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Delay-Limited Source and Channel Coding of Quasi-Stationary Sources over Block Fading Channels

Bobbala Manasa
P.G. Scholar (M. Tech),
Dept. of ECE, DVR college of Engineering and Technology, Hyderabad.

P. Ramesh Reddy
Associate Professor
Dept. of ECE, DVR college of Engineering and Technology, Hyderabad.

ABSTRACT: ***In this paper, delay-limited transmission of quasi stationary sources over block fading channels is considered. Considering distortion outage probability as the performance measure, two source and channel coding schemes with power adaptive transmission 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. In high SNR regime, the performance scaling laws in terms of outage distortion exponent and asymptotic outage distortion gain are derived, where two schemes with fixed transmission power and adaptive or optimized fixed rates are considered as benchmarks for comparisons. Various analytical and numerical results are provided which demonstrate a superior performance for source and channel optimized rate and power adaptive scheme. It is also observed that from a distortion outage perspective, the fixed rate adaptive power scheme substantially outperforms an adaptive rate fixed power scheme for delay-limited transmission of quasi-stationary sources over wireless block fading channels. The effect of the characteristics of the quasi-stationary source on performance, and the implication of the results for transmission of stationary sources are also investigated.***

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

I.INTRODUCTION

Multimedia signals such as speech and video are usually quasi-stationary and their transmission in real time or streaming applications is subject to certain delay constraints. The delay limited communications over a wireless block fading channel is studied from a channel coding perspective in, where the performance is quantified in terms of channel outage probability, outage capacity and delay-limited capacity. In this paper, we study the delay limited transmission of a quasi-stationary source over a block fading channel from the perspective of source and channel coding designs and performance scaling laws.The zero outage capacity region of the multiple access and the broadcast block fading channels, respectively are studied. it is shown that the delay limited capacity of a single user Rayleigh block fading channel is zero. In, power adaptation for constant rate transmission over point-to-point, broadcast and multiple access block fading channels is designed for minimum outage probability. The outage performance of the relay block fading channel is investigated.

The end to end mean distortion for transmission of a stationary source over a block fading channel is considered. The performance is studied in terms of the (mean) distortion exponent or the decay rate of the end to end mean distortion with (channel) signal to noise ratio (SNR) in high SNR regime.The transmission of a stationary source over a MIMO block fading channel is considered where the distortion outage probability and the outage distortion exponent are considered as performance measures. For constant power transmission, it is shown in that separate source and channel coding schemes with constant (optimized) or adaptive transmission rate essentially provide the same distortion outage probability. We consider the delay-limited transmission of a quasi stationary source over a wireless block fading channel. The assumption is that the channel state information is known at the transmitter. The source and channel separation does not hold in this setting however, for practical reasons we are interested in exploring the designs that combine conventional high performance source codes and channel codes in an optimized manner. Specifically, a framework for rate and/or power adaptation using source and channel codes, that achieve the rate-distortion and the capacity in a given state of source and channel, is presented. The applicable performance measures of interest, as described, are the probability of distortion outage and the outage distortion exponent. Under an average transmission power constraint, two designs are presented. The first scheme devises a channel optimized power adaptation to minimize the distortion outage probability for a given optimized fixed rate, and hence enjoys the simplicity of single rate transmission. The second scheme formulates adaptation solutions for transmission power and source and channel coding rate such that the distortion outage probability is minimized. As benchmarks, we consider two constant power delay-limited communication schemes with channel optimized adaptive or fixed rates. As we elaborate, the said schemes require different levels of source and channel state information.The performance of the presented schemes are assessed and compared both analytically and numerically. Specifically for large enough SNR, different scaling laws involving outage distortion exponent and asymptotic outage distortion gain are derived. The analyses are mainly derived for wireless block fading channels and are specialized to Rayleigh block fading channels in certain cases. The results demonstrate the superior performance of the source and channel optimized rate and power adaptive scheme. An interesting observation is that from a distortion outage perspective, an adaptive power single rate scheme noticeably outperforms a rate adaptive scheme with constant transmission power. This is the opposite of the observation made from the Shannon capacity perspective. The effect of the statistics of quasi-stationary source on the performance of the presented schemes is also investigated. In the marginal case of a stationary source, our studies reveal that a fixed optimized rate provides the same outage distortion as the optimized rate adaptation scheme, either with adaptive or constant transmission power. The results shed light on proper cross-layer design strategies for efficient and reliable transmission of quasi-stationary sources over block fading channels.

1.2 EXISTING SYSTEM

In this paper, we study the delay limited transmission of a quasi-stationary source over a block fading channel from the perspective of source and channel coding designs and performance scaling laws. The zero outage capacity region of the multiple access and the broadcast block fading channels, respectively are studied.

The transmission of a stationary source over a MIMO blockfading channel is considered, where the distortionoutage probability and the outage distortion exponent areconsidered as performance measures. For constant powertransmission, it is shown in that separate source andchannel coding schemes with constant (optimized) or adaptivetransmission rate essentially provide the same distortionoutage probability.

1.3EXISTING SYSTEM DISADVANTAGES

We consider the delay-limited transmission of a quasi stationary source over a wireless block fading channel. The assumption is that the channel state information is known at the transmitter. The source and channel separation does not hold in this setting, however, for practical reasons we are interested in exploring the designs that combine conventional high performance source codes and channel codes in an optimized manner.

II.PROPOSED SYSTEM

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

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which simplifies the design and implementation of transceivers.

2.1MODULE EXPLANATION
SYSTEM MODEL

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 $\sigma^2 s$ in a given block, where s $\in$ S :S = {1, 2, ...,Ns}. 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 Rs bits per source sample. Hence, according to the distortion-rate function of a Gaussian source, the instantaneous distortion in a block in state s is given by$D = \sigma^2 s\ 2^{-2Rs.}$ 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 N(0, 1). Therefore, we have Y =$Y = \sqrt{\alpha}X +$ +Zwhere$\sqrt{\alpha}$ is the multiplicative fading. The channel gain α is constant across one block and independently varies from one block to another according to the continuous probability density function f(α). For a Rayleigh fading channel,$\sqrt{\alpha}$ is a Rayleigh distributed random variable and consequently, the channel gain α is an exponentially distributed random variable, where we hereconsider E[α] = 1

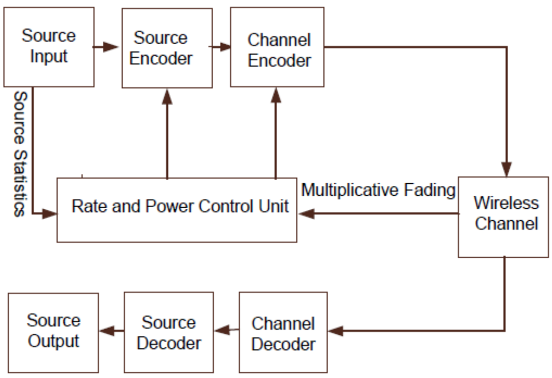

Fig .1 Block diagram of the system

The block diagram of the system is depicted in Fig. 1. We consider Ksource samples spanning one source block coded into a finite index by the source encoder.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 Rs in bits per source sample and channel coding rate R in bits per channel use are related by Rs = bR. Note that in general Rs and R may be both designed to depend on source and channel states, i.e., Rs = Rs(σs, α) and R = R(σs, α). The instantaneous capacity of the fading Gaussian channel over one block (in bits per channel use) is defined as

$C(\alpha, \gamma) = 1/2\log_2(1 + \alpha\gamma)$

Where,γ = γ(σs, α) is the transmission power. We consider the long term power constraint $E[\gamma] \le \overline{P}$, where the ensemble average is resulted from the arithmetic mean as large number of blocks and ergodic channel fading are assumed.

In case of a channel outage, in each state of the source and the channel (s, α), the instantaneous distortion is equal to the variance of the source and the decoder reconstructs the mean of the source. Whereas without channel outage, distortion is given by $\sigma^2_s 2^{-2bR}$. Thus, the distortion at a given state (s, α) is equal to

$$D(\sigma_s, \alpha, \gamma) = \begin{cases} \sigma_s^2 2^{-2bR} & if R \le C(\alpha, \gamma) \\ \sigma_s^2 & if R > C(\alpha, \gamma) \end{cases}$$

Let Dm be a nonnegative constant and represent the maximum allowable distortion. The distortion outage probability evaluated at Dm is defined as

PDout = Pr(D(σs, α, γ) > Dm)

The outage distortion exponent is defined as

$$\Delta_{OD} = \lim_{P \to \infty} -\frac{\ln P_{Dout}}{\ln \overline{P}}$$

Let $P_1$and P_2be the average powers transmitted to asymptoticallyachieve a specific distortion outage probability by twodifferent schemes. We define the asymptotic outage distortiongain as follows

$$G_{OD} = 10\log \overline{P_2} - 10\log \overline{P_1}$$

CHANNEL OPTIMIZED POWER ADAPTATION WITH FIXED RATE SOURCE AND CHANNEL CODING

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. The distortion outage probability is given follows

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

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, α) such that the distortion outage probability is minimized, when the average power is constrained to P. 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

$$\left(2^{2R}-1\right)E_1\left(\frac{2^{2R}-1}{q_1^*(R)}\right) = \bar{P}$$

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

$$P_{Dout} = \left(1-\exp\left(-\frac{2^{2R^*}-1}{q_1^*(R^*)}\right)\right)\Pr(\sigma_s^2 > D_m) + \exp\left(-\frac{2^{2R^*}-1}{q_1^*(R^*)}\right)\Pr(\sigma_s^2 2^{-2bR^*} > D_m)$$

For communication of a quasi-stationarysource over a Rayleigh block fading channel, the COPA-MDO scheme achieves the outage distortion exponent ΔOD of the order O(P/ln P) for large average power limit P.The distortion outage probability obtained by COPA-MDO for transmission of a stationary source over a Rayleigh block fading channel is given by

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

withq_1^*satisfying the following equation

$$\left(\left(\frac{\sigma^2}{D_m}\right)^{1/b}-1\right)E_1\left(\frac{\left(\frac{\sigma^2}{D_m}\right)^{1/b}-1}{q_2^*}\right) = P$$

The optimized source coding rate in SCOPA-MDO reduces to (1/2b)log2 (σ^2/D_m), which is fixed and equal to that of COPAMDO. The power adaptation in both schemes now coincides as they both depend on the same source coding rates and the power constraints. Hence, both schemes provide the same performance with stationary sources.

III.SIMULATION RESULTS

The distortion outage probability performance of the presented schemes as a function of the power constraint $\bar{P}$ for Dm= 8dBand Dm = 5dB, respectively. As expected, for a given $\bar{P}$, PDout decreases as Dm increases. It is evident that the proposed SCOPA-MDO scheme achieves an asymptotic outage distortion gain of about 6.25 dB and 5dB with respect to COPA-MDO, for $\bar{P}$ = 20dB and Dm= 8Db and Dm = 5dB, 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.

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FIGURE 2

Distortion outage probability versus $\overline{P}$; b = 1 and Dm = 8dB

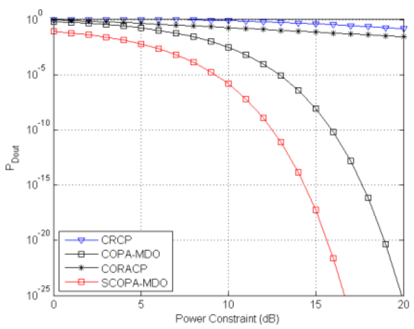
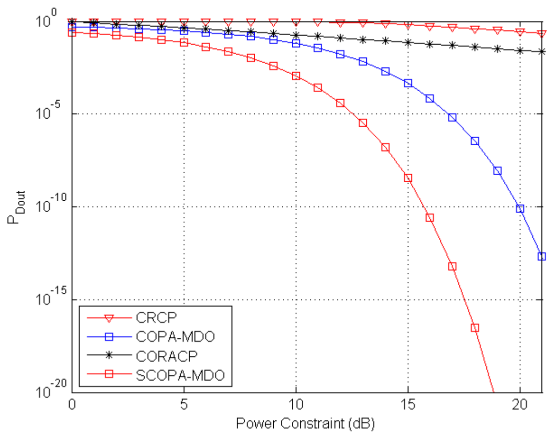


FIGURE 3

Distortion outage probability versus $\overline{P}$; b = 1 and Dm = 5dB



VI. 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. Ourstudies 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 adding low density parity check method for reducing delay.

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