Mixed CSIT DL Channel: Gains with Interference Aware Receivers

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***Abstract*—The broadcast channels (BC), a single transmitter transmitting data to multiple receivers, have been widely studied in literature mostly with and sometimes without the availability of channel state information at the transmitter (CSIT). We study a very practical version of the BC where the transmitter has CSIT of some users and no CSIT for other users.**

We look at the simplest instance of such a heterogeneous BC where a multi-antenna transmitter base-station (BS) is trying to communicate data to two single-antenna user equipments (UEs), having the perfect CSIT about UE-1 and no CSIT about UE-2. We propose a very simple transmission strategy at the BS combined with an intelligent interference-aware receiver at UE-2. We show that under the proposed transmission strategy, the sum rate can be significantly improved (unbounded in SNR) if low complexity interference-aware receiver is employed at UE-2 as compared to the case when UEs resort to suboptimal single-user detection where rates are bounded (in SNR). We then extend the proposed transmission strategy to long term evolution (LTE) scenario and show that the employment of interference aware receivers significantly improve performance in spite of the low resolution LTE precoders. It therefore underlines the necessity of intelligent receivers for modern wireless systems in the pursuit of high spectral efficiency.

I. INTRODUCTION

A. Background and Motivation

In this paper, we look at the broadcast channel (BC) having a base station (BS) equipped with n_t transmit antennas and K ($K \geq n_t$) single antenna users. We study a mixed CSIT downlink (DL) channel where the BS has perfect CSIT of some of the users and no CSIT about other users. This scenario is of wide practical importance as the new generation of cellular systems which are being standardized today, like High-Speed Downlink Packet Access (HSDPA) Release-9, Long Term Evolution (LTE) and LTE-Advanced, have the possibility of users feeding back some form of CSIT (mostly in the form of desired precoding matrices suitable to their channel realizations) and as these systems have to be backward compatible and support the legacy users (which rely only on some scalar channel quality indicator (CQI) or Ack-Nak mechanism of Automatic Repeat reQuest (ARQ) protocols), the pool of users to which a BS will be transmitting data simultaneously will consist of some users whose CSIT is available and a sub-group of users for which no channel realizations are known. This naturally gives rise to our mixed CSIT model of the BC. Secondly, this mixed CSIT model is also justified when a BS has multiple users with different mobility levels. The users with low mobility levels (large coherence lengths) would be able to track their channels and feed back the estimates to the BS which can successfully use them for scheduling and/or precoding purposes. By contrast, the channel coherence times will be shorter for high mobility users and channel tracking at those users and then feeding them back to the BS will incur delays exceeding the coherence times, making this outdated CSIT almost useless at the BS. So the system ends up again with the BS having the perfect CSIT of some users and no CSIT of others. This perfect fit of mixed CSIT model for practical scenarios motivates the study, design and analysis of suitable transmission and reception techniques for such systems and their relative comparison.

B. Contribution

In this paper, we shall be studying the simplest instance of mixed CSIT DL channel. We deal with a BS having n_t antennas and there are two single-antenna UEs in the system. The BS has perfect CSIT of UE-1 and no channel realization information about UE-2. For this basic system, we propose a simple transmission strategy which consists of choosing precoding vectors at the BS for both UEs based upon the CSIT of UE-1. These precoding vectors maximize the desired signal strength and minimize the interference strength at UE-1 whose CSIT is available. However absence of the CSIT of UE-2 will lead to the propagation of significant interference in it's direction thereby severely limiting it's performance. Here we propose the employment of earlier proposed low complexity matched filter (MF) based detector [1] by UE-2 which is aware of the interference and can subsequently exploit it's structure. We focus on the practical case of finite alphabets rather than the idealized Gaussian alphabets and derive the achievable rates for both the UEs. We compare these achievable rates to the rates achieved through the use of suboptimal single-user detectors by the UEs for such mixed CSIT systems. The results show that the proposed scheme performs significantly better than single-user detector solution and achieves more degrees of freedom. As a next step, we study this mixed CSIT system for long term evolution (LTE) systems where UEs feedback the indices of their desired precoders. Due to the low resolution of

LTE precoders, the proposed strategy for the scenario of mixed CSIT (now mixed feedback of the desired precoders) leads to non-negligible interference at both the UEs. For this scenario, we propose the employment of low complexity interference aware detectors at both the UEs which leads to significant improvement in the performance.

C. Organization

This paper is structured as follows: First the system model is described in section II. The proposed strategy and achievable rates for the case of finite alphabets are presented in section III. Adaptation of the proposed strategy in the LTE framework along with the system performance is detailed in section IV which is followed by the conclusions.

Notation: $\mathbb{E}$ denotes statistical expectation. Lowercase letters represent scalars, boldface lowercase letters represent vectors, and boldface uppercase letters denote matrices. $\mathbf{A}^\dagger$ denotes the Hermitian transpose of matrix $\mathbf{A}$. The identity matrix of n_t dimensions is denoted by $\mathbf{I}_{n_t}$. The logarithm with base 2 is denoted by $\log(.)$.

II. SYSTEM MODEL

The frequency-flat system we consider consists of a BS having n_t transmit antennas and 2 single-antenna UEs. In the DL, the signal received by the k-th UE can be expressed as

$$\begin{aligned} y_k &= \mathbf{h}_k^\dagger \mathbf{P}\mathbf{x} + z_k \qquad\qquad k = 1,2 \\ &= \mathbf{h}_k^\dagger \mathbf{p}_1 x_1 + \mathbf{h}_k^\dagger \mathbf{p}_2 x_2 + z_k \end{aligned} \tag{1}$$

where $\mathbf{h}_k^\dagger$ is the channel vector of user k with $\mathbf{h}_k^\dagger \in \mathbb{C}^{1\times n_t}$ ($\mathbb{C}^{1\times n_t}$ denotes the n_t-dimensional complex space), the precoding matrix $\mathbf{P}$ has two unit-norm columns ($\mathbf{p_1}$ and $\mathbf{p_2}$), $\mathbf{x}$ denotes the vector of information symbols x_1 and x_2 of variances σ_1^2 and σ_2^2 respectively. $x_1 \in \chi_1$ is a QAM symbol where the size of constellation is $|\chi_1| = M_1$ while $x_2 \in \chi_2$ with $|\chi_2| = M_2$. The channel input from the BS must satisfy an (average) transmit power constraint of P_t, i.e. $\mathbb{E}[||\mathbf{x}||^2] \leq P_t$. The n_t entries of the channel vector for each UE are independent and identically distributed (i.i.d.) standard complex Gaussian with zero mean and unit variance, i.e. $\mathbf{h}_k^\dagger \sim \mathcal{CN}(\mathbf{0}, \mathbf{I}_{n_t})$. z_k is the standard complex white Gaussian noise, i.e. $z_k \sim \mathcal{CN}(0,1)$. In this setting, the transmit power is equal to the true signal-to-noise ratio (SNR) at each user.

The CSIR is assumed to be perfect both for the desired ($\mathbf{h}_k^\dagger \mathbf{p}_1$) and interfering signals ($\mathbf{h}_k^\dagger \mathbf{p}_2$). As the UE knows its channel $\mathbf{h}_k^\dagger$, so it needs the information of its desired precoder $\mathbf{p}_1$ and the precoder of other co-scheduled UE $\mathbf{p}_2$. The CSIR can also be acquired once BSs transmit orthogonal precoded pilot symbols to the UEs, a feature already incorporated in the standardization of LTE-Advanced [2]. Further, the BS has perfect CSIT of UE-1 and no CSIT about UE-2. So in this setting UE-1 is the user with low mobility and UE-2 is the one with high mobility. We would like to point out that with such assumptions about channel state information (CSI) and our proposed scheme, it really does not matter how the channel fading processes evolve in time for two users. Hence the achievable rate results of our proposed scheme are fairly general and they hold for a variety of channel variation mechanisms including block fading [3], per symbol interval varying independently or with some time correlation or even for ”staggered” fading model [4].

III. MIXED CSIT DL CHANNEL

A. Proposed Transmission Strategy

The signal received at UE-1 is given by

$$y_1 = \mathbf{h}_1^\dagger \mathbf{p}_1 x_1 + \mathbf{h}_1^\dagger \mathbf{p}_2 x_2 + z_1. \tag{2}$$

The BS has perfect knowledge of $\mathbf{h}_1^\dagger$ but no information about $\mathbf{h}_2^\dagger$. Hence the design of precoding vectors can not be based upon $\mathbf{h}_2^\dagger$. The SINR at UE-1 based upon the perfect knowledge of the effective channels (the cascade of precoding vector and the true channel, i.e. $\mathbf{h}_1^\dagger \mathbf{p}_1$ and $\mathbf{h}_1^\dagger \mathbf{p}_2$) is given by

$$\mathrm{SINR}_1 = \frac{\sigma_1^2 |\mathbf{h}_1^\dagger \mathbf{p}_1|^2}{1 + \sigma_2^2 |\mathbf{h}_1^\dagger \mathbf{p}_2|^2} \tag{3}$$

Similarly the SINR at UE-2 can be written as

$$\mathrm{SINR}_2 = \frac{\sigma_2^2 |\mathbf{h}_2^\dagger \mathbf{p}_2|^2}{1 + \sigma_1^2 |\mathbf{h}_2^\dagger \mathbf{p}_1|^2} \tag{4}$$

As the BS has no information about $\mathbf{h}_2^\dagger$, a very reasonable strategy would be to adapt the precoding vectors according to $\mathbf{h}_1^\dagger$, all the information it has. This simplifies the design of precoding vectors enormously and the precoding vectors based upon the criterion of maximizing the instantaneous SINR of UE-1 are given by

$$\mathbf{p}_1 = \frac{\mathbf{h}_1}{||\mathbf{h}_1||} \tag{5}$$

and

$$\mathbf{p}_2 = \perp \mathbf{h}_1 \Rightarrow \mathbf{h}_1^\dagger \mathbf{p}_2 = 0 \tag{6}$$

This design leads to the choice of precoding vectors such that $\mathbf{p}_1$ is the normalized MF (to the channel of UE-1) and $\mathbf{p}_2$ is chosen orthogonal to $\mathbf{h}_1$ rendering zero interference at UE-1 (ZF precoder design). This precoder design causes to maximize the SINR at UE-1 over any other design and later we will see clearly while comparing the performance in section IV-B that this choice gives a significant performance advantage to UE-1 over UE-2 even if their streams are allocated equal power.

B. Information Theoretic Perspective

The rate of UE-1 for a given channel realization takes the form as

$$\begin{aligned} \mathrm{R}_1 &= \mathcal{H}\left(X_1 \big| \mathbf{h}_1^\dagger \mathbf{p}_1\right) - \mathcal{H}\left(X_1 \big| Y_1, \mathbf{h}_1^\dagger \mathbf{p}_1\right) \\ &= \log M_1 - \mathcal{H}\left(X_1 \big| Y_1, \mathbf{h}_1^\dagger \mathbf{p}_1\right) \end{aligned} \tag{7}$$

where $\mathcal{H}(.) = -\mathbb{E}\log p(.)$ is the entropy function. Note that as $\mathbf{h}_1^\dagger \mathbf{p}_2 = 0$, so UE-1 sees no interference. The second term of (7) is given as

$$\mathcal{H}\left(X_1|Y_1,\mathbf{h}_1^{\dagger}\mathbf{p}_1\right)$$
$$=\sum_{x_1}\int_{y_1}\int_{\mathbf{h}_1^{\dagger}\mathbf{p}_1} p\left(x_1,y_1,\mathbf{h}_1^{\dagger}\mathbf{p}_1\right)\log\frac{\sum_{x_1^{'}} p\left(y_1|x_1^{'},\mathbf{h}_1^{\dagger}\mathbf{p}_1\right)}{p\left(y_1|x_1,\mathbf{h}_1^{\dagger}\mathbf{p}_1\right)}dy_1 d(\mathbf{h}_1^{\dagger}\mathbf{p}_1) \tag{8}$$

where $x_1^{'} \in \chi_1$. Conditioned on the channel and the precoder, there is one source of randomness, i.e. noise. So (8) can be extended as

$$\mathcal{H}\left(X_1|Y_1,\mathbf{h}_1^{\dagger}\mathbf{p}_1\right)$$
$$=\frac{1}{M_1}\sum_{x_1}E_{z_1}\log\frac{\sum_{x_1^{'}}\exp\left[-\frac{1}{N_0}\left|\mathbf{h}_1^{\dagger}\mathbf{p}_1\left(x_1-x_1^{'}\right)+z_1\right|^2\right]}{\exp\left[-\frac{1}{N_0}\left|z_1\right|^2\right]}$$

The above quantities can be easily approximated using sampling (Monte-Carlo) methods with N_z realizations of noise and N_{h_1} realizations of the channel $\mathbf{h}_1$ thereby leading to

$$\mathrm{R}_1=\log M_1-\frac{1}{M_1 N_z N_{h_1}}\sum_{x_1}\sum_{\mathbf{h}_1}^{N_{h_1}}\sum_{z_1}^{N_z}\log\frac{\sum_{x_1^{'}}\exp\left[-\frac{1}{N_0}\left|\mathbf{h}_1^{\dagger}\mathbf{p}_1\left(x_1-x_1^{'}\right)+z_1\right|^2\right]}{\exp\left[-\frac{1}{N_0}\left|z_1\right|^2\right]}$$

For the case of UE-2, note that both of the precoding vectors are independent of $\mathbf{h}_2^{\dagger}$. So the effective UE-2 desired link $\mathbf{h}_2^{\dagger}\mathbf{p}_2$ (through which it receives desired signal) and the effective interference link $\mathbf{h}_2^{\dagger}\mathbf{p}_1$ are standard complex Gaussian scalars (zero mean and unit variance). The rate of UE-2 for a given channel realization takes the form as

$$\mathrm{R}_2=\log M_2-\mathcal{H}\left(X_2\middle|Y_2,\mathbf{h}_2^{\dagger}\mathbf{p}_1,\mathbf{h}_2^{\dagger}\mathbf{p}_2\right) \tag{9}$$

The second term of (9) is given as

$$\mathcal{H}\left(X_2|Y_2,\mathbf{h}_2^{\dagger}\mathbf{p}_1,\mathbf{h}_2^{\dagger}\mathbf{p}_2\right)$$
$$=\sum_{x_1}\sum_{x_2}\int_{y_2}\int_{\mathbf{h}_2^{\dagger}\mathbf{p}_1}\int_{\mathbf{h}_2^{\dagger}\mathbf{p}_2} p\left(x_1,x_2,y_2,\mathbf{h}_2^{\dagger}\mathbf{p}_1,\mathbf{h}_2^{\dagger}\mathbf{p}_2\right)$$
$$\times\log\frac{\sum_{x_1^{'}}\sum_{x_2^{'}} p\left(y_2|x_1^{'},x_2^{'},\mathbf{h}_2^{\dagger}\mathbf{p}_1,\mathbf{h}_2^{\dagger}\mathbf{p}_2\right)}{\sum_{x_1^{'}} p\left(y_2|x_2,x_1^{'},\mathbf{h}_2^{\dagger}\mathbf{p}_1,\mathbf{h}_2^{\dagger}\mathbf{p}_2\right)}dy_2 d(\mathbf{h}_2^{\dagger}\mathbf{p}_1)d(\mathbf{h}_2^{\dagger}\mathbf{p}_2) \tag{10}$$

where $x_2^{'} \in \chi_2$. There are three sources of randomness i.e. noise and two effective channels. Using Monte-Carlo methods with N_z realizations of noise, N_1 realizations of $\mathbf{h}_2^{\dagger}\mathbf{p}_1$ and N_2 realizations of $\mathbf{h}_2^{\dagger}\mathbf{p}_2$ which all are standard complex Gaussian random variables, we get

$$\mathrm{R}_2=\log M_2-\frac{1}{M_1 M_2 N_1 N_2 N_z}\sum_{\mathbf{x}}\sum_{\mathbf{h}_2^{\dagger}\mathbf{p}_1}^{N_1}\sum_{\mathbf{h}_2^{\dagger}\mathbf{p}_2}^{N_2}\sum_{z_2}^{N_z}$$
$$\times\log\frac{\sum_{\mathbf{x}'}\exp\left[-\frac{1}{N_0}\left|\mathbf{h}_2^{\dagger}\mathbf{p}_1\left(x_1-x_1^{'}\right)+\mathbf{h}_2^{\dagger}\mathbf{p}_2\left(x_2-x_2^{'}\right)+z_2\right|^2\right]}{\sum_{x_1^{'}}\exp\left[-\frac{1}{N_0}\left|\mathbf{h}_2^{\dagger}\mathbf{p}_1 x_1+z_2-\mathbf{h}_2^{\dagger}\mathbf{p}_1 x_1^{'}\right|^2\right]} \tag{11}$$

where $\mathbf{x}^{'}=\left[x_1^{'}\ x_2^{'}\right]^T$. If UE-2 assumes interference to be Gaussian and puts it in noise, then the rate of UE-2 is given as

$$\mathrm{R}_2=\log M_2-\frac{1}{M_1 M_2 N_1 N_2 N_z}\sum_{\mathbf{x}}\sum_{\mathbf{h}_2^{\dagger}\mathbf{p}_1}^{N_1}\sum_{\mathbf{h}_2^{\dagger}\mathbf{p}_2}^{N_2}\sum_{z_2}^{N_z}$$
$$\times\log\frac{\sum_{x_2^{'}}\exp\left[-\frac{1}{\left(N_0+\left|\mathbf{h}_2^{\dagger}\mathbf{p}_1\right|^2\sigma_1^2\right)}\left|\mathbf{h}_2^{\dagger}\mathbf{p}_1 x_1+\mathbf{h}_2^{\dagger}\mathbf{p}_2\left(x_2-x_2^{'}\right)+z_2\right|^2\right]}{\exp\left[-\frac{1}{\left(N_0+\left|\mathbf{h}_2^{\dagger}\mathbf{p}_1\right|^2\sigma_1^2\right)}\left|\mathbf{h}_2^{\dagger}\mathbf{p}_1 x_1+z_2\right|^2\right]} \tag{12}$$

C. Receiver Structures

Note that the rate of UE-2 in (11) assumes optimal receiver while it's rate in (12) assumes single-user detection at UE-2. A low complexity matched filter (MF) based receiver was proposed in [1] where it was shown that this receiver reduces one complex dimension of the system without introducing any suboptimality in the detection. This receiver structure being based on the MF outputs and devoid of any division operation can be easily implemented in the existing hardware. Moreover this low complexity receiver exploits the structure of interference in the detection process rather than putting it in noise. For subsequent discussion, we call this receiver structure as interference aware receiver.

For a better understanding of the system under different receivers, we now plot the sum rates of the system for the proposed transmission strategy. The system consists of dual antenna BS transmitting data to 2 single antenna UEs, where the CSIT for UE-1 is available whereas no channel information about UE-2 is available at the BS. The system wide sum rates are plotted in Fig. 1 for the transmission strategy proposed in section III where the precoding vectors for two UEs are computed based only upon the CSIT of UE-1, i.e. the precoder for UE-1 is the normalized MF to its channel and the precoder for UE-2 is chosen through ZF design, orthogonal to the channel of UE-1. We don't employ any sophisticated power allocation and split the BS power equally among two UEs. It's clear that the power allocation for sum rate maximization will favor UE-1 (whose CSIT is available) over UE-2 (no CSIT present at the BS) for most of the channel realizations. Hence for better comparison of different schemes and to keep some fairness among UEs at least in terms of power allocation, we have chosen to do equal power allocation. Fig. 1 shows the sum rate of the system once the proposed transmission strategy is adopted. We compare the two cases once UE-2 resorts to intelligent interference aware detection strategy and conventional single-user detection. As the rate of UE-1 is same in both the cases, so this figure effectively compares the rates of UE-2 under two detection strategies for the proposed transmission scheme. For the case of single-user detection, the rate of UE-2 is bounded by almost 1.6 bits/channel use and there is small variation in it's rate as the size of constellation of UE-2 as well as UE-1 changes. This behavior is attributed to the fact that single-user detection considers interference

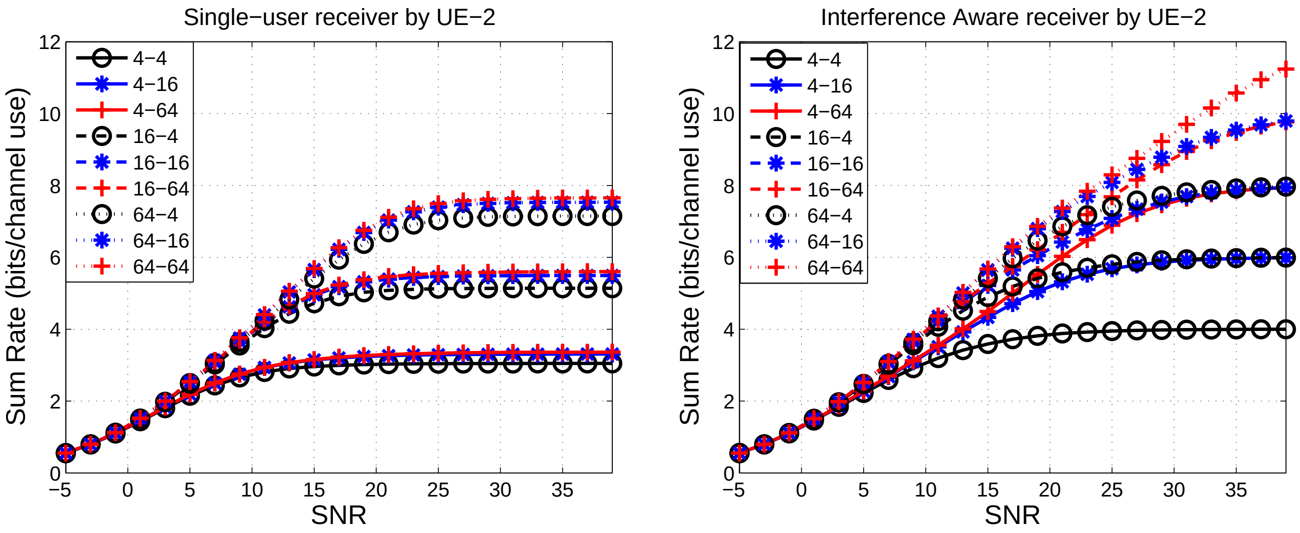

Fig. 1. Sum Rates for the strategies of intelligent interference aware detection and single-user detection by UE-2. BS has 2 antennas while both the UEs have single antennas. SNR is the transmit SNR, i.e. it is equivalent to BS power constraint. 4-16 indicates that QPSK is served to UE-1 while QAM16 is served to UE-2

as noise so at high SNR at the BS, the SINR at UE-2 is nearly 1. A slight improvement in the rate of UE-2 is observed as the size of interfering constellation increases which seems contrary to the intuition. This behavior is related to the fact that single-user detection assumes interference to be Gaussian which is actually discrete. The behavior of interference gets closer to Gaussianity as the size of interfering constellation increases (due to higher peak to average power ratio) which enhances the fidelity of Gaussian assumption of single-user detection. There is significant improvement in the rate of UE-2 once it resorts to intelligent interference aware detection strategy. In this case, the rate of UE-2 is unbounded if its rate (constellation size) is adapted with the SNR.

IV. LTE FRAMEWORK ADAPTATION

A. *Precoding Design*

Acquisition of perfect CSIT is indebted to a dedicated feedback channel in frequency division duplex (FDD) systems while it resorts to reciprocity [5] in time division duplex (TDD) systems. This acquisition in a practical system is far from realizable thereby leading to the precoding schemes based on partial CSIT or quantized CSIT [6]. 3GPP LTE and LTE-advanced have focused on the low resolution precoder codebook based approach [7] which underlines the difficulties in the acquisition of CSIT in modern wireless systems. The system under consideration in this paper is the baseline configuration in LTE for which the codebook comprises of the following four precoding vectors.

$$\mathbf{p} = \frac{1}{\sqrt{4}}\begin{bmatrix} 1 \\ 1 \end{bmatrix}, \frac{1}{\sqrt{4}}\begin{bmatrix} 1 \\ -1 \end{bmatrix}, \frac{1}{\sqrt{4}}\begin{bmatrix} 1 \\ j \end{bmatrix}, \frac{1}{\sqrt{4}}\begin{bmatrix} 1 \\ -j \end{bmatrix} \tag{13}$$

These four precoders represent four points on the unit circle. The proposed transmission strategy is modified in LTE as the BS selects the precoder for UE-1 which is closest (minimum euclidean distance) to it's MF precoder while for UE-2, BS selects the precoder which is $180°$ out of phase of the precoder of UE-1. This strategy would lead to reduced interference at UE-1 but this residual interference would still be significant, indebted to the low resolution of LTE precoders. UE-2 would face the similar channel conditions as in the case of full CSIT of UE-1 seeing that the two precoders employed by the BS are independent of it's channel or feedback. Here we propose the employment of low complexity interference aware detectors at both the UEs. Fig. 2 compares the sum rates once BS has full CSIT of UE-1 as compared to the LTE system once it has only the feedback of the precoder index of UE-1. The constellation size (rate) is adapted amongst QPSK, QAM16 and QAM64 (three possible modulations in LTE) with increasing SNR to maximize the sum rate. Though there is loss in the sum rate with the application of LTE precoders in the medium SNR regime, but the sum rate is still unbounded (in SNR). There is significant improvement once interference aware intelligent receivers are used as compared to the conventional single-user receivers even if low resolution LTE precoders are employed.

B. *Performance Comparison within LTE*

Now we look at the system performance by looking at the frame error rates (FER) of the system where the frame length is fixed to 1056 information bits. We consider the downlink of LTE system which is based on bit interleaved coded modulation (BICM) OFDM transmission from the BS equipped with two antennas using rate-$1/3$ LTE turbo code [7] with rate matching to rate $1/2$. We deliberate on the case of single antenna UEs. We consider an ideal OFDM system (no ISI) and analyze it in the frequency domain where the channel has iid Gaussian matrix entries with unit variance and is independently generated for each channel use. We assume

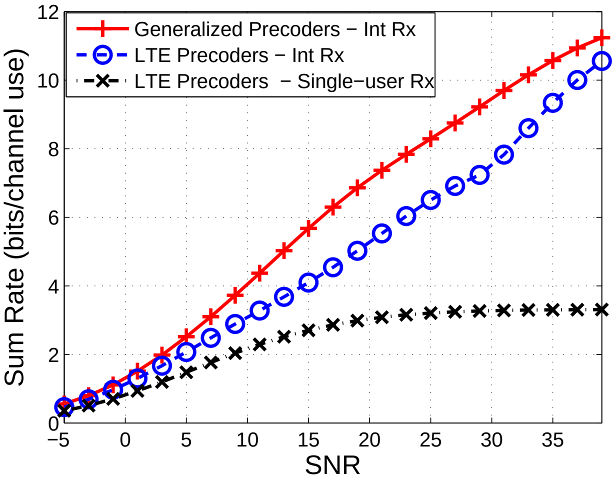

Fig. 2. Comparison of the sum rates once UE-1 feeds back the index of it's desired LTE precoder and once it feeds back the complete CSIT (Generalized precoder case). In both scenarios, neither precoder information nor CSIT of UE-2 is available at the BS. UEs employ low complexity interference aware receivers (Int Rx) and single-user receivers. Note that the constellation (rate) is adapted amongst QPSK, QAM16 and QAM64 with increasing SNR so as to maximize the sum rate.

no power control at the BS so two UEs have equal power distribution. The BS has the feedback of the precoder index of UE-1 while no such information is available for UE-2. The BS employs the proposed transmission strategy while the UEs employ low complexity interference aware receivers and single-user receivers. Fig. 3 shows the FERs of UE-1 and UE-2 for different combinations of constellations. These results are in conformity with the rate analysis and show significant gains of the proposed transmission strategy combined with interference aware detection as compared to the case of single-user detection. As the rate for the case of single-user detection is bounded by 1.6 bits per channel use, so UE-1 is only able to detect QPSK with the rate $1/2$ code while UE-2 is not even able to detect QPSK in the considered SNR regime. Though we have not considered power optimization between the two UEs, but it will definitely lower the required transmit SNR to achieve a desires QoS for the system.

V. CONCLUDING REMARKS

This paper has treated the simplest mixed CSIT system where the BS has perfect CSIT about one UE and no CSIT about the other. A simple transmission technique along with a low complexity interference aware detection strategy is proposed. In the transmission scheme, the precoding vectors for both UEs are computed based upon the available channel knowledge whereas in the detection technique, low complexity detection based on the exploitation of interference structure is proposed. The strategy is then extended to LTE systems and the achievable rates and system level performance are analyzed. The results show that the spectral efficiency can be significantly improved if intelligent receivers are employed along with efficient transmission techniques as compared to the conventional suboptimal single-user detection solutions.

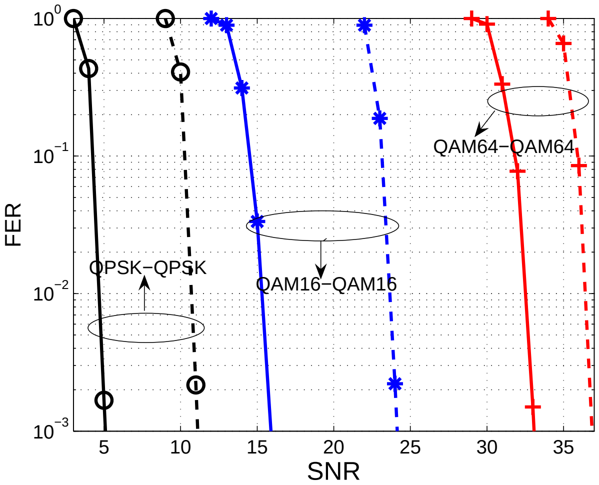

Fig. 3. Performance of LTE system with dual antenna BS and two single antenna UEs. Continuous lines indicate performance curves of UE-1 (whose precoder information is available at BS) while dashed curves indicate UE-2 (no precoder information available at BS). Rate $1/2$ LTE turbo code is used. Both UEs employ low complexity interference aware receivers. SNR is the transmit SNR. QPSK-QPSK indicates that both UE-1 and UE-2 are served QPSK constellation. Note that no such performance is possible without the use of intelligent receivers by the UEs.

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