Opportunistic Cooperative Communications with Reed-Solomon Convolutional Concatenated Codes

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***Abstract*—Cooperative communications delivers spatial diversity for a communication system through the collaborated transmission of network users. Assisted by the intelligent relay selection, opportunistic cooperative communications in which the best relay is always selected for signal re-transmission can deliver a diversity gain on the order of number of relay candidates. It has the advantages of requiring low implementation complexity, alleviating user interference and reducing network power consumption. This paper proposes the coded opportunistic cooperative communication systems in which the widely used Reed-Solomon convolutional concatenated (RSCC) code is applied. Two coded opportunistic cooperative schemes are considered, the coded opportunistic amplify-and-forward (COAF) and the coded opportunistic decode-and-forward (CODF). Information theoretic analyses in term of their diversity-multiplexing tradeoff (DMT) are re-investigated. Those analyses are substantiated by the design of a practical RSCC coded system and its frame error rate (FER) performance.**

***Index Terms*—Cooperative communications, diversity-multiplexing tradeoff, opportunistic relay selection, Reed-Solomon convolutional concatenated codes**

I. Introduction

Cooperative communications [1] introduces spatial diversity for a communication system through user collaboration, generating a multi-path propagation for the transmitted signal. Depending on the signal re-transmission strategies, there are the amplify-and-forward (AF) scheme [1] [2] and the decode-and-forward (DF) scheme [2] [3] [4]. The cooperative diversity gain can be enhanced by introducing multiple relays for signal re-transmission [5], which is named the distributed cooperation. Distributed cooperation schemes [5] [6] [7] can achieve a diversity gain on the order of number of relay candidates and enhance the reliability of system performance.

Although distributed cooperation provides a better diversity gain, it also raises a few implementation concerns. They include the system complexity that is spent on the network user coordination and interference cancellation. It will increase the network power consumption due the signal re-transmissions of multiple relays. Finally, due to the mobility of network users, the strength of a source-relay-destination channel does not remain static. It will be unwise to always engage with a relay that cannot provide a strong uplink channel to the destination. Therefore, ref [9] first showed that assisted by intelligent relay selection, always choosing the best relay to re-transmit the signal will also achieve the same diversity gain as the schemes of [5] [6] [7]. It is called the opportunistic cooperative communications. They include the opportunistic AF (OAF) and opportunistic DF (ODF) schemes. The relay selection can be carried out either with the knowledge of the network channel state information (CSI) [9] [10] [11] [12] [13], or with the knowledge of the network topology [14].

However, most of the current research on opportunistic cooperation concern the information theoretic performances, e.g., the diversity-multiplexing tradeoff (DMT) and the outage probability. Those information theoretic analyses are elaborated with the assumption of applying an ideal error-correction code. It is still unclear how much performance improvement can a practical coded system achieve as a result of the information theoretic advantages. Therefore, this paper proposes the coded opportunistic cooperation systems, in which the widely used Reed-Solomon convolutional concatenated (RSCC) code is applied for error-correction. This paper provides a thorough treatment for the coded system from both the information theoretic and the practical aspects. Although the DMT performance of the coded OAF (COAF) and coded ODF (CODF) schemes were earlier characterised in [9], our DMT re-investigation shows the CSI of the source-relay channels is not necessary to be known at the relays for the CODF scheme. A simple 'max' relay selection criterion can replace the conventional 'max-min' criterion. Finally, in order to evaluate the information theoretic advantage, the RSCC code is employed in both of the COAF and CODF schemes. Frame error rate (FER) performance of both of the schemes are presented.

II. System Model

This section presents the system model for both the COAF and the CODF schemes.

An opportunistic cooperation network consists of a source node (S) and a destination node (D). There exists a set of relay candidates $S_r = \{1, 2, \ldots, N\}$ that are willing to re-transmit the information of S. It is assumed that all nodes transmit with the equal energy ε that is normalised as $\varepsilon = 1$. Let σ^2 denote the variance of noise observed at the receiver, the channel signal-to-noise ratio (SNR) is measured by:

$$\rho = \frac{\varepsilon}{\sigma^2}. \tag{1}$$

For simplicity, it is assumed that all channels of the network exhibit a similar ρ value and all the nodes operate with the half-duplex constraint.

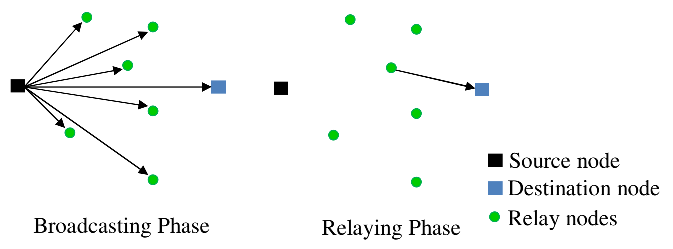

Fig. 1. Opportunistic cooperative communications

Both the COAF and CODF schemes can be described by a two-phase transmission as indicated by Fig.1. In the broadcasting phase, S will broadcast its signal to both D and the relays as:

$$y_D[i] = \alpha_{SD} x_s[i] + n_D[i], \;\; i = 1, 2, \ldots, l, \tag{2}$$

$$y_k[i] = \alpha_{Sk} x_s[i] + n_k[i], \;\; i = 1, 2, \ldots, l, \tag{3}$$

where $k \in S_r$. In this paper, x_S is the modulated symbols of an RSCC codeword of S and l denotes the length of the symbol sequence. n_D and n_k denote the additive white Gaussian noise (AWGN) observed at D and relay k respectively. They are modelled as zero-mean, mutually independent complex random sequences with variances σ_D^2 and σ_k^2. In the relaying phase, if b ($b \in S_r$) is selected as the best relay for signal re-transmission, D will receive:

$$y_D[i] = \alpha_{bD} x_b[i] + n_D[i], \;\; i = l+1, l+2, \ldots, 2l. \tag{4}$$

Depending on the opportunistic cooperation strategies, there are different interpretations of re-transmitted symbols x_b.

In the COAF scheme, the best relay is selected according to the 'max-min' criterion as [9]:

$$b = \arg \max_{k \in S_r} \{\min\{|\alpha_{Sk}|^2, |\alpha_{kD}|^2\}\}. \tag{5}$$

x_b is the amplified and delayed version of y_b:

$$x_b[i] = \beta_b y_b[i - l], \tag{6}$$

where the amplification factor $\beta_b \leq (|\alpha_{Sb}|^2 \varepsilon + \sigma_b^2)^{-\frac{1}{2}}$ [2].

In the CODF scheme, all the relays will try to decode the message of S. Only those relays that can decode the message correctly will be selected for signal re-transmission. If the transmission rate of the system is R bits/s/Hz, a correct decoding at relay k requires:

$$\log(1 + |\alpha_{Sk}|^2 \rho) > \mathrm{R}, \tag{7}$$

where the base of the logarithm is 2. Those relays with the source-relay channel gain satisfying the above inequality will form a set S_r^* as:

$$S_r^* = \{k | \log(1 + |\alpha_{Sk}|^2 \rho) > \mathrm{R}\}. \tag{8}$$

Note that $S_r^* \subseteq S_r$. The best relay b is then selected from S_r^* according to:

$$b = \arg \max_{k \in S_r^*} \{|\alpha_{kD}|^2\}. \tag{9}$$

This is called the 'max' criterion. In Section III, it will be shown that this criterion can enable the CODF scheme to fully exploit the diversity gain. Moreover, x_b is an accurate estimation of x_S as:

$$x_b[i] = x_S[i - l]. \tag{10}$$

Notice that S_r^* can be an empty set implying none of the relays of S_r can decode S's message correctly. In such a scenario, S will re-transmit its signal again in the relaying phase. Consequently, in the relaying phase, D receives:

$$y_D[i] = \alpha_{SD} x_S[i - l/2] + n_D[i], \;\; i = l+1, l+2, \ldots, 2l. \tag{11}$$

In the above equations, α_{AB} denotes the complex Rayleigh fading coefficient of channel between nodes A and B. All the channels of the network are statistically independent and exhibit Quasi-Static fading. The channel quality is represented by the averaged squared channel gain that is defined as:

$$\Omega_{AB} = \mathbb{E}\{|\alpha_{AB}|^2\}. \tag{12}$$

Moreover, $|\alpha_{AB}|^2$ follows a chi-square distribution [9]:

$$\Pr[|\alpha_{AB}|^2 \leq \rho^{-v}] = 1 - e^{-\frac{1}{2}\rho^{-v}} \doteq \rho^{-v}, \tag{13}$$

where v is a nonnegative real value. Note that $\doteq$ denotes the asymptotic equality with $\rho \to \infty$, and $\dot{\leq}$ is defined similarly.

III. Information Theoretic Analysis

This section presents the information theoretic analysis for the COAF and CODF schemes. Our analysis re-characterises the DMT performances for the schemes.

The following DMT definition is given as the prerequisite knowledge of our analysis.

Definition I: Let us consider a coded system that operates at a SNR of ρ. If it can achieve an outage probability of $P_O(\rho)$ and an average transmission rate of $\mathrm{R}(\rho)$ bits/s/Hz, the diversity gain d and multiplexing gain r are defined as [8]:

$$d = -\lim_{\rho \to \infty} \frac{\log P_O(\rho)}{\log \rho}, r = \lim_{\rho \to \infty} \frac{\mathrm{R}(\rho)}{\log \rho}. \tag{14}$$

The derived relationship between d and r is called the diversity-multiplexing tradeoff, denoted as $d(r)$. The system outage probability can be expressed as: $P_O(\rho) \dot{\leq} \rho^{-d(r)}$.

A. The COAF scheme

The signal model of the COAF scheme presented in Section II can be written in a matrix form as:

$$\begin{bmatrix} y_D[i] \\ y_D[i+l] \end{bmatrix} = \underbrace{\begin{bmatrix} \alpha_{SD} \\ \alpha_{Sb}\beta_b\alpha_{bD} \end{bmatrix}}_{\Sigma} x_S[i] + \underbrace{\begin{bmatrix} 1 & 0 & 0 \\ 0 & \beta_b\alpha_{bD} & 1 \end{bmatrix}}_{\Omega} \underbrace{\begin{bmatrix} n_D[i] \\ n_b[i] \\ n_D[i+l] \end{bmatrix}}_{\Gamma} \tag{15}$$

and $i = 1, 2, \ldots, l$. The mutual information of the COAF scheme ($\mathcal{I}_{\text{COAF}}$) can be determined by:

$$\begin{aligned}\mathcal{I}_{\text{COAF}} &= \frac{1}{2}\log\det(\mathbf{I}_2 + \varepsilon\Sigma\Sigma^\dagger(\Omega\mathbb{E}\{\Gamma\Gamma^\dagger\}\Omega^\dagger)^{-1}) \\ &= \frac{1}{2}\log(1 + |\alpha_{SD}|^2\rho + \frac{|\alpha_{Sb}|^2\beta_b^2|\alpha_{bD}|^2\rho}{\beta_b^2|\alpha_{bD}|^2+1}) \\ &= \frac{1}{2}\log(1 + |\alpha_{SD}|^2\rho + f(|\alpha_{Sb}|^2\rho, |\alpha_{bD}|^2\rho)).\end{aligned} \tag{16}$$

Note that $\mathbf{I}_2$ denotes a 2×2 identity matrix, M^{-1} and $\mathrm{M}^\dagger$ denote the inverse and Hermitian conjugate of matrix M respectively. The third equality is achieved with $\beta_b = (|\alpha_{Sb}|^2\varepsilon + \sigma_b^2)^{-\frac{1}{2}}$ and function $f(\omega, \mu) = \frac{\omega\mu}{\omega+\mu+1}$.

Given a system transmission rate of $\mathrm{R} \doteq r\log\rho$ bits/s/Hz, the outage probability of the scheme can be determined by:

$$P_O^{\text{COAF}} = \Pr[\mathcal{I}_{\text{COAF}} \le \mathrm{R}] \doteq \Pr[\mathcal{I}_{\text{COAF}} \le r\log\rho]. \tag{17}$$

By substituting (16) into (17), we have

$$\begin{aligned}P_O^{\text{COAF}} &\doteq \Pr[1 + |\alpha_{SD}|^2\rho + f(|\alpha_{Sb}|^2\rho, |\alpha_{bD}|^2\rho) \le \rho^{2r}] \\ &\le \Pr[|\alpha_{SD}|^2\rho + f(|\alpha_{Sb}|^2\rho, |\alpha_{bD}|^2\rho) \le \rho^{2r}] \\ &\le \Pr[|\alpha_{SD}|^2 \le \rho^{-(1-2r)^+}] \times \\ &\quad\ \Pr[f(|\alpha_{Sb}|^2\rho, |\alpha_{bD}|^2\rho) \le \rho^{2r}],\end{aligned} \tag{18}$$

where $(\omega)^+ = \max\{\omega, 0\}$. According to (13), it is known:

$$\Pr[|\alpha_{SD}|^2 \le \rho^{-(1-2r)^+}] \doteq \rho^{-(1-2r)^+}. \tag{19}$$

Furthermore, according to Lemma 4 of [9], it is known:

$$\begin{aligned}&\Pr[f(|\alpha_{Sb}|^2\rho, |\alpha_{bD}|^2\rho) \le \rho^{2r}] \\ &\quad\le \Pr[\min\{|\alpha_{Sb}|^2, |\alpha_{bD}|^2\} \le \rho^{2r-1} + \rho^{r-1}\sqrt{1+\rho^{2r}}] \\ &\quad\doteq \Pr[\min\{|\alpha_{Sb}|^2, |\alpha_{bD}|^2\} \le \rho^{-(1-2r)^+}].\end{aligned} \tag{20}$$

Recalling the 'max-min' criterion of (5), we have:

$$\begin{aligned}&\Pr[\min\{|\alpha_{Sb}|^2, |\alpha_{bD}|^2\} \le \rho^{-(1-2r)^+}] \\ &\quad= \prod_{k=1}^{N}\Pr[\min\{|\alpha_{Sk}|^2, |\alpha_{kD}|^2\} \le \rho^{-(1-2r)^+}] \\ &\quad\doteq \rho^{-N(1-2r)^+}.\end{aligned} \tag{21}$$

Therefore, outage probability of the COAF scheme is upper bounded by:

$$P_O^{\text{COAF}} \dot{\le} \rho^{-(N+1)(1-2r)^+}. \tag{22}$$

It shows that the COAF scheme can achieve a maximal diversity gain on the order of number of relay candidates.

B. The CODF Scheme

The CODF scheme has two possible transmission scenarios: Scenario I where S_r^* is not an empty set ($S_r^* \ne \emptyset$), the selected relay b will re-transmit the signal of S to D in the relaying phase; Scenario II where S_r^* is an empty set ($S_r^* = \emptyset$), S will re-transmit its signal again in the relaying phase.

In Scenario I, the signal model of the CODF scheme can be written in a matrix form as:

$$\begin{bmatrix} y_D[i] \\ y_D[i+l] \end{bmatrix} = \underbrace{\begin{bmatrix} \alpha_{SD} \\ \alpha_{bD} \end{bmatrix}}_{\Sigma} x_S[i] + \underbrace{\begin{bmatrix} n_D[i] \\ n_D[i+l] \end{bmatrix}}_{\Gamma}, \tag{23}$$

where $i = 1, 2, \ldots, l$. The mutual information of such a transmission can be determined by:

$$\begin{aligned}\mathcal{I}_{\text{CODF(I)}} &= \frac{1}{2}\log\det(\mathbf{I}_2 + \varepsilon\Sigma\Sigma^\dagger(\mathbb{E}\{\Gamma\Gamma^\dagger\})^{-1}) \\ &= \frac{1}{2}\log(1 + |\alpha_{SD}|^2\rho + |\alpha_{bD}|^2\rho).\end{aligned} \tag{24}$$

The outage probability can be determined by:

$$P_O^{\text{CODF(I)}} = \Pr[\mathcal{I}_{\text{CODF(I)}} \le \mathrm{R}] \doteq \Pr[\mathcal{I}_{\text{CODF(I)}} \le r\log\rho]. \tag{25}$$

By substituting (24) into (25), we have:

$$\begin{aligned}P_O^{\text{CODF(I)}} &\doteq \Pr[1 + |\alpha_{SD}|^2\rho + |\alpha_{bD}|^2\rho \le \rho^{2r}] \\ &\le \Pr[|\alpha_{SD}|^2 \le \rho^{-(1-2r)^+}] \times \\ &\quad\ \Pr[|\alpha_{bD}|^2 \le \rho^{-(1-2r)^+}].\end{aligned} \tag{26}$$

Again, based on the 'max' criterion of (9), we have:

$$\begin{aligned}\Pr[|\alpha_{bD}|^2 \le \rho^{-(1-2r)^+}] &= \prod_{k\in S_r^*}\Pr[|\alpha_{kD}|^2 \le \rho^{-(1-2r)^+}] \\ &\doteq \rho^{-|S_r^*|(1-2r)^+}.\end{aligned} \tag{27}$$

Assisted by (19), the outage probability of (26) can be further simplified to:

$$P_O^{\text{CODF(I)}} \dot{\le} \rho^{-(|S_r^*|+1)(1-2r)^+}. \tag{28}$$

In Scenario II, the mutual information of the scheme is:

$$\mathcal{I}_{\text{CODF(II)}} = \frac{1}{2}\log(1 + |\alpha_{SD}|^2\rho). \tag{29}$$

The outage probability of Scenario II can be determined by:

$$\begin{aligned}P_O^{\text{CODF(II)}} &= \Pr[\mathcal{I}_{\text{CODF(II)}} \le \mathrm{R}] \doteq \Pr[\mathcal{I}_{\text{CODF(II)}} \le r\log\rho] \\ &= \Pr[1 + |\alpha_{SD}|^2\rho \le \rho^{2r}] \\ &\le \Pr[|\alpha_{SD}|^2 \le \rho^{-(1-2r)^+}] \\ &\doteq \rho^{-(1-2r)^+}.\end{aligned} \tag{30}$$

Let $\Pr[S_r^* = \emptyset]$ denote the probability of S_r^* being an empty set, which can be determined by:

$$\Pr[S_r^* = \emptyset] = \prod_{k=1}^{N}\Pr[\log(1 + |\alpha_{Sk}|^2\rho) \le \mathrm{R}]. \tag{31}$$

The outage probability of the CODF scheme can therefore be determined by:

$$P_O^{\text{CODF}} = (1 - \Pr[S_r^* = \emptyset])P_O^{\text{CODF(I)}} + \Pr[S_r^* = \emptyset]P_O^{\text{CODF(II)}}. \tag{32}$$

Based on both (31) and (8), it can be aware that with $\rho \to \infty$, $\Pr[S_r^* = \emptyset]$ and $|S_r^*| = |S_r| = N$. Therefore, the asymptotic behavior of CODF scheme's outage probability is dominated by Scenario I and

$$P_O^{\mathrm{CODF}} \doteq P_O^{\mathrm{CODF(I)}} \dot{\leq} \rho^{-(N+1)(1-2r)^+}. \tag{33}$$

It indicates the CODF scheme can also achieve a diversity gain on the order of number of relay candidates. Moreover, equation (27) shows that the 'max' criterion of (9) can enable the CODF scheme to fully exploit the diversity gains.

IV. RSCC Coded System Design

The above information theoretic analysis shows that for both of the COAF and CODF schemes, diversity gain can be raised by increasing the number of relay candidates. Since the DMT performances are characterised under the assumption of the deployment of an error-correction code, it is desirable to investigate the application of some of the currently used coding schemes and evaluate their practical performance gains.

Due to its strong error-correction capability and efficient decoding process, the RSCC code is widely used in modern communication systems [15]. In this concatenated coding scheme, the Reed-Solomon (RS) code and the convolutional code are used as an outer code and an inner code respectively. In most of such concatenated coding schemes, the block interleaver and deinterleaver are introduced between the two encoders and decoders respectively. They introduce the time diversity of the fading coefficients into the RS codeword. However, in the presented cooperative system, each channel of the network exhibits a Quasi-Static fading implying the fading coefficients remain unchanged during the transmission of one codeword. For consistency, the assumption of Quasi-Static fading is also adopted in the proposed coded system. The time diversity of fading coefficients does not exist within each codeword. Hence, the block interleaver and deinterleaver are omitted in the coded system.

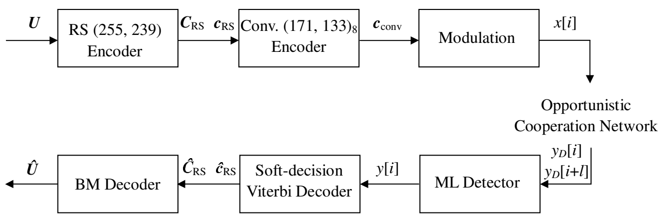

Fig. 2. The RSCC coded communication system

Fig.2 shows the design of the RSCC coded communication system. The (255, 239) RS code and the rate half $(171, 133)_8$ convolutional code are used as the outer code and inner code respectively. The RS code is defined in the finite field of 256 that is denoted by $\mathbb{F}_{256}$. 255 and 239 are the length and dimension of the code respectively. This RS code has a Hamming distance of 17 and is capable of correcting up to 8 symbol errors. The $(171, 133)_8$ convolutional code is a 64-state trellis code with a constraint length of 7. $(171, 133)_8$ represents its generator polynomials that are written in an octal form. The quadrature phase shift keying (QPSK) modulation scheme is used to generate the transmitted symbols $x_S[i]$ (or $x_b[i]$). The Maximum Likelihood (ML) detector is used to detect and combine the received symbols $y_D[i]$ and $y_D[i+l]$ as:

$$y[i] = w_D y_D[i] + w_D' y_D[i+l], \ \ i = 1, 2, ..., l, \tag{34}$$

where w_D and w_D' are ML combining gains [1].

Let $\boldsymbol{U}$ denote the non-binary message vector that contains 239 message symbols. It is to be encoded by a (255, 239) RS encoder, yielding an RS codeword $\boldsymbol{C}_{\mathrm{RS}}$ that contains 255 codeword symbols. Codeword vector $\boldsymbol{C}_{\mathrm{RS}}$ is further decomposed into a binary vector $\boldsymbol{c}_{\mathrm{RS}}$ of 2040 bits. The binary codeword vector $\boldsymbol{c}_{\mathrm{RS}}$ is then taken as an input to the $(177, 133)_8$ convolutional encoder, generating the codeword vector $\boldsymbol{c}_{\mathrm{conv}}$ of 4080 bits. Every two consecutive bits of $\boldsymbol{c}_{\mathrm{conv}}$ are mapped to a QPSK symbol that is ready to be transmitted through the cooperative channel.

At the receiver, the detected symbols $y[i]$ are then passed into the soft-decision Viterbi decoder [16]. The decoder yields an estimation of the binary codeword vector $\boldsymbol{c}_{\mathrm{RS}}$, and it is denoted by $\hat{\boldsymbol{c}}_{\mathrm{RS}}$. Each eight consecutive bits of $\hat{\boldsymbol{c}}_{\mathrm{RS}}$ will form a $\mathbb{F}_{256}$ symbol and $\hat{\boldsymbol{c}}_{\mathrm{RS}}$ will then form the estimated non-binary RS codeword vector $\hat{\boldsymbol{C}}_{\mathrm{RS}}$. $\hat{\boldsymbol{C}}_{\mathrm{RS}}$ will then be taken as an input to the Berlekamp-Massey decoder [17] to produce the decoded message vector $\hat{\boldsymbol{U}}$. $\hat{\boldsymbol{U}}$ is to be compared with $\boldsymbol{U}$ in order to evaluate if a frame error occurs.

V. Performance Evaluations

This section presents the FER performance of the COAF and CODF schemes in which the above mentioned RSCC code is deployed. Depending on the channel quality that is represented by the averaged squared channel gain, there are two different simulation platforms. Platform A: all the channels of the cooperative network exhibit statistically similar qualities ($\Omega_{Sk} = \Omega_{kD} = \Omega_{SD} = 2.0$). Platform B: the relay-destination channels exhibit better qualities than the source-relay and source-destination channels ($\Omega_{kD} = 2.0, \Omega_{Sk} = \Omega_{SD} = 1.0$).

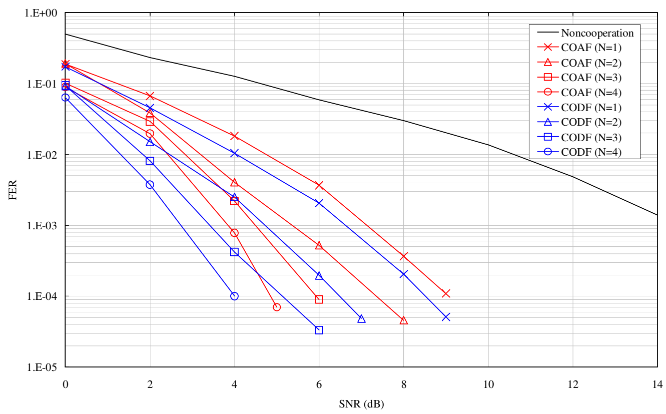

Fig. 3. FER performance of the COAF and CODF schemes in platform A

Figs.3 and 4 show the FER performance of the COAF and CODF schemes in platforms A and B respectively. Both of the figures show that by increasing the number of relay candidates, significant performance gains can be achieved. In a coded system, these performance gains are sustained by the transmission

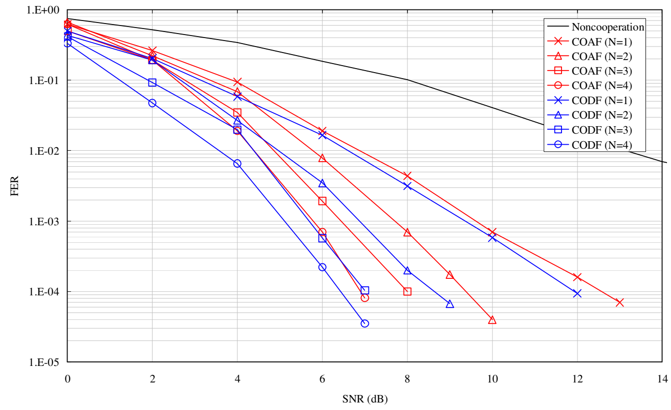

Fig. 4. FER performance of the COAF and CODF schemes in platform B

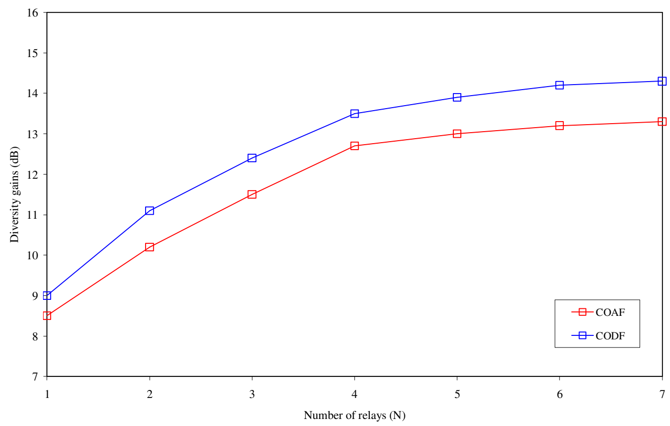

Fig. 5. Achievable diversity gains with respect to the number of relays

diversity gains and coding gains. For example, in platform A, with increasing the number of relay candidates from 1 to 4, 4.5dB performance gain can be achieved for the CODF scheme at FER of 10^{-4}. A similar performance improvement can also be achieved for the COAF scheme. With the same number of relay candidates, the CODF scheme outperforms the COAF scheme. This is due to the fact that through the decoding/re-encoding process at the relays, the noise interference of the source-relay channel is eliminated in the relaying phase. It can also be noticed that the performance improvement is more significant in platform B where the relays have better quality uplink channels to node D. For example, with increasing the number of relay candidates from 1 to 4, 5.5dB diversity gain can be achieved for the CODF scheme at FER of 10^{-4}. It demonstrates the advantage of opportunistic cooperation, especially when the relay-destination channels have a better quality than other channels of the network. Moreover, fig. 5 shows the achievable diversity gains with respect to the number of relays in platform A. They are measured at FER of 10^{-4} and against noncooperation. It shows for both of the schemes, when $N > 5$, only marginal diversity gain can be achieved. In general, the presented results validate the promised diversity gains that are analysed in Section III.

VI. Conclusions

This paper has proposed the coded opportunistic cooperative communication systems in which the RSCC code is applied. Two opportunistic cooperative schemes: the COAF and CODF schemes were considered. Their information theoretic analyses in term of DMT performance were re-investigated, aiming to show their capability of achieving a diversity gain on the order of number of relay candidates. Knowing the promised diversity gains are derived with the assumption of using an error-correction code, we have designed an RSCC coded system in order to evaluate the information theoretic gains in a practical coded system. Our simulation results demonstrated that the RSCC coded opportunistic cooperative system can indeed exploit the diversity benefit. Due to the wide applications of the RSCC code in modern communication systems, this paper provides a useful insight into the practicality of the opportunistic cooperative communications.

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