-interleaver operate in the same fashion for both the non-cooperative and the cooperative transmissions, the two schemes can be compared fairly. The two MSs transmit on independent time-variant flat-fading channels with the average SNR $\bar{\gamma}_i$ and time-bandwidth product TBP_i, with $i \in \{1, 2\}$. In Fig. 3, 4 and 5 the fading statistics are the same for both uplink channels, i.e. $\bar{\gamma} = \bar{\gamma}_i$ and $\text{TBP} = \text{TBP}_i$, which is almost true if the two MSs are moving at the same speed and are close to each other with respect to the location of the BS. The Jakes' model is implemented as in [9, App. A]: when the MSs do not move, channels remain constant during a frame (BF model), while the channels' coefficients become i.i.d. (FF model) when the speed scales to infinite.

In Fig. 3 and 4, the average BER performance is plotted versus the average SNR $\bar{\gamma}$ at different values of TBP for, respectively, the cooperative and the non-cooperative case. The analytical BER bounds are computed truncating the first summation in (4) at $d = 23$, or at values that are smaller but sufficient to upper bound the simulation results. The average PEP is computed both according to (10) and (11), (for the latter we truncate (4) at $d_{\text{free}} = 15$). We observe that the performance is close to the one obtained for FF if the uplink channel is relatively uncorrelated. Nevertheless, real channels are far from being FF. It is clearly necessary to establish a realistic value of the temporal variability of the channel. We get for instance into a vehicle-to-vehicle communications system with carrier frequency $f_{\text{C}} = 5.2\text{GHz}$. Recent channel measurements presented in [14] show that the delay spread in that specific environment is around $1\mu\text{s}$. This means that, setting the symbol duration $T_{\text{S}} = 10\mu\text{s}$, we ensure that the channel' spectrum is flat. Keeping those values, when the MSs exhibit velocities up to $v = 160\text{km/h}$, the time-bandwidth product TBP goes proportionally up to 4.

In Fig. 5 the validated bounds on the average BER, with PEP computed according to (11), are plotted versus TBP. Coded cooperation and no-cooperation are compared at different average SNR values $\bar{\gamma}$. Up to $\text{TBP} \approx 3$ ($v = 120\text{km/h}$), the performance gain of coded cooperation increases with increasing average SNR. At higher velocities the gain is almost negligible, which means that coded cooperation may become unuseful for $\text{TBP} \gtrsim 3$.

When the two uplink channels show two different values of average SNR and/or velocity, the advantages of cooperation are no longer the same for the two MSs. In Fig. 6 MS-1 moves at $\text{TBP}_1 = 1$ and transmits on a channel with average SNR $\bar{\gamma}_1 = 10\text{dB}$. On the other hand, MS-2's channel conditions are worse, with average SNR that varies from 5dB to 10dB (see the x-axis), and velocity values $\text{TBP}_2 = \{0, 0.5, 1\}$. The performance results suggest that coded cooperation outperforms remarkably no-cooperation only if the MSs are moving approximately at the same speed. The larger is the difference between MSs' velocities, the less advantageous it is for the fastest MS to cooperate. This result needs to be taken into account in the selection of the joint partners.

V. Conclusions

We have provided an analytical method to evaluate the average BER performance of coded cooperation over time-variant flat fading channels. The key of such a method consists of recognizing the algebraic structure of the fading channel autocorrelation associated to the decision variable. The theoretical results have been corroborated and validated by simulation results. The present work has focused on a generic single-carrier transmission system with narrowband channels, but the methodology can be transposed to broadband frequency-selective OFDM systems taking into account the correlation

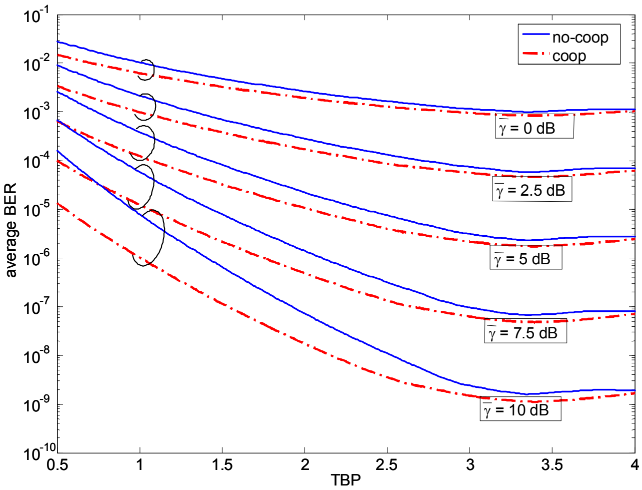

Fig. 5. Coded cooperation and no-cooperation performance comparison.

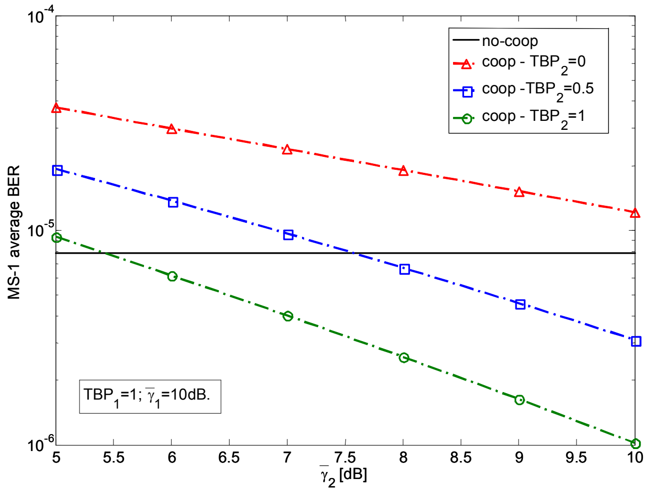

Fig. 6. Performance of MS-1 for asymmetric uplink channel conditions: MS-1 moves with $\text{TBP}_1 = 1$ and $\bar{\gamma}_1 = 10$dB; MS-2 moves at different velocities with varying $\bar{\gamma}_2$.

of the fading channel over the subcarriers. The analysis has at first encompassed the widest range of temporal variability of the fading process, from the BF to the FF model. However, the temporal variability strictly depends on the velocity of the mobile stations, which is necessarily limited. This physical limitation has been taken into account by circumscribing the performance evaluations to a more realistic range of temporal variability of the channel.

Analytical results, validated by simulations, have shown that coded cooperation outperforms significantly a comparable non-cooperative transmission only up to a certain degree of mobility, approximately for a time-bandwidth product TBP $\lesssim 3$. Beyond this limit, coded cooperation and non-cooperative transmissions perform similarly (even for ideal inter-MS channel conditions), since the gain already offered by the temporal diversity is dominant. Moreover, we have investigated how MSs' speed difference affects the BER performance. As expected, the larger is this difference the less advantageous it is to cooperate for the fastest MS. We think that the selection of the cooperating MSs and the optimization of the cooperation level [2] should take also this result into account. We believe that the present work contributes to build the base for future evaluations of coded cooperation in real mobile communication systems, with the support of detailed channel and mobility models.

The straightforward step of this work is the extension of the performance analysis to the case of imperfect inter-MSs channels, i.e. when coded cooperation successes partially or even fails. Preliminary results, not presented here for space limitations, have shown that the velocity limit, beyond which coded cooperation is no more advantageous, decreases with increasing block error probability on the inter-MSs link.

Acknowledgements

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