Decentralized Receiver in a MIMO system

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***Abstract*— In this paper we investigate the achievable rate of a system that includes a nomadic transmitter with several antennas, which is received by multiple agents, each with a single antenna, suffering independent channel coefficients and additive Gaussian noises. Since the transmitter is nomadic, the agents do not have any decoding ability. These agents process their channel observations and forward it to the final destination through lossless links with a fixed given capacity. Assuming Gaussian signalling, we get lower and upper bounds on the achievable rates, and demonstrate the achievability of the full multiplexing gain. We also extend the model to address multi-user systems. The asymptotic setting with numbers of agents and transmitter's antennas taken to infinity is examined, and the incompetence of the simple compression when compared to a Wyner-Ziv scheme is demonstrated. For finite setting, an upper-bound is derived, which turns out to be quite tight when compared to the Wyner-Ziv achievable rate, even for a rather small 4×4 system.**

I. Introduction

In this paper we deal with a network setting in which a nomadic transmitter has several antennas and is communicating to a remote destination, where no direct link exists between the transmitter and the final destination. The final destination receives all of its inputs from several separated agents, which are connected to it through lossless links with a given capacity. The channel between the transmitting antennas and the agents is the standard ergodic Rayleigh fast fading channel with independent fading. The channel state is known to the agents and the final destination, but not to the transmitter. Since the transmitter is nomadic, the agents do not possess the codebook in use, and thus do not have any decoding ability [1]. This setting is closely related to the setting of the Multiple input multiple output (MIMO) channel, which is thoroughly treated in the literature, see [2] and others. We focus here on the multiplexing gain [3], which is a typical characterizing feature for MIMO systems. The results here have also implications on more complicated channels that include MIMO, such as the MIMO broadcast channel [4], the MIMO relay channel [5], and ad-hoc network [6]. All these works deal with situations where multiple antennas are transmitting and are received in a distributed fashion, either by relays, destinations or any combination of the above. In addition, results regarding ad-hoc networks [7], relay channels [8], and joint processing [9] are closely related, providing another aspect of the achievable rates in wireless networks, where relays form, in a distributed manner the required spacial dimensions. This paper is also linked to source coding problems, since we limit the agents to process only source related algorithms, such as compression. Relevant works are e.g. [10], who deals with the multiple Wyner-Ziv problem, the Gaussian CEO solution by [11] and many others.

This paper is organized as follows, in section II the setting is described and the basic definitions and notations are given. Section III describes the simple compression approach and gives several results about the achievable rates when using this approach. Section IV improves upon the approach taken in section III by including Wyner-Ziv compression in the agents and the final destination. An upper bound to the achievable rate, when using nomadic transmitter and non-decoding agents, is given in section V, and then demonstrated by some numeric example, to be rather close to the achievable rate when using the Wyner-Ziv compression. Concluding remarks are presented in section VI.

II. Setting and Model definition

We consider a system with a transmitter S which has t transmitting antennas and which transmits during n channel uses. In each channel use, the transmitter sends a vector $X \in \mathbb{C}^{[t\times 1]}$ to the channel, where $\mathrm{E}[X^*X] \leq P$[1]. By restricting $\mathrm{E}[XX^*] = Q$ to be diagonal, the setting is extended also to multi-user, where each user has a single antenna. Such restriction would not limit the achievable rate, as will become evident, we let $Q = \frac{P}{t} I_t$. The transmitter uses Gaussian signalling, which are known to be optimal for various problems involving Gaussian channel, although there is no proof of optimality in our setting. The communication rate is R. In addition, we have r agents $A_1, \ldots, A_r$, each receiving the scalar channel outputs:

$$Y_i(k) = h_i(k)X(k)+N_i(k), \;\; i = 1, \ldots, r, \; k = 1, \ldots, n \quad (1)$$

where $h_i(k) \in \mathbb{C}^{[1\times t]}$ is the vector of the channel transfer coefficients, which are either ergodic (fast fading) or block fading, and distributed independently from each other, and from any other variable, according to complex Gaussian distribution $\mathcal{CN}(0, 1)$. N_i are the additive complex Gaussian noises, with variance of 1. Some of the results which are reported here can be easily extended by including other fading distributions, such as Ricean, invoking the results of [12]. For the sake of brevity, we drop in the sequel the k index. The r agents are connected to a remote destination with lossless links, each with capacity C bits per channel use. The transmitter has no information regarding $H = [h_1, \ldots, h_r]$, while the final destination is fully informed about $H = [h_1, \ldots, h_r]$. By default, each agent has the full channel information H. However, many of the presented schemes require each agent

[1]The statistical mean is denoted by E and * denotes the transpose conjugate.

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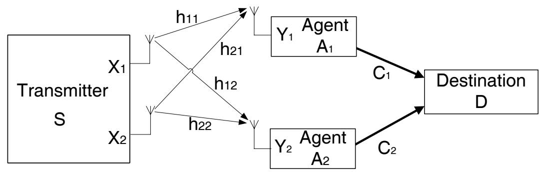

Fig. 1. A system that includes a transmitter with $t = 2$ and two agents A_1 and A_2 ($r = 2$), connected to the final destination with capacities of C_1 and C_2, respectively. The channel fading coefficients H are designated by $\{h_{i,j}\}$.

to know only its own channel coefficients h_i, as is stated in the text. We define V_j to be the message sent from A_j after receiving n channel outputs. This setting is depicted in figure 1. The transmitter (or the multi-users) is nomadic [1], that is the codebook that is used is unknown to the agents, but is fully known to the final destination. This way the agents treat input signals not accounting for the coded transmission, in a multiple Wyner-Ziv approach, which is solved for two agents in [10]. Here however, we are interested in the total communication rate given H rather than the minimum capacity to allow some quadratic distortions on Y_i. So we are interested in the distortions of X_i rather than Y_i, thus making our result not tight. Because the decoding ability of each agent decreases as the number of users increases, we expect the effect of the nomadic limitation to decrease, in a multiuser system.

III. Simple compression scheme

In this section, a scheme that includes simple compression at the agents site is analyzed. By simple compression, we mean compression process that does not use the correlations between $\{Y_i\}$, and thus does not requires the agents to have full knowledge of H. In addition, the implementation of such compression is rather simple and it is realized with low complexity algorithms at both agents and final destination.

A. Multiplexing gain

An analysis for the multiplexing gain is given next, which shows that the simple compression approach is sufficient to maintain to the full multiplexing gain.

Proposition 1: The links capacity must be $C \sim \log_2(P)$ to achieve the full multiplexing gain [3] for $r \leq t$.

Proof sketch:

- Proof that $C \gtrsim \log_2(P)$ is necessary to achieve the full multiplexing gain:
  From the cut-set upper bound (R is the rate used by the transmitter),
  $$R \leq rC. \tag{2}$$
  On the other hand, since the full multiplexing gain is r,
  $$r = \lim_{P\to\infty} \frac{R}{\log_2(P)} \leq \lim_{P\to\infty} \frac{rC}{\log_2(P)}. \tag{3}$$
  So that
  $$C \gtrsim \log_2(P). \tag{4}$$
- Proof that $C \sim \log_2(P)$ is sufficient to achieve the full-multiplexing gain r:

Each agent employs a simple compression scheme which can be described as adding independent quantization noise, unlike standard rate-distortion compression. The quantization noise variance depends on h_i according to [2]:

$$P_{D_i} = \frac{|h_i|^2 P + 1}{2^C - 1} \sim \frac{|h_i|^2 P + 1}{P - 1}. \tag{5}$$

The resulting rate (R_{SC}, for simple-compression) which is supported by this scheme can be calculated because the distortion is independent of the signal. Using the mutual information expressions of [2]:

$$R_{SC} = \mathrm{E}_H\{R_{SC}(H)\}, \tag{6}$$

$$R_{SC}(H) \triangleq \log_2 \det \left(\boldsymbol{I}_r + \begin{pmatrix} \frac{1}{1+P_{D_1}} & & \\ & \ddots & \\ & & \frac{1}{1+P_{D_r}} \end{pmatrix} HQH^* \right) \tag{7}$$

where $\mathrm{E}[XX^*] = Q$ and $\mathrm{trace}(Q) = P$. Signalling with $Q = \frac{P}{t} I_t$ maximizes (6), since the channel is unknown to the transmitter, since VH is distributed as H for unitary V (eigenvectors of Q) and since $\log_2 \det(I + \mathrm{diag}(\frac{1}{1+P_{D_{1,\dots,r}}}) HQH^*)$ is a concave function of Q. This means that the achievable rate applies also to the multi-user communication, see [12]. Notice that this achievable rate (6) is calculated for the fast fading channel, where the averaged rate when the channel is block fading, is calculated the same way. To the end of examining the multiplexing gain, we can now take a lower bound by considering only the maximum $i^* = \mathrm{argmax} P_{D_i}, P_D^* \triangleq P_{D_{i^*}}$:

$$R_{SC}(H) \geq \log_2 \det \left(\boldsymbol{I}_r + \frac{P}{t} \frac{1}{1+P_D^*} \mathrm{diag}(\lambda_1, \dots, \lambda_r) \right) = \sum_{i=1}^{r} \log_2 \left(1 + \frac{P\lambda_i/t}{1+P_D^*} \right) \sim \sum_{i=1}^{r} \log_2 \left(1 + \frac{P\lambda_i/t}{1 + \frac{|h_{i^*}|^2 P + 1}{P-1}} \right), \tag{8}$$

where $\{\lambda_i\}$ are the eigenvalues of HH^*. Now since

$$\lim_{P\to\infty} \frac{\log_2 \left(1 + \frac{P\lambda_i/t}{1+\frac{|h_{i^*}|^2 P+1}{P-1}} \right)}{\log_2(P)} = 1 \tag{9}$$

we have that

$$\lim_{P\to\infty} \frac{R_{SC}}{\log_2(P)} = \mathrm{E}_H \left\{ \lim_{P\to\infty} \frac{R_{SC}(H)}{\log_2(P)} \right\} = r. \tag{10}$$

■

Remark 1: Despite the name simple compression, it requires an infinite number of codebooks at the agents and the

[2] From $C = \log_2 \left(1 + |h_i|^2 \frac{P}{P_{D_i}+1} \right)$

final destination, since they should correspond to infinitely many fading coefficients. This can be circumvented by using amplify & compress at the agents.

Remark 2: For the case where $r > t$, when each agent uses its own compression, we can achieve the full multiplexing gain of t only if $C \sim \log_2(P)$. Thus an overhead of $(r-t)\log_2(P)$ is wasted due to the simple compression. The necessity of $C \sim \log_2(P)$ is evident by repeating (8) and taking $i_* = \text{argmin}_{1\le i\le r} P_{D_i}$, which changes the inequality direction and proves the claim. This overhead is waved when the agents apply time sharing or, as seen in the sequel, Wyner-Ziv compression.

The above proposition has several implications. From the implementation perspective, the case when $r \le t$ is common, for example, in a cellular system which encompasses some form of joint decoding and where few base stations serve many users. The above result quantifies the required capacities between the base stations as to maintain the full multiplexing gain.

Another implication of the result stems from the MIMO broadcast channel, where for an effective linear $\log_2(P)$ MIMO scaling, the transmitter is required to have full channel knowledge [4]. Here, a simple compression scheme, with limited cooperation between the destinations achieves the full multiplexing gain without channel state knowledge at the transmitter (which usually requires some feedback). Such a cooperation is usually easier to obtain when the destinations are co-located.

B. Achievable rate when $r, t \to \infty$

Let us consider the case where $r = \tau t$, constant total capacity from the agents to the final destination ($C = C_t/r$), and constant total power P of all the transmitting antennas. Such scheme accounts for bottleneck effects in the channel between the agents and the final destination. Let us take $r \to \infty$, and find the limiting rate which is reliably supported by the scheme ($\tilde{\tau} \triangleq \min\{1, 1/\tau\}$).

$$\begin{aligned}\lim_{r\to\infty} R_{SC} &\le \tilde{\tau} \lim_{r\to\infty} r\mathrm{E}_H\left[\log_2\left(1+\frac{\tau P\lambda/r}{1+P_{D_*}}\right)\right] \\ &= \tilde{\tau} \lim_{r\to\infty} r\mathrm{E}_{\nu,\zeta}\left[\log_2\left(1+\frac{P\nu}{1+\frac{\zeta r P+1}{2^{C/r}-1}}\right)\right] \qquad (11)\end{aligned}$$

where $\nu \triangleq \frac{\lambda}{t}, \zeta \triangleq \frac{|h_{i_*}|^2}{r}$ are two random variables with some finite mean. We can exchange the order of the expectation and the limit due to dominant convergence, to get that:

$$\lim_{r\to\infty} R_{SC} \le \tilde{\tau}\mathrm{E}_{\nu,\zeta}\left[\lim_{r\to\infty} r\log_2\left(1+\frac{P\nu}{1+\frac{\zeta r P+1}{2^{C/r}-1}}\right)\right] = 0. \qquad (12)$$

Proposition 2: The achievable rate using simple compression is zero when $r, t \to \infty$.

Using simple compression severely degrades the performance of the network, and different approaches, such as Wyner-Ziv compression, should be used.

IV. Achievable rate for the nomadic setting using Wyner-Ziv

We consider the same setting as in the previous section, but use the technique from [13], that is Wyner-Ziv compression for reduced quantization noise. We again refer to the quantization noise which is independent of the signal. Define P_{D_j} as the power of the additive Gaussian noise plus the quantization noise. Let r_j be calculated through:

$$\frac{1}{P_{D_j(H)}} = \frac{1-2^{-r_j(H)}}{P_N}. \qquad (13)$$

As in [13], r_j stands for the rate wasted on the compression of the additive noise. Then for the fast fading channel, using [13] and channel ergodicity, the achievable rate turns out to be:

$$\begin{aligned}R_{WZ} = \mathrm{E}_H\Bigg[\max_{\{0\le r_i(H)\}_{i=1}^r} \min_{\mathcal{S}\subseteq\{1,\ldots,r\}} \Bigg\{ \sum_{i\in\mathcal{S}^C}[C_i - r_i(H)] + \\ \log_2\det\left(I_{|\mathcal{S}|} + \frac{P}{t}\mathrm{diag}\left(\frac{1}{P_{D_i}(r_i(H))}\right)_{i\in\mathcal{S}} H_{\mathcal{S}}H_{\mathcal{S}}^*\right)\Bigg\}\Bigg]. \qquad (14)\end{aligned}$$

Remark 3: Notice that the above problem is convex and thus can be efficiently solved. The optimization should be performed for every channel use, and requires the complete knowledge of H in the final destination and in all the agents. However, this does not impose severe limitations, since the channel can be assumed to change relatively slowly. In addition, at the agents, the knowledge of H is used only to determine the binning resolution and as $r \to \infty$, the channel coefficients matrix hardens, and so are the binning resolutions, so that the specific H is required only at the final destination.

Remark 4: For the non-ergodic block fading channel, equation (14), stands for the averaged rate, that is the achievable rate, averaged over many instances of communications that feature independent fading coefficients.

Consider now a sub-optimal scheme where $r_j = r^*$, $0 < j \le r$, $0 < k \le n$. Because this sub-optimal approach is limited by a predetermined r^*, each agent A_i is required to know only its own channel coefficients h_i, and there is no need to perform the per channel use optimization.

A. Multiplexing gain

For the multiplexing gain (where $P \to \infty$) take $C = x\log_2(P)$, where x is some positive real, and for all $j = [1,\ldots,r]$, fix $r_j = r^* = \varepsilon C$. We get the following achievable rate:

$$R_{WZ} = m\log_2(P) + o(\log_2(P)), \qquad (15)$$

where $m = \min\{r, t\}$ and $\lim_{P\to\infty}\frac{o(\log_2(P))}{\log_2(P)} = 0$. This is since

$$\begin{aligned}m\log_2(P) + o(\log_2(P)) \le \min_{\mathcal{S}\subseteq\{1,\ldots,r\}} \Big\{|\mathcal{S}|(1-\varepsilon)x\log_2(P) \\ + \min\{r-|\mathcal{S}|, m\}\log_2(P)\Big\} \qquad (16)\end{aligned}$$

is fulfilled, as long as $x \geq \frac{m}{r(1-\varepsilon)}$. The following is thus evident:

Proposition 3: $C \sim \frac{m}{r(1-\varepsilon)} \log_2(P)$ is sufficient to achieve the full multiplexing gain m.
Notice that here, unlike simple compression, we get the full multiplexing gain with no excess capacity on the links to the final destination.

B. Achievable rate when $r, t \to \infty$

For the case where $r/t = \tau$, $C = C_t/r$ and $r \to \infty$, we repeat the suboptimal approach and again fix $r^* = \varepsilon C$.
By considering the results of [2] on the asymptotic eigenvalue distribution, and the fact that $||\text{any collection of raws of A}||_2 \leq ||A||_2 = \sqrt{\max \lambda(A^*A)}$ ($\max \lambda(A)$ is the maximal eigenvalue of A), almost surly, the maximum eigenvalue of $H_{\mathcal{S}}$ grows at most linearly with r, for when $r \to \infty$, for all $\mathcal{S}$. Namely, with probability 1:

$$\lim_{r\to\infty} \left\{ \max_{\mathcal{S}, j \in [1,\ldots,|\mathcal{S}| \vee t]} \frac{\lambda_j(H_{\mathcal{S}})}{t} \right\} \leq (\tau \vee 1)\nu^+$$
$$= (\tau \vee 1) \left(\sqrt{\frac{r \wedge t}{r \vee t}} + 1 \right)^2 = (\sqrt{\tau} + 1)^2 \quad (17)$$

Where $\vee$ and $\wedge$ denote min and max respectively. Then for r sufficiently large, there exist $\varepsilon > 0$ sufficiently small such that the minimum in (14) is obtained by taking $\mathcal{S} = \{1, \ldots, r\}$. This is since

$$\Pr\Big\{ \lim_{r\to\infty} \Big\{ \log_2 \left(1 + P\frac{\lambda_j(H_{\mathcal{S}})}{t}(1 - 2^{-\varepsilon C_t/r}) \right) - C_t/r(1-\varepsilon) \Big\} < 0 \Big\}$$
$$\geq \Pr\Big\{ \lim_{r\to\infty} \Big\{ \max_{\mathcal{S}, j \in [1,\ldots,m]} \log_2 \left(1 + P\frac{\lambda_j(H_{\mathcal{S}})}{t}(1 - 2^{-\varepsilon C_t/r}) \right) - C_t/r(1-\varepsilon) \Big\} < 0 \Big\}$$
$$= \Pr\Big\{ \lim_{r\to\infty} \Big\{ r\log_2 \left(1 + P(\sqrt{\tau}+1)^2(1 - 2^{-\varepsilon C_t/r}) \right) - C_t(1-\varepsilon) \Big\} < 0 \Big\}$$
$$= \Pr\left\{ \varepsilon P(\sqrt{\tau}+1)^2 C_t - C_t(1-\varepsilon) < 0 \right\}$$
$$= \begin{cases} 1 & \varepsilon < \frac{1}{1+P(\sqrt{\tau}+1)^2} \\ 0 & \varepsilon \geq \frac{1}{1+P(\sqrt{\tau}+1)^2} \end{cases} \quad (18)$$

The next proposition then follows by changing the order of taking limit and expectation, due to dominant convergence.

Proposition 4: The achievable rate of a scheme which uses Wyner-Ziv compression, for $r, t \to \infty$, is

$$R_{WZ} = \tilde{\tau}\mathrm{E}_\nu \left[\lim_{r\to\infty} r\log_2 \left(1 + P\nu(\tau \vee 1)(1 - 2^{-\varepsilon C_t/r}) \right) \right]$$
$$> \frac{P(\tau \vee 1/\tau)C_t}{1 + P(\sqrt{\tau}+1)^2}\mathrm{E}_\nu[\nu] - \delta = \frac{PC_t}{1 + P(\sqrt{\tau}+1)^2} - \delta \quad (19)$$

for any $\delta > 0$.
The last equality in (19) is since $\mathrm{E}[\nu] = \tau \wedge 1/\tau$, which is derived from $P_\nu(\nu)$ presented in [2]. So unlike the simple compression, for infinitely many transmitters and agents, but with a fixed total capacity to the final destination, the achievable rate is larger than zero. We note that although this effect is shown for infinitely many agents and transmitters, it is still dominant when r and t are very large, but finite. In addition, the above rate approaches the cut-set upper bound when $P >> 1$ and $\tau << 1$.

V. Upper bounds on the achievable rate of the nomadic setting - block fading

We consider two methods to upper-bound the average rate of the block fading setting, so that the upper bound is the minimum of the two bounds. We then demonstrate these bounds for a specific scheme and show their tightness.

A. Joint processing at the agents upper bound

For the sake of the upper bound, we allow the agents to fully collaborate, that is they still are not cognizant of the codebook, but now they can jointly quantize the received signal before forwarding to the final destination.
This means that the joint agent receives the channel output (1), where again, we assume Gaussian channel outputs, although we do not prove that Gaussian signalling is indeed optimal. For the sake of brevity we switch to vector notations, and write (1) again, with unitary $U_1 \in \mathbb{C}^{r\times r}$ and $U_2 \in \mathbb{C}^{t\times t}$ such that:

$$Y = HX + N = U_1 \Lambda U_2^* X + N. \quad (20)$$

We can further switch notations by the singular value decomposition:

$$\tilde{Y} = U_1^* Y = \Lambda \tilde{X} + \tilde{N}, \quad (21)$$

where $\Lambda \in \mathbb{C}^{r\times t}$ is a diagonal matrix with the diagonal containing the squared roots of the eigenvalues of H^*H (or HH^*), $\tilde{X} = U_2^* X \in \mathbb{C}^{t\times 1}$ and $\tilde{N} = U_1^* N \in \mathbb{C}^{r\times 1}$. Notice that N and $\tilde{N}$ have the same distribution law. This is true also for X and $\tilde{X}$ since, using similar arguments as section III-A, $Q = \frac{P}{t} I_t$ is optimal.
Since $\tilde{Y} = U_1^* Y$ is sufficient statistics of Y, with independent entries (nomadic setting), the entries of the vector $\tilde{Y}$ can be compressed independently from each other. Then we use [13] and take the case of a single agent (signal to noise ratio of $\frac{P\lambda_i}{t}$), connected to a final destination with the bandwidth of $\tilde{C}_i$ ($0 < i \leq r \vee t$):

$$R_i(H, \tilde{C}_i) \triangleq \log_2 \left(1 + \frac{P\lambda_i}{t} \frac{2^{\tilde{C}_i} - 1}{2^{\tilde{C}_i} + \frac{P\lambda_i}{t}} \right). \quad (22)$$

Which results with the upper bound:

Proposition 5: The averaged achievable rate of a block fading, distributed MIMO scheme, with a nomadic transmitter, is upper bounded by:

$$R \leq R_{joint} \triangleq E_H\{R^*(H)\}. \quad (23)$$

Where $R^*(H)$ is defined as

$$R^*(H) \triangleq \max_{\sum \tilde{C}_i = rC,\ 0 \leq \tilde{C}_i} \sum_{i\in I} R_i(H, \tilde{C}_i). \quad (24)$$

B. Non-cooperative upper bound

For the second upper bound, we do not assume that the agents can cooperate, instead we upper-bound the achievable rate from every agent, as if no other agent had existed. Recall that V_j is the message sent from the A_j. Since $X^n - Y_j^n - V_j$ forms a Markov chain, $\forall j, \mathcal{S}, j \notin \mathcal{S}$:

$$I(X^n; V_j|V_{\mathcal{S}}, H) = H(V_j|V_{\mathcal{S}}, H) - H(V_j|X^n, H) \leq I(X^n; V_j|H).$$

So that we have:

$$R \leq \frac{1}{n} I(X^n; V_{\{1,\ldots,r\}}|H) \leq \sum_{j=1}^{r} \frac{1}{n} I(X^n; V_j|H). \qquad (25)$$

Now we can use [13] again, for every agent. This gets us to:

$$\frac{1}{n} I(X; V_j|H) \leq \mathrm{E}_H \left\{ \log_2 \left(1 + P|h_j|^2 \frac{2^C - 1}{2^C + P|h_j|^2} \right) \right\}$$

and to the second upper bound.

Proposition 6: The achievable rate of a block fading distributed MIMO scheme, with a nomadic transmitter, is upper bounded by:

$$R \leq R_{ind} \triangleq \mathrm{E}_H \left\{ \sum_{j=1}^{r} \log_2 \left(1 + P|h_j|^2 \frac{2^C - 1}{2^C + P|h_j|^2} \right) \right\}. \qquad (26)$$

C. Numerical example

The above upper bounds and achievable average rates are tested for a 4×4 setting and averaged over the channel matrices H, randomly generated from the complex Gaussian distribution. Each agent has lossless links with capacity of $C = 2$ bits per channel use to the final destination. The resulting average of 20 channel realizations are plotted in figure 2. It is seen there that the joint upper bound is rather tight, and that the Wyner-Ziv compression scheme, which requires sophisticated processing at the destination, significantly outperforms the simple compression scheme. This is although they both achieve the full-multiplexing gain. The joint upper bound of subsection V-A is tighter than the upper bound of V-B, since the separated upper bound assumes independent transmissions to each agent, without considering the interferences of the other transmissions. We expect it to be tighter when $r << t$. The joint upper bound V-A is tight mainly due to the nomadic setting, which does not allow any decoding at the agents. Thus allowing joint processing without decoding is not very beneficial.

VI. Conclusion

In this paper we showed the effectiveness of several compression techniques for decentralized reception in fast fading and block fading MIMO channels. We proved that in many cases, the simple compression is sufficient to get the full-multiplexing gain. In addition, we showed the advantages of the Wyner-Ziv approach, which were evident in an asymptotic analysis and in a finite example. We presented an upper bound for the block fading channel, which is based on the nomadic characteristic of the scheme, and which turned out to be quite tight even for relatively a small 4×4 scheme.

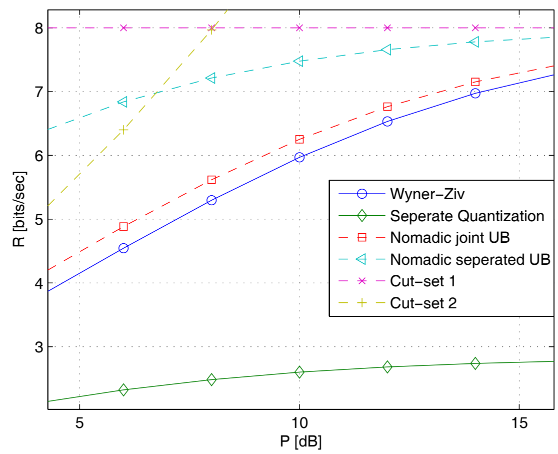

Fig. 2. Averaged rates of Wyner-Ziv and of simple compression schemes and the upper bounds over a block fading 4×4 system with $C = 2$, averaged over H.

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