

# Delay Limited Transmission Techniques with Low Density Parity Check Method of Quasi Stationary Sources Over Block Fading Channels

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**Abstract**-In a Quasi stationary sources time utilization takes a major role. To implement the delay limited transmission of Quasi stationary sources over block fading channels is considered. Here to reduce the delay we propose the power adaption schemes here we can implement the analytical distortion outage probability as performance measure and also derive the power of each transmission scheme are presented. The first one is optimized for fixed rate transmission, and hence enjoys simplicity of implementation. The second one is a high performance scheme, which also benefits from optimized rate adaptation with respect to source and channel states for High SNR regime, the asymptotic outage distortion gain are derived. Here another two schemes with fixed transmission powers and adaptive rates are consider for comparisons here source and channel coded optimized power adaption scheme outperforms compare to other schemes, by adding the low density parity check method the delay can be reduced rapidly by using the proposed method.

**Keywords:** *Quasi stationary sources, Channel coding, Block fading*

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## I. INTRODUCTION

Shannon's source-channel separation theorem states that, in point-to-point communication systems, a source can be reliably transmitted over a channel if and only if the minimum source coding rate is below the channel capacity [1]. This means that a simple comparison of the rates of the optimal source and channel codes for the underlying source and channel distributions, respectively, suffices to conclude whether reliable transmission is possible or not. Furthermore, the separation theorem dictates that the source and channel codes can be designed independently without loss of optimality. This theoretical optimality of modularity has reinforced the notion of network layers, leading to the separate development of source and channel coding aspects of a communication system. The separation theorem holds for stationary and ergodic sources and channels under the usual information theoretic assumptions of infinite delay and complexity (see [2] for more general conditions under which separation holds). However, Shannon's source channel separation theorem does not generalize to multiuser networks. Sub optimality of separation for multiuser systems was first shown by Shannon in [3], where an example of correlated source transmission over the two-way channel was provided. Later, a similar observation was made for transmitting correlated sources over multiple access channels (MACs) in [4]. The example provided in [4] reveals that comparison

Multiuser channel coding in this very general setting is extremely complicated. If the channels are assumed to be noise free finite capacity links, the problem reduces to a multiterminal source coding problem [1]; alternatively, if the sources are independent, then we must find the capacity region of a general communication network. Furthermore, considering that we do not have a separation result for source and channel coding even in the case of very simple networks, the hope for solving this problem in the general setting is slight.

The paper is organized as follows. Following the proposed method in Section II, Section III presents the design based on fixed source coding rate for minimized distortion

outage probability. Next, in Section IV, we present the adaptive rate and power source and channel coding design. Finally performance evaluations and comparisons are presented in Section V

## II. PROPOSED METHOD

We consider the transmission of a quasi-stationary source over a block fading channel. Specifically, the source is finite state quasi-stationary Gaussian with zero mean and variance  $2s$  in a given block, where  $s \in S : S = \{1, 2, \dots, N_s\}$  [18]. The source state  $s$  from the set  $S$  is a discrete random variable with the probability mass function (pmf)  $P(s)$ . The source coding rate in a block in state  $s$ , is denoted by  $R_s$  bits per source sample. Hence, according to the distortion-rate function of a Gaussian source [18][19], the instantaneous distortion in a block in state  $s$  is given by  $D = 2s 2^{-2R_s}$ . We consider a point to point wireless block fading channel for transmitting the source information to the destination. Let  $X$ ,  $Y$  and  $Z$ , respectively indicate channel input, output and additive noise, where  $Z$  is an i.i.d Gaussian noise  $\sim N(0, 1)$ . Therefore, we have  $Y = X + Z$ , where  $\alpha$  is the multiplicative fading. The channel gain  $\alpha$  is constant across one block and independently varies from one block to another according to the continuous probability density function  $f(\alpha)$ . For a Rayleigh fading channel,  $\alpha$  is a Rayleigh distributed random variable and consequently, the channel gain  $\alpha$  is an exponentially distributed random variable, where we here consider  $E[\alpha] = 1$ . The block diagram of the system is depicted in Fig. 1. We consider  $K$  source samples spanning one source block coded into a finite index by the source encoder. This index is transmitted in  $N$  channel uses spanning one fading block (bandwidth expansion ratio  $b = NK$ , where  $b \geq 1$ ). We assume that  $K$  and  $N$  are large enough such that, over a given state of source and channel, the rate distortion function of the quasi stationary source and the instantaneous capacity of the block fading channel may be achieved. The source coding rate  $R_s$  in bits per source sample and channel coding rate  $R$  in bits per channel use are related by  $R_s = bR$ . Note that in general  $R_s$  and  $R$  may be both designed to depend on source and channel states, i.e.,  $R_s = R_s(\alpha, s)$  and  $R = R(\alpha, s)$ .

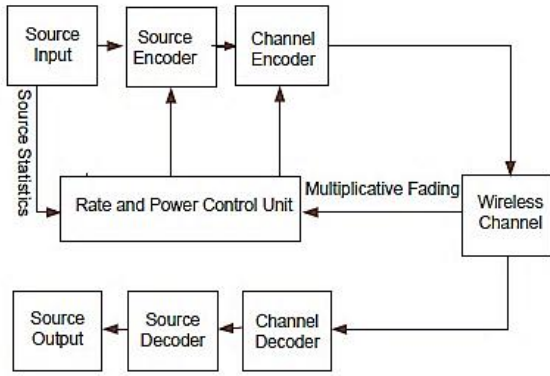


Fig. 1. Block diagram of the system.

$R(s, \gamma)$ . The instantaneous capacity of the fading Gaussian channel [3] over one block (in bits per channel use) is defined as

$$C(\alpha, \gamma) = \frac{1}{2} \log_2(1 + \alpha\gamma), \tag{1}$$

The outage distortion exponent is defined as

$$\Delta_{OD} = \lim_{\bar{P} \rightarrow \infty} -\frac{\ln P_{Dout}}{\ln \bar{P}}. \tag{2}$$

Let  $P_1$  and  $P_2$  be the average powers transmitted to asymptotically achieve a specific distortion outage probability by two different schemes. We define the asymptotic outage distortion gain as follows

$$G_{OD} = 10 \log_{10} \bar{P}_2 - 10 \log_{10} \bar{P}_1. \tag{3}$$

### III. CHANNEL OPTIMIZED POWER ADAPTATION SCHEMES

In this section, the aim is to find the optimized power allocation strategy and fixed rate such that the distortion outage probability for communication of a quasi-stationary source over a wireless fading channel is minimized. With a fixed rate ( $R$  does not change from one block to another), the encoders do not need to be rate adaptive which simplifies the design and implementation of transceivers. Noting (3) the distortion outage probability is computed as follows

$$P_{Dout} = \Pr(R > C(\alpha, \gamma)) \Pr(\sigma_s^2 > D_m) + (1 - \Pr(R > C(\alpha, \gamma))) \Pr(\sigma_s^2 2^{-2bR} > D_m) \tag{4}$$

The power allocation in this setting may be interpreted as water-filling with respect to the channel state and the source and channel statistics. The next two Propositions quantify the performance of the proposed COPA-MDO scheme in terms of the

resulting distortion outage probability and outage distortion exponent, respectively.

The distortion outage probability obtained by COPA-MDO scheme for transmission of a quasi-stationary source over a Rayleigh block fading channel is given by Thus, we have

$$P_{Dout} \cong \Pr(\sigma_s^2 > D_m) \exp\left(\frac{-\bar{P}}{\left(\frac{\max\{\sigma_s^2\}}{D_m}\right)^{\frac{1}{b}} - 1}\right) \tag{5}$$

And therefore,

$$\Delta_{OD} = \lim_{\bar{P} \rightarrow \infty} \frac{\frac{\bar{P}}{\left(\frac{\max\{\sigma_s^2\}}{D_m}\right)^{\frac{1}{b}} - 1} - \ln \Pr(\sigma_s^2 > D_m)}{\ln \bar{P}} \tag{6}$$

Hence, the proof is complete. For the optimized fixed rate  $R^*$ , the distortion outage exponent enhances when the average power limit  $\bar{P}$  increases. In the following three Corollaries, we summarize the implications of the COPA-MDO design for transmission of stationary sources over block fading channels. The stationary source is a Gaussian with zero mean and variance  $2 D_m$ . Obviously, with  $2 < D_m$ , the distortion outage probability is equal to zero. The results are directly obtained from Propositions 1, 2, 3 and 4 and allows for insights into the system performance as it relates to source statistical characteristics.

*Corollary 1:* The optimum power adaptation and channel coding rate prescribed by COPA-MDO for transmission of a stationary source over a block fading channel are given by

$$R^* = \frac{1}{2b} \log_2 \frac{\sigma^2}{D_m} \tag{7}$$

and

$$\gamma^* = \begin{cases} \frac{\left(\frac{\sigma^2}{D_m}\right)^{\frac{1}{b}} - 1}{\alpha} & \text{if } \alpha \geq \frac{\left(\frac{\sigma^2}{D_m}\right)^{\frac{1}{b}} - 1}{q_1^*} \\ 0 & \text{otherwise} \end{cases} \tag{8}$$

*Corollary 2:* The distortion outage probability obtained by COPA-MDO for transmission of a stationary source over a Rayleigh block fading channel is given by

$$P_{Dout} = 1 - \exp\left(-\frac{\left(\frac{\sigma^2}{D_m}\right)^{\frac{1}{b}} - 1}{q_1^*}\right) \tag{9}$$

with  $q_1^*$  satisfying the following equation. The results in Corollary 2 is obtained noting that  $2 > D_m$  and  $\Pr(2s2^{-2bR^*} > D_m) = 0$  for stationary sources.

*Corollary 3:* For communication of a stationary source over a Rayleigh block fading channel and with large average power limit  $\bar{P}$ , the COPA-MDO scheme achieves the outage distortion exponent.

### IV.SOURCE AND CHANNEL OPTIMIZED POWER AND RATE ADAPTATION

In this section, we consider power and rate adaptation with regard to source and channel states for improved performance of communications of a quasi-stationary source over a wireless block fading channel. Thus, the objective in this section is to devise power and rate adaptation strategies for each state ( $s, \gamma$ ) such that the distortion outage probability is minimized, when the average power is constrained to  $\bar{P}$ . We have the following design problem.

**Problem:** The problem of delay-limited source and channel optimized power adaptation for transmission of a quasi stationary source with minimum distortion outage probability (SCOPA-MDO) over a block fading channel is formulated as follows

$$\begin{aligned} \min_{\gamma, R} P_{\text{Dout}} &= \Pr(D(\sigma_s, \alpha, \gamma) > D_m) \\ \text{subject to } E[\gamma] &\leq P, \end{aligned} \quad (10)$$

The distortion outage probability for transmission of a quasi-stationary source using the SCOPA-MDO scheme over a Rayleigh block fading channel is given by

$$P_{\text{Dout}} = \Pr(\sigma_s^2 > D_m) - \sum_{s: \sigma_s^2 > D_m} \exp\left(-\frac{\left(\frac{\sigma_s^2}{D_m}\right)^{\frac{1}{b}} - 1}{q_s^*}\right) P(s) \quad (11)$$

Hence, noting for  $q \neq 2$  we obtain

$$\Delta_{OD} = \lim_{\bar{P} \rightarrow \infty} \frac{\bar{P}}{\ln \bar{P} \sum_{s: \sigma_s^2 > D_m} \left(\left(\frac{\sigma_s^2}{D_m}\right)^{\frac{1}{b}} - 1\right) P(s)} \quad (12)$$

Thus, the proof is completed. The following Corollary expresses the implication of the SCOPA-MDO design for transmission of a stationary source over block fading channels. This is directly obtained from Proposition 5 when a stationary source is assumed.

In the case of a stationary source, the optimized source coding rate in SCOPA-MDO reduces to  $12b \log_2(2D_m)$ , which is fixed and equal to that of COPAMDO. The power adaptation in both schemes now coincide as they both depend on the same source coding rates and the power constraints. Hence, both schemes provide the same performance with stationary sources.

**4.1 Low Density parity check Method:**

A parity check matrix is an r-row by n-column binary matrix. Remember k=n-r. The rows represent the equations and the columns represent the digits in the code word. There is a 1 in the i-th row and j-th column if and only if the i-th code digit is contained in the j-th equation.

For a code word of the form c1, c2, c3, c4, c5, c6, c7, the equations are:

$$c1 + c2 + c3 + c5 = 0$$

$$c1 + c2 + c4 + c6 = 0$$

$$c1 + c3 + c4 + c7 = 0.$$

The inherent parallelism in decoding LDPC codes suggests their use in high data rates systems. The performance of SCOPA-MDO scheme is studied in Section V.

**IV. PERFORMANCE EVALUATION**

In this section, we first present two constant power transmission schemes as benchmarks for comparisons. Next, we consider analytical performance comparison of different schemes followed by numerical results. To this end, we consider three quasi-stationary sources, with  $N_s = 25$  where the variance of the source in the state  $s$  is given by  $2s (s) = (1 + s - 16) / 2 : \forall s \in \{1, \dots, N_s\}$ . For two of the sources, labeled as G1 and G2, the probability of being in different states follows a discrete Gaussian distribution with means 14.34, 13.89 and variances 2, 19, respectively. For the third source, U, the said distribution is considered uniform with mean 13 and a

variance of 52. We also consider an stationary source S with  $2 = 10.44$  for a meaningful comparison. Unless otherwise mentioned, we consider the source G2 for the following results and simulations.

Two constant power schemes for transmission of a quasi stationary source over a block fading channel are considered as benchmarks for comparisons. In the first scheme, the channel coding rate is adjusted based on the channel state to minimize the distortion outage probability; hence the scheme is labeled as Channel Optimized Rate Adaptation with Constant Power (CORACP). In the second scheme with Constant Rate and Constant Power (CRCP), the aim is to find the optimized fixed rate such that the distortion outage probability is minimized.

**51. Channel Optimized Rate Adaptation with Constant Power:**

With CORACP and constant transmission power  $P$ , the instantaneous capacity is given by  $C(\cdot) = 12 \log_2(1 + \frac{\cdot}{P})$ ; and hence to minimize PDout it is logical to consider the rate adaptation strategy of  $R(\cdot) = C(\cdot)$ . The source coding rate is then set as  $R_s = bR$ . The next two Propositions quantify the distortion outage performance of CORACP.

The distortion outage probability for transmission of a quasi-stationary source over a Rayleigh block fading channel using CORACP is given by

$$\Delta_{OD} = \lim_{\bar{P} \rightarrow \infty} \frac{\ln \bar{P} - \ln \sum_{s: \sigma_s^2 > D_m} \left(\left(\frac{\sigma_s^2}{D_m}\right)^{\frac{1}{b}} - 1\right) P(s)}{\ln \bar{P}} = 1$$

It is evident in Proposition 10 that the optimized fixed rate  $R$  with CRCP is related to the source statistics and equals  $1/2b \log_2(2s^*D_m)$ , where  $s^*$  is given in (64). Therefore, the distortion outage probability is

$$\begin{aligned} P_{\text{Dout}} &= \Pr\left(C(\alpha) < \frac{1}{2b} \log_2\left(\frac{\sigma_{s^*}^2}{D_m}\right)\right) \Pr(\sigma_s^2 > D_m) + \\ &\Pr\left(C(\alpha) \geq \frac{1}{2b} \log_2\left(\frac{\sigma_{s^*}^2}{D_m}\right)\right) \Pr\left(\frac{\sigma_s^2 D_m}{\sigma_{s^*}^2} > D_m\right) \end{aligned} \quad (13)$$

the CRCP scheme achieves the distortion outage probability of

$$\Delta_{OD} = \lim_{\bar{P} \rightarrow \infty} \frac{-\ln(\bar{P})}{\ln \bar{P}} = 1. \quad (14)$$

For communication of a stationary source over a Rayleigh block fading channel, the CRCP scheme achieves a distortion outage probability of

$$P_{\text{Dout}} = 1 - \exp\left(-\frac{\left(\frac{\sigma_s^2}{D_m}\right)^{\frac{1}{b}} - 1}{\bar{P}}\right) \quad (15)$$

and an outage distortion exponent of  $\Delta_{OD}$  of the order  $O(1)$ .

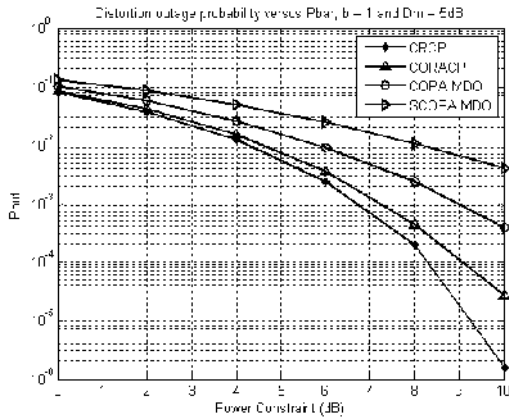
**5.2 Analytical Performance Comparison:**

In the sequel, we quantify the respective asymptotic outage distortion gain  $G_{OD}$  of SCOPA-MDO, COPA-MDO, CORACP and CRCP for transmission of a quasi-stationary source over a block fading channel.

*Proposition 12:* In transmission of a quasi-stationary source over a Rayleigh block fading channel, the asymptotic outage distortion gain obtained by scheme 1 with respect to scheme 2 (see Table I) is given by

$$G_{OD}^3 = 10 \log_{10} \left( \left( \left( \frac{\max\{\sigma_s^2\}}{D_m} \right)^{\frac{1}{b}} - 1 \right) \Pr(\sigma_s^2 > D_m) \right) - 10 \log_{10} \sum_{s: \sigma_s^2 > D_m} \left( \left( \frac{\sigma_s^2}{D_m} \right)^{\frac{1}{b}} - 1 \right) P(s).$$

The distortion outage exponent  $OD$  of the COPA-MDO and SCOPA-MDO schemes which are derived in line with the proofs of the Propositions 4 and 7, are quantified in Table II. As denoted in Propositions 9 and 11, CORACP.

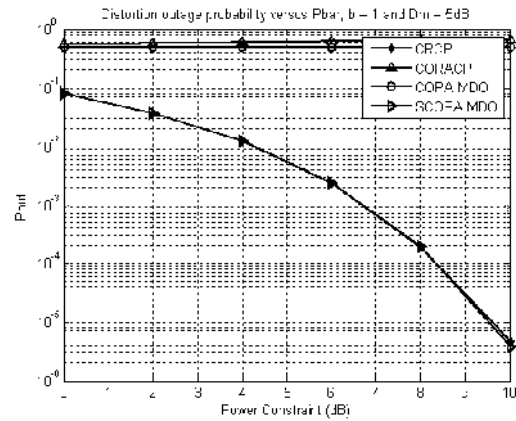


CRCP schemes give  $OD = 1$ . The distortion outage exponent indicates the speed at which the distortion outage (dB) reduces as the average power (limit) (dB) increases. Therefore, as evident, this speed is noticeably high with SCOPA-MDO and very low with CORACP and CRCP. Furthermore, the  $OD$  obtained by SCOPA-MDO and COPA-MDO depends on the average power limit  $\bar{P}$ , maximum allowable distortion  $D_m$  and bandwidth expansion ratio  $b$ . It is observed that with SCOPA-MDO and COPA-MDO,  $OD$  improves as  $b$ ,  $\bar{P}$  or  $D_m$  increase.

In fact, for a given value of  $N$ , a larger  $b$  implies a more finely encoded source that is more sensitive to channel errors and hence can more greatly benefit from increased power. The results in Tables I and II indicate that from the perspective of probability of distortion outage, for delay limited communication of quasi-stationary sources, CORACP and

CRCP schemes may not be appropriate designs. The following three Corollaries quantify the asymptotic outage distortion gain in transmission of a stationary source over block fading channels. These are directly obtained from Proposition 12 when a stationary source is considered.

**Corollary 8:** In transmission of a stationary source over a Rayleigh block fading channel, the asymptote outage distortion gain obtained by SCOPA-MDO with respect to COPAMDO is equal to zero

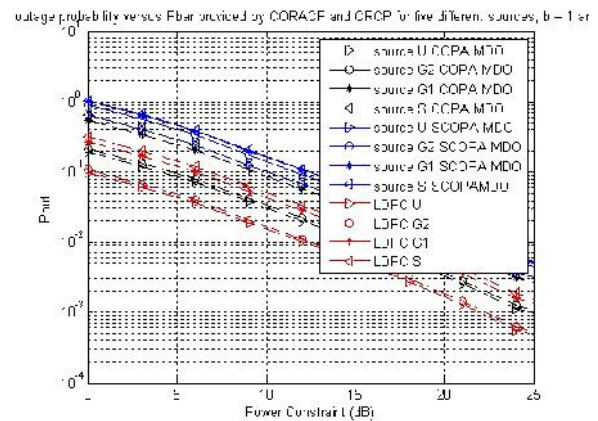


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**C. Numerical Results**

Figs. 2 and 3 depict the distortion outage probability performance of the presented schemes as a function of the power constraint  $\bar{P}$  for  $D_m = 8\text{dB}$  and  $D_m = 5\text{dB}$ , respectively. As expected, for a given  $\bar{P}$ ,  $P_{\text{out}}$  decreases as  $D_m$  increases. It is evident that the proposed SCOPA-MDO scheme achieves an asymptotic outage distortion gain of about 6.25 dB



**Corollary 9:** In transmission of a stationary source over a Rayleigh block fading channel, the asymptotic outage distortion gain of COPA-MDO with respect to CORACP is equal to

$$G_{OD} = 10 \log_{10} \frac{T}{\ln T}, \tag{16}$$

and 5dB with respect to COPA-MDO, for  $\bar{P} = 20\text{dB}$  and  $D_m = 8\text{dB}$  and  $D_m = 5\text{dB}$ , respectively. In the same settings, the COPAMDO scheme achieves asymptotic outage distortion gains of about 8.4dB and 6.4dB with respect to CORACP; and CORACP achieves gains of 5dB and 4.6dB with respect to CRCP. The results obtained from simulations and what is reported in Table I from analyses match reasonably well given

the assumption of very high average SNR considered in the analytical performance evaluations. The analytical results in Table II for  $OD$  performance, may also be observed in numerical results of Figs. 2 and 3. Specifically, at each point on the curves, the corresponding value in the vertical coordinate in dB, i.e.,  $10 \log_{10} PD_{out}$  divided by the value in the horizontal coordinate, i.e.,  $\bar{P}$ (dB), indicates  $-OD$ . For example, as seen in Fig. 2,  $OD$  for SCOPA-MDO is almost equal to 30.86 at  $\bar{P} = 20$ dB with  $D_m = 8$ dB. It is noteworthy that the four methods discussed, on different levels of source and channel state information (SSI and CSI). Specifically, it can be verified that three schemes of SCOPA-MDO, COPA-MDO and CORACP require instantaneous CSI for rate and/or power adaptation, while CRCP needs CSI statistics. The SCOPA-MDO scheme also needs instantaneous SSI, while COPA-MDO and CRCP simply need SSI statistics.

## I. CONCLUSION

In this paper, delay-limited transmission of a quasi stationary source over a block fading channel was considered. Aiming at minimizing the distortion outage probability, two transmission strategies namely channel-optimized power adaptation with fixed rate (COPA-MDO) and source and channel optimized power (and rate) adaptation (SCOPA-MDO) were introduced. The SCOPA-MDO scheme provides a superior performance, while the COPA-MDO scheme enjoys the simplicity of single rate transmission. In high SNR regime, different scaling laws involving outage distortion exponent and asymptotic outage distortion gain were derived. Our studies confirm the benefit of power adaption from a distortion outage perspective and for delay-limited transmission of quasi stationary sources over wireless block fading channels. The analyses of the presented schemes in the case of stationary sources indicate the same outage distortion performance with or without rate adaptation. Here we added low density parity check method for reducing delay.

## IV. APPENDIX PROOF OF PROPOSITION

Noting (42) for  $\bar{P}$ , distortion can be written as follows

$$D(\sigma_s, \alpha, \gamma = \bar{P}) = \sigma_s^2 2^{-2bR} = \frac{\sigma_s^2}{(1 + \alpha \bar{P})^b} \quad (17)$$

and then we can derive

$$P_{Dout} = \Pr \left( \frac{\sigma_s^2}{(1 + \alpha \bar{P})^b} > D_m, \sigma_s^2 > D_m \right) = \Pr \left( \alpha < \frac{1}{\bar{P}} \left( \left( \frac{\sigma_s^2}{D_m} \right)^{\frac{1}{b}} - 1 \right), \sigma_s^2 > D_m \right). \quad (18)$$

## REFERENCES

- [1] V. Hanly and D. Tse, "Multiaccess fading channels. Part II: Delaylimited capacities," *IEEE Trans. Inf. Theory*, vol. 44, pp. 2816–2831, Nov. 1998.
- [2] L. Li and A. J. Goldsmith, "Capacity and optimal resource allocation for fading broadcast channels. Part II: Outage capacity," *IEEE Trans. Inf. Theory*, vol. 47, pp. 1103–1127, Mar. 2001.
- [3] G. Caire, G. Taricco, and E. Biglieri, "Optimum power control over fading channels," *IEEE Trans. Inf. Theory*, vol. 45, pp. 1468–1489, July 1999.

- [4] L. Li, N. Jindal, and A. Goldsmith, "Outage capacities and optimal power allocation for fading multiple-access channels," *IEEE Trans. Inf. Theory*, vol. 51, pp. 1326–1347, Nov. 2005.
- [5] J. N. Laneman, D. N. C. Tse, and G. W. Wornell, "Cooperative diversity in wireless networks: Efficient protocols and outage behavior," *IEEE Trans. Inf. Theory*, vol. 50, pp. 3062–3080, Nov. 2004.
- [6] Y. Liang, V. V. Veeravalli, and H. V. Poor, "Resource allocation for wireless fading relay channels: Max-min solution," *IEEE Trans. Inf. Theory*, vol. 53, pp. 3432–3453, Oct. 2007.
- [7] D. Gunduz and E. Erkip, "Opportunistic cooperation by dynamic resource allocation," *IEEE Trans. Wireless Commun.*, vol. 6, pp. 1446–1454, Oct. 2007.