Interference Reduction using DCI in Multiuser MIMO Channels

K.Susmitha
PG Scholar
Department of Electronics and Communication Engineering,
Narayana Engineering College, Gudur, AP, India

B.Malakonda Reddy
Associate Professor
Department of Electronics and Communication Engineering,
Narayana Engineering College, Gudur, AP, India

Y.Neeraja
AssociateProfessor
Department of Electronics and Communication Engineering,
Narayana Engineering College, Gudur, AP, India

Abstract: This paper considers splitting messages into private and common parts in a multi-cell multi-user MIMO IN. Specifically, the covariances of the private messages and common messages are designed to optimize either the sum rate or the minimal rate. The common messages and private messages are decoded in sequence using successive decoding. It shows how these difficult optimization problems can be adequately solved by means of d.c. (difference of concave functions) optimization over a simple convex set. Numerical and simulation results also reveal the great advantage of our proposed solutions for various types of INs. In particular, the proposed solutions are shown to outperform the algorithm developed by Dahrouj and Yu for the simpler case of the MISO IN.Mitigation of Interference for multi-cell multi-user in multi-input single-output interference network(MISO IN) is designed. In this proposed system, messages are splitting into private message and common message. In order to optimize the sum rate and minimal rate, covariances of private message and common messages are estimated. Successive decoding algorithm proposed for decoding both private and common messages. The optimization problems will solve by implementing the difference of concave functions (d.c.).Developing an efficient d.c. optimization framework, which is implemented over the disconnected region of split private and common rates in multi-user MIMO Ins for minimizing the sum rate and minimal user's rate. Han-Kobayashi (HK) rate splitting scheme is viewed as the best strategy to cancel the interference and improve the performance.Accordingly, D.C. iterations are derived to locate its optimized solution. DCI algorithm provides to improve the rate of performance at anyiteration.

I.INTRODUCTION

DUE to the increasing demand for high data rates, wireless cellular systems are being increasingly designed with full frequency reuse. This leads to significant out-of-cell interference. Conventional wireless cellular systems, however, are typically designed to be interference-limited. This is because each base-station in a conventional cellular system transmits to the mobile terminals in its cell independently from other base-stations and the out-of-cell interference is simply treated as noise. Although there are new approaches to coordinate transmissions of base-stations in multi-cell downlink communications (see e.g., the residual signal interference is still treated as noise. A wireless multi-cell system can be modeled as an interference network (IN) with N cells and K users (e.g., mobile terminals) in each cell. By treating residual interference as noise, the network capacity is achieved only at low interference regime for a general multi-user IN The achievable rate region for two-user INs with two cells, each serving one user in it, has been examined extensively in . The Han-Kobayashi (H-K) strategy yields the best inner bound on the capacity region, while various outer bounds were also reported in the H-K strategy, the transmit signals are purposely designed so that they are partially decodable by both user's receivers. In particular, the transmit signal of each user is split into two parts: (i) a private message that is decoded by the intended user's receiver only, and (ii) a common message that is decoded by both users' receivers for the purpose of interference mitigation. Under the H-K strategy for a two-user single-input single-output (SISO) IN, reference allocates power to private and common messages in such a way that the power of the private message of each user is received at the level of the Gaussian noise at the other receiver. In this way, the interference caused by the private message has a small effect on the other link as compared to the impairments already caused by the noise. At the same time, a large amount of private information can still be conveyed in the user's own link if the direct gain is appreciably larger than the cross gain With such a power allocation strategy, reference shows that a very simple H-K scheme can achieve the capacity region to within one bit.. They show that a H-K type coding scheme achieves the capacity region to within Nr bits (Nr is the number of receive antennas) or to within a constant gap. Reference establishes the capacity region of the MIMO IN, but only for the so-called aligned strong interference regime, where the direct and cross link channel matrices satisfy a matrix equation.

Dahrouj and Yuapply the H-K strategy for a multiuser multiple-input single-output (MISO) IN. The transmission scheme proposed has both the common and private messages beamformed at the base-stations and then sequentially decoded at the receivers. Different from the two-user IN in which user pairing is obvious, for the case of multi-user IN one also needs to consider selection of users for common message decoding (i.e., user pairing) in order to improve the IN capacity. Given a pre-defined user pairing protocol, the problem of splitting common and private rates and associated beamforming design is still difficult. Given that the achievable rate region is very complicated and no characterization is yet available, such a problem is approached in by an ad-hoc intensive search at discrete points in the joint space of common and private message rates. The optimality of the worst user's rate is not granted. Also, the extensive search is not suitable for the problem ofsum-rate maximization, which is a more popular metric for INs.

Inspired by the study, the present paper is concerned with a multi-user MIMO IN that is more general than the multiuser MISO IN is considered. Specifically, each message is split into a common and private parts and the covariances of these message parts are designed to maximize the sum rate or the worst (minimal) user's rate under the base-station power constraints. Like the approach proposed in, the common and private messages are sequentially decoded at the receivers.We show that such design problems for theMIMO IN can be formulated as nonsmooth function optimizations over a simple convex set. Furthermore, these nonsmooth functions are shown to be d.c. (difference of two concave functions/sets) , hence the optimization problems can be solved very efficiently by a sequence of convex programs, known as d.c. iterations (DCI) of d.c. programming (for the developments and successful applications of DCIs to various design problems in wireless communications). The DCI is a path-following procedure, which surely improves the solution at any iteration. As such, the DCI is guaranteed to converge to a local optimum. Intensive simulations for diverse design problems show that DCIs typically converge in small number of iterations. The implementation of DCIs is simple and does not involve the control of step size To summarize, the contribution of the present paper is three-fold:

- Developing an efficient d.c. optimization framework for maximizing the sum rate and minimal user's rate over the disconnected region of split private and common rates in multi-user MIMO INs;
- Numerically showing the benefit of rate splitting in mitigating multi-user interference;
- Comparing and contrasting the proposed inner bound with the existing inner and outer bounds for different cases of MIMO INs.

II.PROPOSED SYSTEM

Deploy the transmit antenna and receiver antenna for every users, the transmit antenna placed at every base station.Decode the private as well as common message of each users based on their covariance of the messages.Private message will be decoded only by the own receivers, but the common messages are decode by both own receiver and remaining users.Based on the Beamforming optimization problem, BS power constraints are estimated.Sum rate and Minimal rate are estimated with maximum achievable rate.

The proposed system is to Developing an efficient d.c. optimization framework formaximizing the sum rate and minimal user's rate over thedisconnected region of split private and common rates inmulti-user MIMO INs; Numerically showing the benefit of rate splitting in mitigating multi-user interference; Comparing and contrasting the proposed inner boundwith the existing inner and outer bounds for differentcases of MIMO Ins.

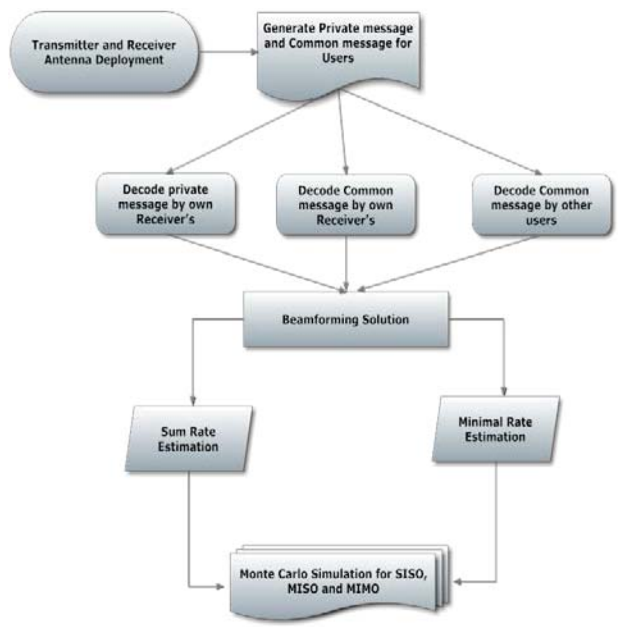
Thereare two transmitters each equipped with antennas. Thefirst receiver has 3 antennas and the second receiver has 2antennas. It reveals the solution. It does not perform better than the conventionalscheme (without common message) for this weak interference setting. The rates obtained by DCI for the sum-rate andmaximin-rate problems exceed well the inner bound. In termsof the minimal rate, the advantage of the new scheme overthe conventional is marginal. To see the benefit of the common message, the system increases theinterfering channel strength. The achievable rates are provided with the obtained solutions given.

The new scheme improves both thesum rate and the minimal rate from those of the conventional one.Moreover, when moving from joint decoding to successive decoding its achievable minimal rate dropssignificantly. On the contrary, the solutions found by DCIappear to be immune from such side-effects.

Advantages:

- The implementation of DCIs is simple and does not involve the control of step size.
- It surely improves the solution at every iteration.
- The ability of splitting user messages into private and common messages to increase the achievable rate region of a multi-user MIMO interference network.
- A large amount of private information can still be conveyed in the user's own link if the direct gain is appreciably larger than the cross gain.

III. SYSTEM ARCHITECTURE



IV. MODULES

MODULES:

- Antenna Deployment
- Decode Private and Common Message
- Beamforming Problem
- Sum Rate and Minimal Rate Estimation

MODULE DESCRIPTION

Antenna Deployment:

Each cell has one base-station (BS) equipped with Nt ≥1 antennas that serves its K mobile users, each of which is equipped with Nr ≥1 antennas. Define I := {1,2, . . . , N} and J:= {1,2, . . . , K}. User j in the ith cell is referred to as user (i, j). Transmit precoding is implemented at the base-station to separate signals from users within each cell. Thus, interference mitigation needs only occur between users belonging to different cells. This paper is concerned with joint precoding and common message decoding approach to mitigate intercell interference. Introduce a pairing operator a(i, j)that describes which other user, beside user(i, j), decodes the common message of user (i, j). When the user (i, j) has no common message, let a (i, j)be the empty set. Formally, it is a mapping a: I × J →(I × J)∪ { Ø }with the restriction that a(i, j) = (˜ i, ˜j) always has ˜i=i and a −1 (˜ i, ˜j) has cardinality no more than one.

Decode Private and Common Message:

The system adopted a two-stage scheme, where each receiver jointly decodes the two common messages in the first stage and then decodes the private message in the second stage. Therefore, its achievable capacity region should lie in between that achieved by the joint decoding and the successive decoding as employed in the current paper. The computational solution is based on nonconvex optimization in covariance matrices over sample power factors in[0,1]×[0,1]. Its computation implementation with 225uniformly sample points consumed hours. provide the plot of the sum rate performance versus the number Nt =Nr of antennas, with PB = 0dB and PB = 30dB, respectively.

Beamforming Problem:

The system focus on a direct formulation involves the original beamforming variable w only. The BS power constraint in terms of w is

$$\widetilde{W}_B = \{\boldsymbol{w} := [\boldsymbol{w}^{p}_{i,j} \quad \boldsymbol{w}^{c}_{i,j}]_{(i,j)\in\mathcal{I}\times\mathcal{J}} \ : \ \sum_{j\in\mathcal{J}} (\|\boldsymbol{w}^{p}_{i,j}\|^2 + \|\boldsymbol{w}^{c}_{i,j}\|^2) \leq P_B, i \in \mathcal{I}\}.$$

Sum Rate and Minimal Rate Estimation:

The form of these optimal power splits by the DCI is consistent with the conjecture that for two-user symmetric INs, the maximal sum rate is achieved either by using symmetric power splits or by constraining one of the users to send a common message only. At PB = 50dB, the gap between joint decoding and successive decoding is 1.01bps/Hz, which is the same as its counterpart for PB = 30dB. However, forPB≤10 dB, the gap is obviously zero.

V. SIMULATION RESULTS

In this section, numerical results are presented to show the rate performances achieved by different schemes. For ease of presentation, the conventional coordinated transmission involving only private messages is referred to as "conventional scheme", whereas the common-private successive decoding message scheme as "new scheme". In the implementation, the number L of common user pairs is equal to the total number NK of users (L=NK). The pairing map a∈AL is predetermined according to the procedure described at the beginning . The computational tolerance in DCIs is set as 10^−5. Each plotted point for the Monte Carlo simulations is based on 200 random network realizations.

A.Two User SISO Networks Revisited:

Consider three randomly generated examples. The corresponding numerical data is provided by the second and third of Table I.

we provide in Table I the numerical solution in terms of the ratios of private-messageinduced interference to noise at each receiver i defined by αi = |Hi,j,1|2Qp i,1/σ 2, j = i. At the solutions found by DCI (for successive decoding) the rates with successive decoding and joint decoding are the same though they are different at the solution. All the results in Table 'I'are in terms of rates achievable by joint decoding. It is observed that the minimal rate improvement of the new scheme over the conventional scheme is very essential (35.88% and 52.38% in weak IN and mixed IN). The computational performance of the proposed DCI was observed to not be sensitive to initial solutions. For these particular low dimension problems, the optimality of DCI is also confirmed by a heuristic search over 105 × 105 sample points (α1, α2). Consider another symmetric weak IN with |H1,1,1|2=|H2,2,1|2=0 dB, |H2,1,1|2 =|H1,2,1|2=−7.6955 dB and σ2 = 0 dB, where the sum rates achieved by joint and successive decoding schemes may be different. Fig. 1 provides the plot of sum rate versus the private message power to noise

	Sum rate(in bps/Hz)	Minimal rate(in bps/Hz)
Conv.Scheme	15.7200	7.6400
New Scheme-Joint	14.8517	16
New Scheme-Successive	14.9565	16
[18,Th.3]	16.5300	7.5000

TABLE1

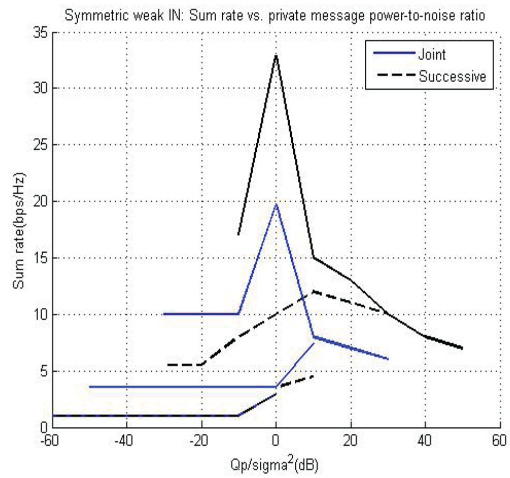


Fig1. SymmetricWeak IN: Sum rate vs. private message power-to-noise ratio.

B. Covariance Split for MIMO Ins

The initial feasible solutions for DCI are generated as follows:

$$Q_{i,j}^{p(0)} = \beta \left[\frac{\sigma^2 P_B}{K N_t} \left(I_{N_t} + H_{i,\hat{i},\hat{j}}^H H_{i,\hat{i},\hat{j}} \right)^{-1} + Z \right],$$

$$Q_{i,j}^{c(0)} = \beta \left[\frac{P_B}{K N_t} \left(I_{N_t} - \sigma^2 \left(I_{N_t} + H_{i,\hat{i},\hat{j}}^H H_{i,\hat{i},\hat{j}} \right)^{-1} \right) + Z \right]$$

Here random matrix $Z \in \mathcal{S}_+^{N_t}$ and real factor β ∈ (0, 1) are added to avoid trapped local optimal solutions. The entries of Z are i.i.d. standard uniform random variables, while β ensures that the initial solution takes 10% of the available power. The rationale behind this setting is to keep user (i, j)'s private message received by user (ˆ i,ˆj) below the noise level .

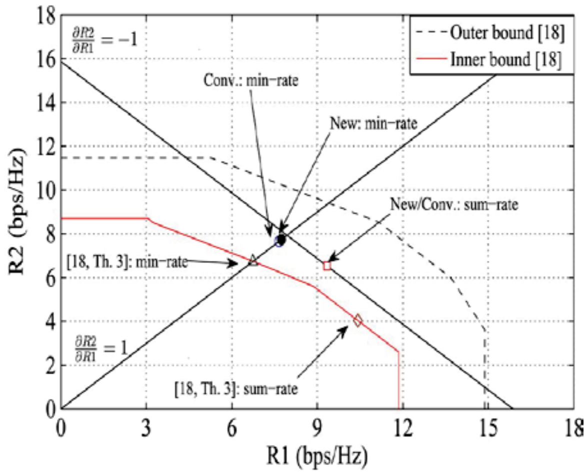


Fig2. Rate region and achievable rates

the rates obtained by DCI for the sum-rate and maxim-rate problems exceed well the inner bound. In terms of the minimal rate, the advantage of the new scheme over the conventional is marginal, i.e., having common messages is not beneficial in this example. The numerical results of Table II are visualized in Fig. 2 together with the inner bound plotted by solving the linear inequalities.

	Sum rate(in bps/Hz)	Minimal rate(in bps/Hz)
Conv.Scheme	15.8700	7.6600
New Scheme-Joint	15.8197	15.8700
New Scheme-Successive	15.9548	15.8700
[18,Th.3]	4.0400	6.7400

TABLE: II

C. Beamforming Split for MISO IN

Suppose $(Q_{i,j}^{p(0)}, Q_{i,j}^{c(0)})$ are the covariance with maximum eigenvalues $(\lambda_{i,j}^{p(0)}, \lambda_{i,j}^{c(0)})$ and corresponding eigenvectors $(v_{i,j}^{p(0)}, v_{i,j}^{c(0)})$. Then the initial feasible solutions for implementing DCI are taken by

$$w^{p(0)} = \sqrt{\lambda^{p(0)}}\, v^{p(0)} \text{ and } w^{c(0)} = \sqrt{\lambda^{c(0)}}\, v^{c(0)}.$$

1) Four-User MISO IN (N = 2,K = 2,Nt = 4,Nr = 1):

All direct channel strengths ηi,i,j are fixed at 5 dB. The interfering channel strengths η1,2,1 = η1,2,2 vary from 0 dB to 30 dB while all other interfering channels are virtually removed by setting them to −50 dB. The SNR PB/σ 2 is set at 20 dB. Fig. 3(a) and (b) depict the sum rate and minimal rate performances versus the interference channel strengths. The conventional scheme fails to maintain both sum rate and minimal rate. On the contrary, the new scheme is able to maintain and even improve these two rate metrics in this scenario.

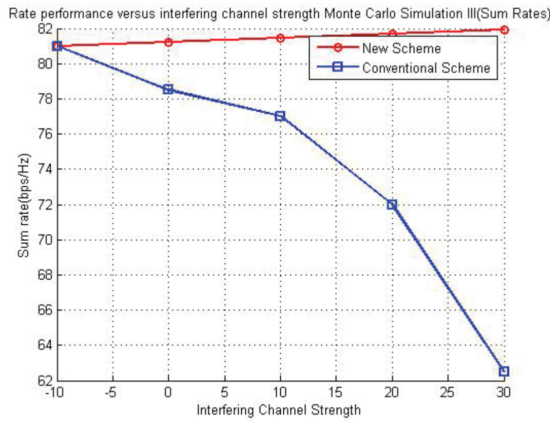


FIGURE:3(a)

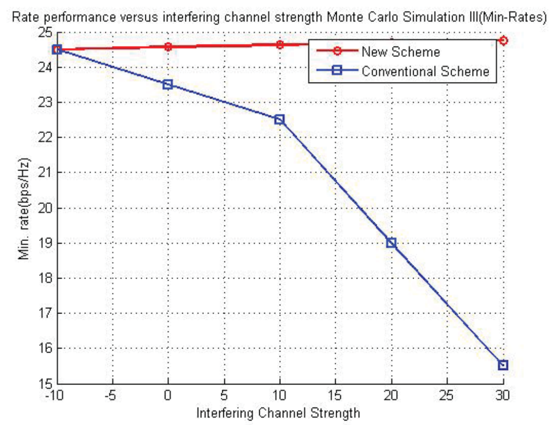


FIGURE:3(b)

2) Nine-User MISO IN (N = 3, K = 3, Nt = 4, Nr = 1):

Consider a more practical three-cell network with three users per cell. The BSs are 1.4 km apart from each other. The users are uniformly distributed within their respective cells.

VI CONCLUSION

This paper studied the optimized transmission strategies for interference mitigation in multi-cell multi-user MIMO networks, which are commonly modeled as multi-user MIMO interference networks. The ability of splitting user messages into private and common messages to increase the achievable rate region of a multi-user MIMO interference network has been well understood, but its optimization has never been adequately addressed. As an important contribution to addressing this problem, this paper formulated the optimal rate splitting problem as a nonsmooth d.c. objective function minimization subject to convex constraints in the reduced space of the designed covariance variables only. Then tailored DCI algorithms were provided to obtain the solutions, which guarantee rate improvement after each iteration. In the presence of mild-to-strong interferences, comprehensive simulation results demonstrated significant rate gains obtained by the proposed message-splitting scheme, for both MIMO and MISO interference networks. The results also showed that our proposed DCIs outperform other existing methods and converge within relatively smallnumbers of iterations.

REFERENCES

[1] O. Mehanna, J. Marcos, and N. Jindal, "On achievable rates of the two-user symmetric Gaussian interference channel," in 48th Annual Allerton Conference on Commun., Control, and Computing, Sep. 2010.

[2] Y. Zhao, C. W. Tan, A. S. Avestimehr, S. N. Diggavi, and G. J. Pottie, "On the maximum achievable sum-rate with successive decoding in interference channels," IEEE Trans. Inf. Theory,, vol. 58, pp. 3798–3820, Jun. 2012.

[3] H. H. Kha, H. D. Tuan, H. H. Nguyen, and T. T. Pham, "Optimization of cooperative beamforming for SC-FDMA multi-user multi-relay networks by tractable D.C. programming,"IEEE Trans. Signal Process., vol. 61, pp. 467–479, Jan. 2013.

[4] H. H. Kha, H. D. Tuan, and H. H. Nguyen, “Fast global optimal power allocation in wireless networks by local d.c. programming,”IEEE Trans. Wireless Commun., vol. 11, pp. 510–515, Feb. 2012.
[5] S. Karmakar and M. K. Varanasi, “The capacity region of the MIMO interference channel and its reciprocity to within a constant gap,”IEEE Trans. Inf. Theory, vol. 59, pp. 4781–4797, Aug. 2013.
[6] S. Motahari and A. K. Khandani, “Capacity bounds for the Gaussian interference channel,”IEEE Trans. Inf. Theory, vol. 55, pp. 620 –643, Feb. 2009.
[7] R. H. Etkin, D. Tse, and H. Wang, “Gaussian interference channel capacity to within one bit,”IEEE Trans. Inf. Theory, vol. 54, pp. 5534 – 5562, Dec. 2008.
[8] V. Annapureddy and V. Veeravalli, “Sum capacity of MIMO interference channels in the low interference regime,”IEEE Trans. Inf. Theory, vol. 57, pp. 2565–2581, May. 2011.
[9] S. A. Jafar and S. Vishwanath, “Generalized degrees of freedom of the symmetric Gaussian K user interference channel,” IEEE Trans. Inf. Theory, vol. 56, no. 7, pp. 3297–3303, 2010.