Optimize Power Allocation Scheme to Maximize Sum Rate in CoMP with Limited Channel State Information

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This Thesis entitled Optimize Power Allocation Scheme to Maximize Sum Rate in CoMP with Limited Channel State Information by Naveen Kumar Saini is approved for the degree of MS By Research from IIT Hyderabad

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Dedication

I dedicate my thesis to my parents and friends who have been a constant source of support in my challenging days.

Abstract

Extensive use of mobile applications throws many challenges in cellular systems like cell edge throughput, inter cell interference and spectral efficiency. Many of these challenges have been resolved using Coordinated Multi-Point (CoMP), developed in the Third Generation Partnership Project for LTE-Advanced) to a great extent. CoMP cooperatively process signals from base stations that are connected to various multiple terminals (user equipment (UEs)) at transmission and reception. This CoMP improves throughput, reduces or even removes inter-cell interference and increases spectral efficiency in the downlink of multi-antenna coordinated multipoint systems.

Many researchers addressed these issues assuming that BSs have the knowledge of the common control channels dedicated to all UEs and also about the full or partial channel state information (CSI) of all the links. From the CSI available at the BSs, multiuser interference can be managed at the BSs. To make this feasible, UEs are responsible for collecting downlink CSI. But, CSI measurement (instantaneous and/or statistical) is imperfect in nature because of the randomly varying nature of the channels at random times. These incorrect CSI values available at the BSs may, in turn, create multi-user interference. There are many techniques to suppress the multi-user interference, among which the feedback scheme is the one which is gaining a lot of attention. In feedback schemes, CSI information needs to be fed back to the base station from UEs in the uplink. It is obvious, the question arises on the type and amount of feedback need to be used. Research has been progressing in this front and some feedback techniques have been proposed. Three basic CoMP Feedback schemes are available. Explicit or statistical channel information feedback scheme in which channel information like channels's covariance matrix of the channel are shared between the transmitter and receiver. Next, implicit or statistical channel information feedback which contains information such as Channel quality indication or Precoding matrix indicator or Rank indicator. 1st applied to TDD LTE type structure and 2nd of feedback scheme can be applied in the FDD system. Finally, we have UE which tranmit the sounding reference signal (CSI). This type of feedback scheme is applied to exploit channel reciprocity and to reduce channel intercell interference and this can be applied in the TDD system. We have analyzed the scenario of LTE TDD based system. After this, optimization of power is also required because users at the cell edge required more attention than the user locating at the center of the cell. In my work, it shows estimated power gives exponential divercity for high SNR as low SNR too.

In this method, a compression feedback method is analyzed to provide multi-cell spatial channel information. It improves the feedback efficiency and throughput. The rows and columns of the channel matrix are compressed using Eigenmode of the user and codebook based scheme specified in LTE specification. The main drawback of this scheme is that spectral efficiency is achieved with the cost of increased overheads for feedback and evolved NodeB (eNB). Other factor is complexity of eNodeB which is to be addressed in future work.

Contents

Chapter 1

Introduction

Wireless communication is interference limited in nature. Further, standards and specifications are centralized to resolve issues like efficient spectrum utilization and power policies. It enhances the peak data rate and optimum power allocation. So, the basic idea is to work base stations in a corporation to share information before transmission to make transmission interference immune and user-friendly. Multicellular corporation resolves many issues like cell-edge interference and maximum data reception. As the solution for high data rate and utilization of spectrum 3GPP (3rd Generation Partnership Project) introduced LTE (Long Term Evolution) specification in release 8. LTE standard supports scalable carrier bandwidth to improve peak data rate. All devices supporting LTE uses the Multi-input Multi-output (MIMO) in downlink and uplink transmission which allows separate the desired to the base station to transmit the multiple data stream to the desired users. MIMO uses the different multiple access schemes and provides more degree of freedom.

OFDMA (Orthogonal frequency division multiple access) is used for downlink transmission. SC-FDMA (Single Carrier- Frequency Division Multiple Access) is the soultion to reduce high peak to average power ratio (PAPR) in uplink transmission due to.As per high demand of big data, 3GPP introduced LTE-A (Long term Evolution-Advanced in release 10) in 2011 under 4G (Fourth Generation) which is spectrum aggregation. Introduction of LTE-A standard increases high data rate and improved throughput than LTE. The LTE requirements are limited to less streaming data but LTE-A complete the 4G requirements for high data streaming without losing of its generality. All devices use LTE-A supports VoLTE and peak data rate increased to 1Gbps for downlink and 500Mbps for uplink. LTE-A uses the additional antenna arrays in MIMO (advanced MIMO) transmission access for downlink and uplink as LTE with higher modulation schemes like QPSK, 16QAM, 64QAM to improve the data rates. Usually number of antenna are fixed by the regulatory authority due to cost and form factor. With increasing number of antennas operators dont have sufficient use of spectrum so the technique enable the antenna coverage is carrier aggregation. Carrier aggregation is a bunch of single carrier in a tunnel which increases the overall bandwidth utilization. Advanced MIMO is also called massive MIMO or CoMP (Coordinated Multipoint) which enable the very high streaming of data and voice over carrier aggregation.

Coordinated multipoint is the evolving technique which helps to implement Massive MIMO system for transmission and reception of massive data with high data rates over mobile applications. LTE CoMP was introduced in release 11 [12]. Extensive use of mobile applications throws many challenges in cellular systems like cell edge throughput, inter-cell interference, and spectral efficiency. Many of these challenges have been resolved using Coordinated Multi-Point (CoMP, developed in the Third Generation Partnership Project for LTE-Advanced) to a great extent. CoMP cooperatively process signals from eNodeBs (cooperative Base stations with signal processing) that are connected to various multiple terminals (user equipment (UEs)) at transmission and reception. CoMP improves throughput, and to reduce inter-cell interference in a different perspective and enhances the spectral efficiency in a downlink of a multi-antenna cooperative set.

Many researchers addressed these issues assuming that BSs have the knowledge of the common control channels dedicated to all UEs and also about the full or partial channel state information (CSI) of all the links. With the availability of CSI at the BSs, multiuser interference can be managed effectively. UEs are responsible for collecting downlink CSI and fed back to the dedicated Base station. But, CSI measurement (instantaneous and/or statistical) is imperfect in nature because of the randomly varying nature of the channels at random times. These incorrect CSI values available at the BSs may, in turn, create multi-user interference. There are many techniques to suppress the multi-user interference, among which feedback scheme is the one which is gaining a lot of attention. Desired signal power over interference and noise power at user terminal can be characterized for point to point communication link for which Shannon shown upper bound on capacity. Performance parameter like sum rate in cooperative multi-cell systems enhances the data transmission capacity at high signal to noise ratio region. Transmission policies (precoding techniques) are taking part to achieving exponential diversity when the channel state information at the transmitter and receiver is known. But the challenge arises when channel information is not known and degrades. Spatial and temporal power allocation policies are utilizing to achieve exponential diversity when channel information at the transmitter and receiver degrades. Different feedback schemes are available to fed back channel information from UE to eNodeBs. It enhances many research attention towards the different models and scenarios.

1.1 LTE Frame Structure Overview

3rd Generation Partnership Project (3GPP) released the LTE standard and it's advanced which defines the capabilities of networks and devices. Its standard is defined in release 3GPP Release 8, which is for user equipment categories 1 to 5. This 3GPP group defined different frame structures through which transmission of data and scheduling of users on antenna can be ported.

LTE frame structure is based on half and full duplex techniques. LTE frame structure is divided in two forms Type 1 LTE FDD frame structure and Type 2 TDD frame structure. Downlink and uplink transmission are performed in a different frequency band in type 1 mode system(Fig. 1), while in type 2 mode system transmission perform in same frequency band but different time slots. In both the type, each frame is of 10ms length in time domain and has 307200 number of samples. The frame is divided into 10 subframes and each of subframe is again divided into two slots for a duration of .5ms. Every slot contains 6 or7 OFDM symbols which depend upon cyclic prefix length(normal or extended). In type 2 fame structure, each subframe contains three fields, Downlink Pilot Time Slot, Uplink Pilot Slot and guard period between uplink and downlink subframe. In the context of OFDM, it is a transmission technique which divides whole bandwidth into hundreds of narrowband subcarriers. It is different from the multicarrier transmission technique. OFDM is implemented using Inverse Fast Fourier Transform at the transmitter terminal and demodulated using FFT at the receiving terminal. Single OFDM symbol and one subcarrier in a matrix called resource element. Seven OFDM symbol by 12 subcarriers a resource block. A resource block (Fig. 2) of the 180kHz band (1RB= 12 subcarriers of 15kHz each band) are allocated which are dedicated to the user for the synchronization at the time transmission through the antenna array. Carrier aggregation is the main feature in LTE advanced where different carrier frequency bands are aggregated in a tunnel to maximize the channel bandwidth and increase data rate for the uplink and downlink channel. Depends upon different modulation schemes data rate can be increased and interference can be minimized.

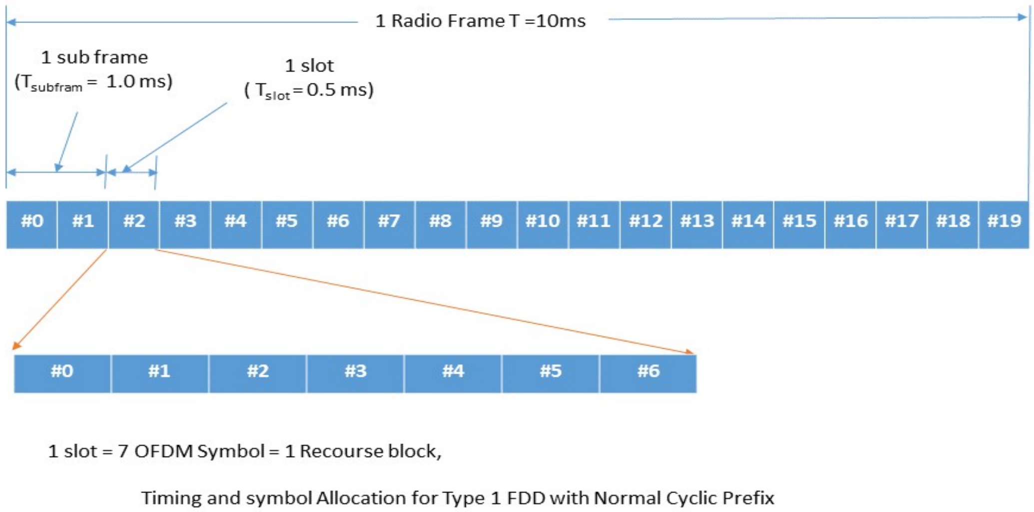

Figure 1.1: LTE_Frame_Structure_Type1

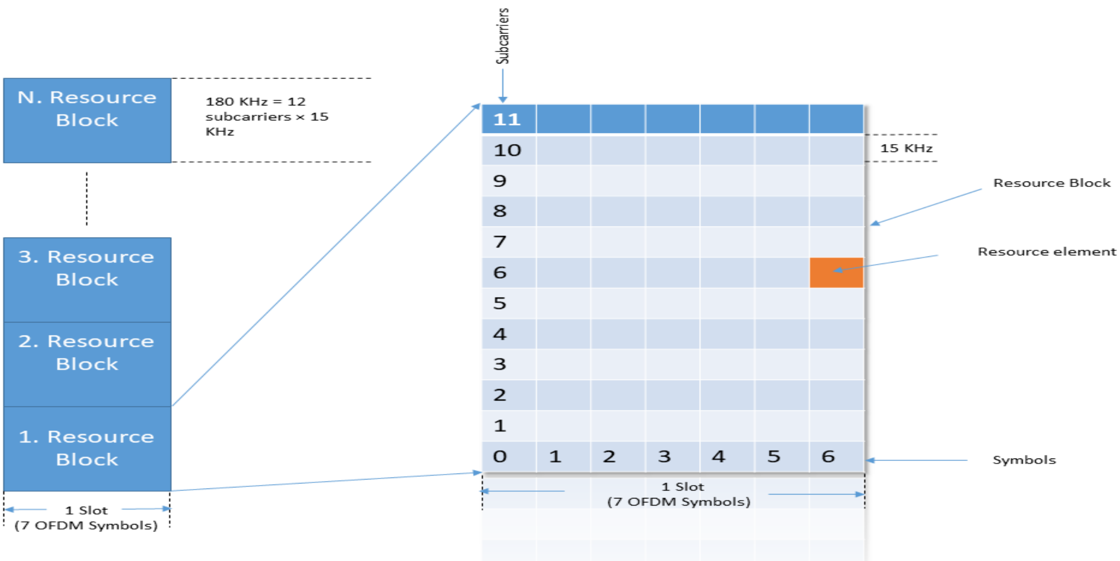

Figure 1.2: Resource_Block_Grid

Table 1.1: LTE Parameter

Parameters	Description
Frequency range	UMTS FDD bands and TDD bands
Duplexing	FDD, TDD, half-duplex FDD
Channel coding	Turbo code
Mobility	350 km/h
Channel Bandwidth (MHz)	1.4, 3, 5, 10, 15, 20
Transmission Bandwidth Configuration NRB : (1 resource block = 180kHz in 1ms TTI)	6, 15, 25, 50,75, 100
Modulation Schemes	UL: QPSK, 16QAM, 64QAM(optional) DL: QPSK, 16QAM, 64QAM
Multiple Access Schemes	UL: SC-FDMA (Single Carrier Frequency Division Multiple Access) supports 50Mbps+ (20MHz spectrum) DL: OFDM (Orthogonal Frequency Division Multiple Access) supports 100Mbps+ (20MHz spectrum)
Multi-Antenna Technology	UL: Multi-user collaborative MIMO DL: Tx AA, spatial multiplexing, CDD ,max 4x4 array
Peak data rate in LTE	UL: 75 Mbps (20MHz bandwidth) DL: 150 Mbps (UE Category 4, 2x2 MIMO, 20MHz bandwidth) DL: 300Mbps(UE category 5, 4x4 MIMO, 20MHz bandwidth)
MIMO (Multiple Input Multiple Output)	UL: 1 x 2, 1 x 4 DL: 2 x 2, 4 x 2, 4 x 4
Coverage	5 - 100km with slight degradation after 30km
QoS	E2E QOS allowing prioritization of different class of service
Latency	End-user latency ¡ 10mS

1.2 Coordinated Multipoint CoMP

Baier et al introduced the Coordinated multipoint first time. The basic concept behind the CoMP was the coordination between small multiple transmitter station and transmit the data collectively to multiple mobile terminals/UEs. In a downlink, the large gain in spectral efficiency and the fairness can be achieved when multiple data streams are transmitted simultaneously through joint precoding schemes. In an uplink, base stations jointly detect the multiple terminals. In fact, CoMP is a facility for developing LTE advanced systems for the cell edge user. CoMP schemes can be classified into three categories based on the corporation and interference. First, non-cooperative aware transceiver scheme, very less information is shared between the transmitter and receiver. In this method upto certain extent ICI can be mitigated due to less extent of coordination of base stations. Because of fairness requirement is mandatory in cellular system , more coordination is necessary between the BSs. Based on reference signals design, interference can be estimated and it includes single-cell multi-user signal processing. Or, we can say this method PMI and CSI method is considered for transmission of CSI to the BSs. Second, interference coordination, where limited information is exchanged between the cells. It reduces the back-haul load requirements. Various precoding techniques like multi-cell cooperative scheduling, multi-cell interference aware link adaptation, or multi-cell interference-aware precoding are used for scheduling and fairness. Third, joint signal processing, which is responsible for the exchange of signals between the base stations.

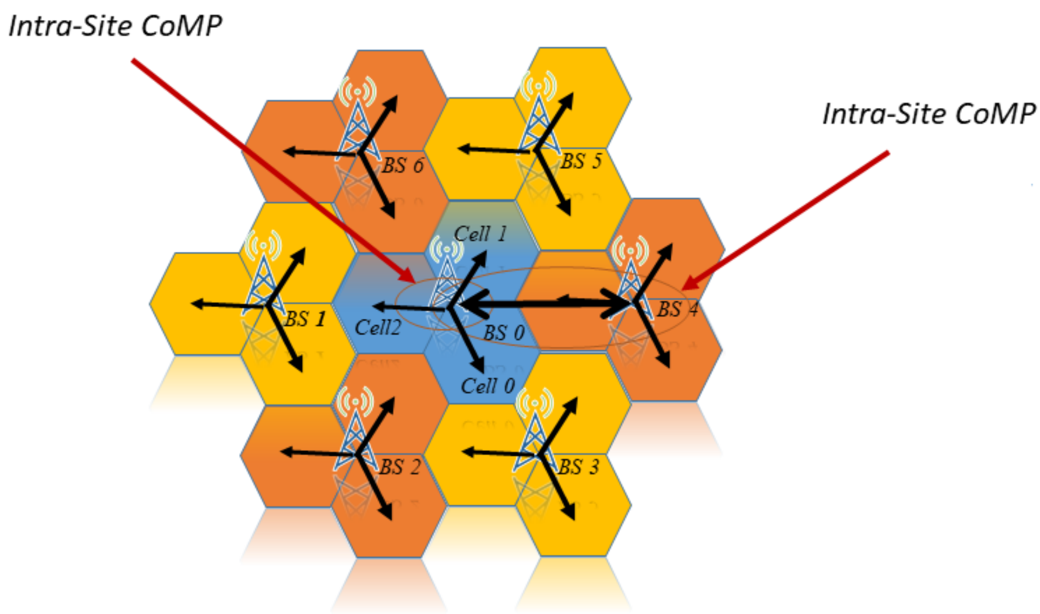

Figure 1.3: Illustration of Inter-site and intra-site CoMP

The main challenge is to deploy flat architecture in an indoor and outdoor environment to explode heavy volume of data which drag attention towards these issues. CoMP analysis is so complex that developing different models for different scenarios is not possible. So, field trials of new technologies are the key solutions for the challenge to refine simulations and analytical models. Moreover, base stations transmit information according to the channel situation. If channel information is known to the eNodes via UEs than eNode B can transmit information to the dedicated UE can be improved based on channel state information.

So, the downlink LTE transmission precoding scheme like Zero Forcing, Block Diagonalization, Multi-user Eigenmode can be utilized. Downlink channel matrix can be formed to create the cooperating set. The cooperating set has a dedicated user to which transmission can happen and rest act as interference. Interferences are intraset and interset. Basic MIMO system is mentioned using the singular value decomposition method. Matrix analysis is utilized to estimate received the symbol by MMSE or ML detection. As we know MMSE is better as compare to ML. MMSE is used when modeling is done in that way as channel matrix is not revertible or if channel matrix is invertable then ZF precoding can be used. At the receiver, maximum ratio combing method can be used to detect by the estimator and transmit back the information.

1.3 Limited Feedback Scheme

Various distributed approach is using nowadays for precoding. But, performance of precoding strategies are highly dependent on what type of feedback scheme is utilizing. It is not necessary based on feedback scheme and precoding scheme, transmit power can be reduced and sum-rate can be increased. It is obvious, the question arises on the type and amount of feedback need to be used. Research has been progressing on this front and some feedback techniques have been proposed. As prediction and estimation of channel information are trivial at the transmitter and receiver so different methods are needed. For non-cooperative single-user MIMO, feedback schemes of CSI are categorized into three basic types implicit, explicit and SRS channel feedback. Directly explained information (channel matrix, channel co-variance matrix, eigenvectors of the channel matrix) is explicit information. Not directly explained information (implicit information) fed back from each user to assigned base station, which contains information such as Channel quality indication /Preceding matrix indicator/Rank indication. This type of feedback can be best applied in the FDD system. And last, UE transmission of the sounding reference signal can be used for channel side information estimate at eNodeB exploiting channel reciprocity. This type of feedback system is the best suited for TDD system.

Chapter 2

Literature Survey

Various solutions are proposed for enhancing the capacity of the system and reduction of inter-symbol interference but there is triad-off between these parameters. In the paper, Jing Jin et al.[1], the author proposed and analyzed CoMP-FDD system with limited feedback scheme which feedback both explicit and implicit channel state/statistical information. Rows and Columns of the channel matrix are reduced and compressed. The row is compressed by eigenmode decomposition and column are compared based on codebook which is defined my LTE. Compressed channel information is sent back towards the transmitter with 6- bit scalar quantizer.

Patrick, J. Zhao et al [2],[3], analyzed the performance of the small cell and took hexagonal cells out of the large cellular system with the same sectored method as GSM and next scenario is based on real word field trial. Nonoverlapping and overlapping clustering scenarios is taken and found that in nonoverlapping clusters user at the cell edge found less SNR value. So, in overlapping UEs at cell edge employed at reuse factor 1. It observed that static clustering requires minimum signaling overhead. The desired codebook is fed back to the transmitter based on LTE specification[4].

Different literature shows various scenarios in wireless communication like COMP heterogeneous network/femtocell/picocell/microcell etc. The purpose is to reduce ICI at the cell edge. In that way, Coordinated Multipoint Joint Transmission helps to reduce inter-cell interferences by scheduling, imperfect CSI, and data information.

Based on limited feedback schemes N. Ravindran et al [5], quantization feeb back scheme is compared and quantified throughput loss due to imperfect channel information. L. U. Choi et al, Q. H. Spencer et al [6] [7], different precoding techniques are analyzed for the joint transmission towards UEs. M. Z. A. Khan[9], exponential diversity for the imperfect channel information at the transmitter and receiver is analyzed and measure the conditions to be satisfied, as feedback rate increases linearly with SNR and channel estimation is at a transmit power greater than or equal to the power to be allotted in Rayleigh fading channel. And we simulated this paper and get optimum results. The drawback of the work is Peak to average power ratio increases for higher values of SNR. Sharma et al [10] claimed polynomial diversity will be obtained at a high SNR region when the quality of CSIT degrades. R. Bhagvatula et al [11], analyzed feedback schemes adaptively and claimed sum rate can be maximized on optimum beamforming technique in coordinated multi-cell systems.

Chapter 3

System Model

Feedback compression scheme is used to improve feedback efficiency to provide multi-cell channel information. In a feedback scheme, rows and columns are compressed due to limited uplink bandwidth. With the help of feedback channel information, joint transmission beamforming scheme can be used to mitigate ICI. Dirty Paper Coding suggested the upper bound capacity for single-cell multi-user. The sum rate of any subset of UEs is bounded by the joint mutual information between these UEs and the BSs given that all other UEs are turned off.

3.1 System Model for CoMP

We considered the a downlink MIMO system where M adjacent cells are coordinating with each other. All the terminals send back estimated feedback bits to the cooperating sets eNodeB. Joint transmission beamforming transmission scheme is used and the shared information (scheduling), imperfect CSI and data are performed at the eNB side to partially cancel ICI. OFDM transmission method is utilized to divide the frequency selective fading channel into multiple flat fading channel. Here we considered a frequency-flat channel for simplicity[1].

k^{th} user received the data as -

$$Y_k = \underbrace{H_k W_k S_k}_{Desired\, signals} + \underbrace{H_k \sum_{j=1, j\neq k}^{M} W_j S_j}_{\substack{Interference\, within\, the \\ cooperating\, set}} + \underbrace{\sum_{i} \sum_{j=1}^{M} {H_k}^{(i)} {W_j}^{(i)} {S_j}^{(i)}}_{\substack{Interference\, from\, other \\ cooperating\, set}} + \underbrace{n_k}_{noise} \tag{3.1}$$

where,

- $H_k \in \mathcal{C}^{n\times Mm}$ – dedicating channel matrix from the coordinating eNBs to the k^{th} UE.
- $W_k \in \mathcal{C}^{Mm\times r_k}$ – precoding matrix for user k.
- $S_k \in \mathcal{C}^{r_k\times 1}$ – data vector symbol
- r_k – independent data streams for user k and $r_k \leq$ to the number of receive antennas.
- i – interference neighboring cooperating set.

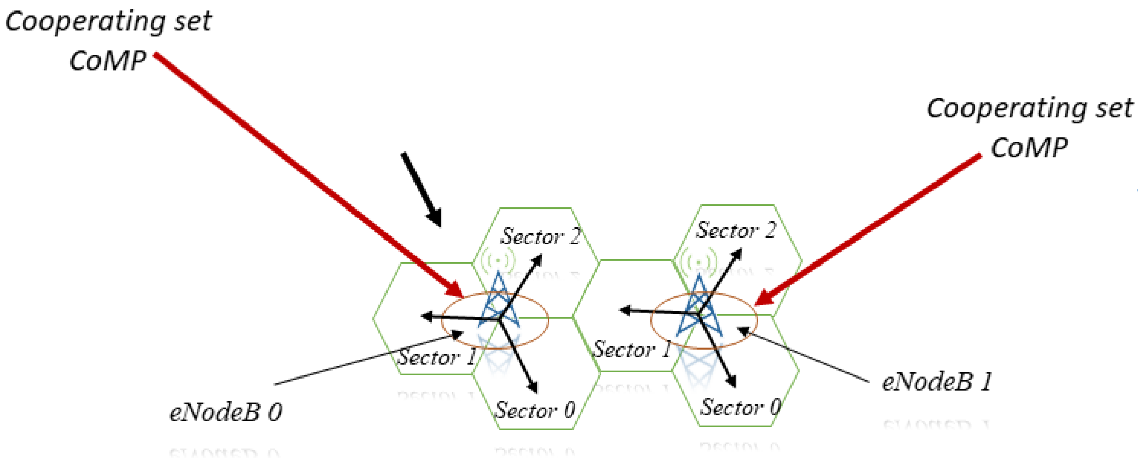

Figure 3.1: System Model

- n_k – additive white Gaussian noise (AWGN) vector
- Total transmit power constraint –

$$\sum_{k=1}^{M} trace(W_k S_k {S_k}^H {W_k}^H) \leq P_{sum} \tag{3.2}$$

Another method for power allocation is the water filling algorithm but it not optimum for general cases. At the cell edge, users may receive less power like an urban area as there are many sources of interference so above mentioned power allocation strategy is proposed to be optimum.

3.2 Feedback Scheme

Limited feedback is a major topic for ongoing research in multichannel transmission wireless communication systems. Code-book defined by LTE specification is boosting factor to inform transmitter about the channel condition. Whereas, the quantization method gives the ways to transmit the estimated CSI from the receiver to transmitter. In this method, CSI is fed back with the scale bits. Various methods are proposed but in order to save uplink resources, the channel needs to be compressed and fed back. By this way, multi-cell spatial channel information is transmitted back towards the transmitter. This technique improves feedback efficiency in the multicell system. Here, the rows of the channel matrix are compressed using Eigenmode of the user and columns of the channel matrix uses the codebook defined by 3GPP LTE standards. The transmitter then applies inter-cell interference mitigation scheme with the fed back compressed channel information. Spectral efficiency can be achieved with the cost of increased overheads for feedback. Other drwaback is the complexity of evolved NodeB (eNB) which required big data information to circulate between the

BSs for joint tranmission.

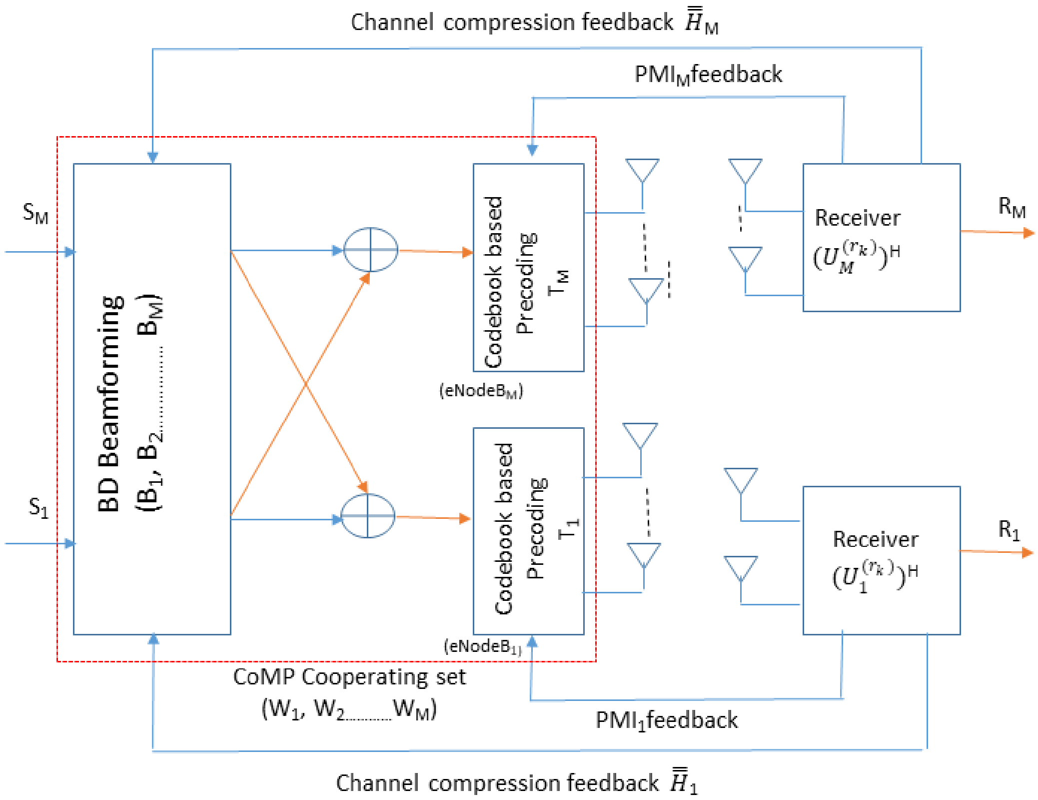

Figure 3.2: Channel Compression

Chapter 4

Simulation Analysis

The system model described is simulated using MATLAB.

4.1 Scenario1: Mean Sum-Rate vs Desired bits/SNR

In the fig 4.1, SNR quantization on sum-rate in a multi-cell system is investigated. In a narrow band model, Nt transmitting antenna and the single antenna at receiver is considered. The input-output relation for the dedicated kth user (or desired signal) is simulated. Interfering parameter interfering parameter, limits the sum-rate for high values of SINR.

$$y_k = \sqrt{\gamma_{k,(d)}}\mathbf{h}_k^T\mathbf{f}_k s_k + \sqrt{\gamma_{k,(i)}}\mathbf{g}_{k+1}^T\mathbf{f}_{k+1}s_{k+1} + n_k \tag{4.1}$$

where $\mathbf{h}_k \in \mathcal{C}^{N_t\times 1}$, $\quad \mathbf{g}_{k+1} \in \mathcal{C}^{N_t\times 1}$, $\quad \gamma_{k,(i)} = \alpha_k, \gamma_{k,(d)}$, $\quad n_k \in \mathcal{C}$

Simulation is performed for different values of with the received SINR of the desired signal (in dB) (fig4.2). We simulated the sum-rate for function with the SINR values and draw the graph for loss mean sum-rate verses quantized SNR. The result shows that for a high value of interfering parameter loss in mean Sum-Rate is high as compared to low values of .

Design of feedback bits partitioning scheme influence the beamforming method. Bits for feedback from the UE is chosen from a codebook. Maximization of sum-rate is influenced by the optimum

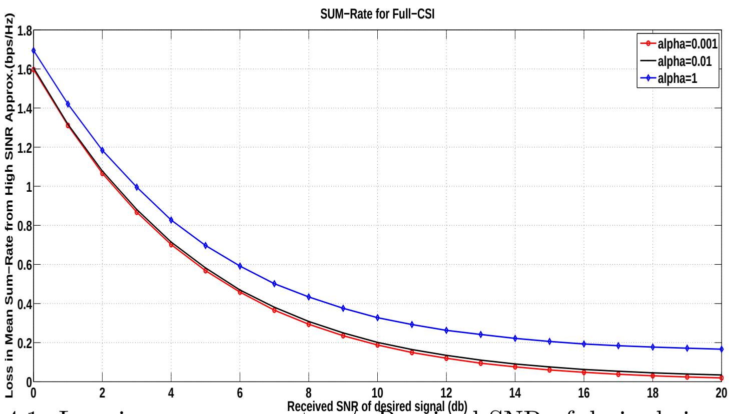

Figure 4.1: Loss in mean sum rate v/s Received SNR of desired signal (dB).

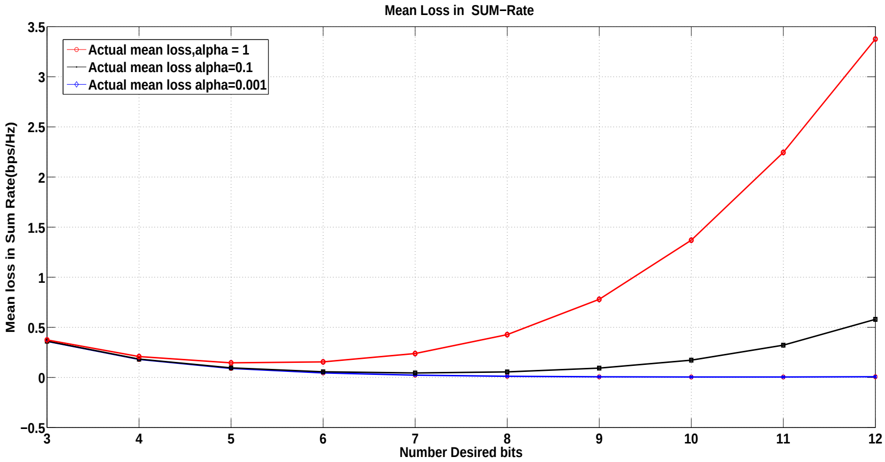

Figure 4.2: Mean loss in sum rate vs desirable bits

feedback scheme. If total B bits are chosen for feedback, then each of 2B vectors from the codebook is chosen as index no. for the channel to feedback desired signaling. Bit allocation strategy opts for desired and interfering channels. Based on feedback strategy, we analyzed the mean sum-rate with high values of quantized desired bits. It shows that mean loss sum rate increases exponentially for different values of as shown in figure7. Optimization of feedback scheme is still a complex phenomenon for CoMP system so field trials are one of the solutions to evaluate the upper and lower bound for maximum sum-rate.

4.2 Scenario2: Applied Generalized Eigen Vector Beam Forming

In this section, maximization of mean sum rate is analyzed. Generalized Eigen Vector Beam Forming (GEBF) method is implemented through different interfering parameters. Simulations for interfering parameters in Fig 4.3 at values = .001, .01 and 1 is considered. It is observed that at = .001, mean sum rate value evaluated maximum as compare to at the values of = .01 and = 1. It shows that as the interfering values goes down with limited CSI, GEBR obtained significant mean sum rate for low as well high SNRs. It shows that cell edge users require more bits for feedback as compare to the desired bits at the cell center to achieve the maximum sum rate.

Further, due to demand for continuous connectivity, various power allocation schemes are proposed. Power allocation schemes depend on the channel quality detected at the receiver and feedback this information to the transmitter. Here, consider the MIMO system model at given below. Received complex symbol vector at time instant

Where H is the Complex channel matrix WT as the precoding matrix, x is the transmitted symbol and N AWGN noise. In fig 4.4, simulation is done to achieve BER for SISO using BPSK modulation in two cases. In case 1, BPSK BER is achieved for channel reciprocity with imperfect ideal channel state information at transmitter and receiver when estimated power is equal to 1. In case2, for linear feedback imperfect CSIT and CSIR, BPSK BER is achieved when estimated power

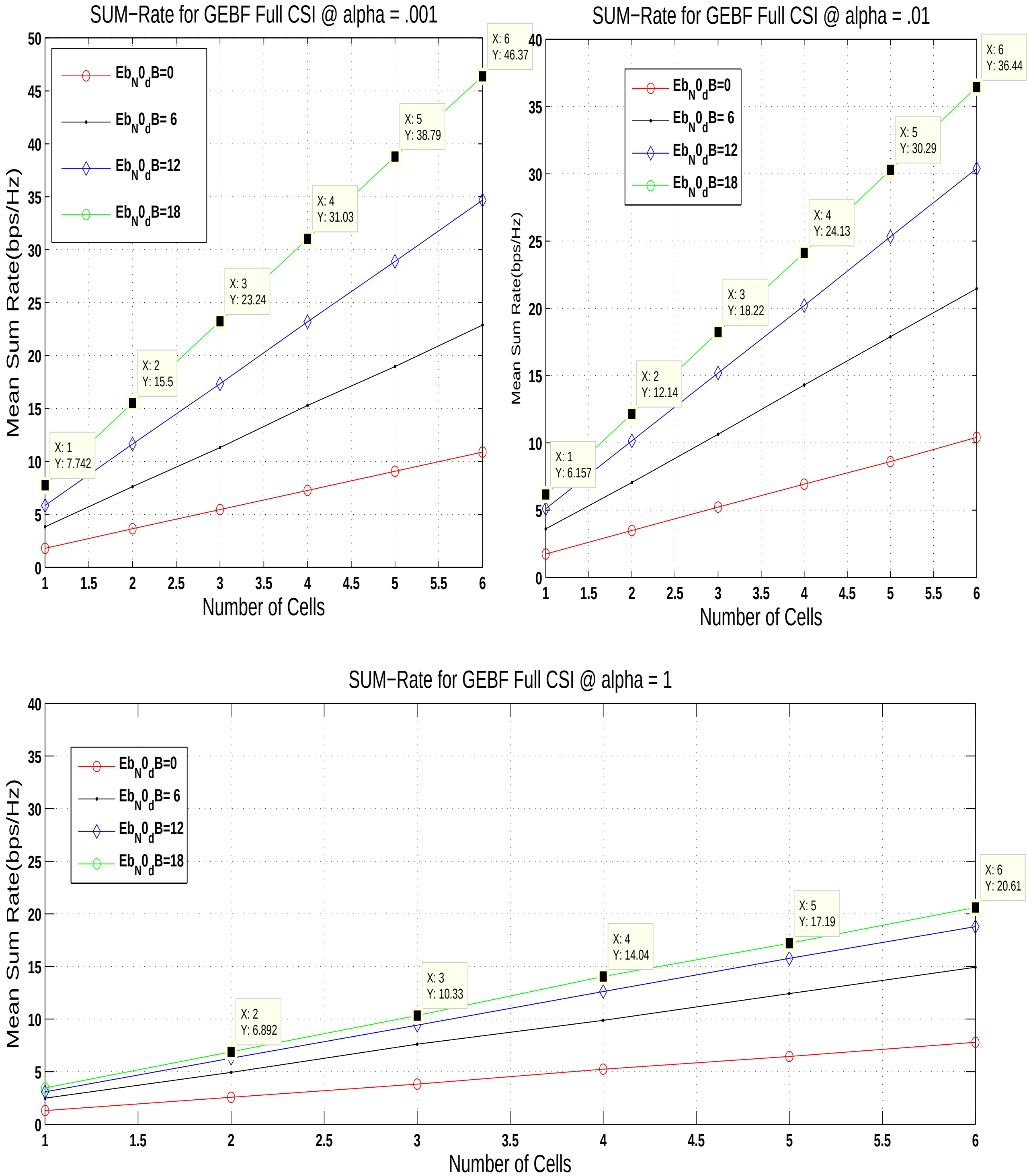

Figure 4.3: Mean sum rate vs Number cells different alpha values

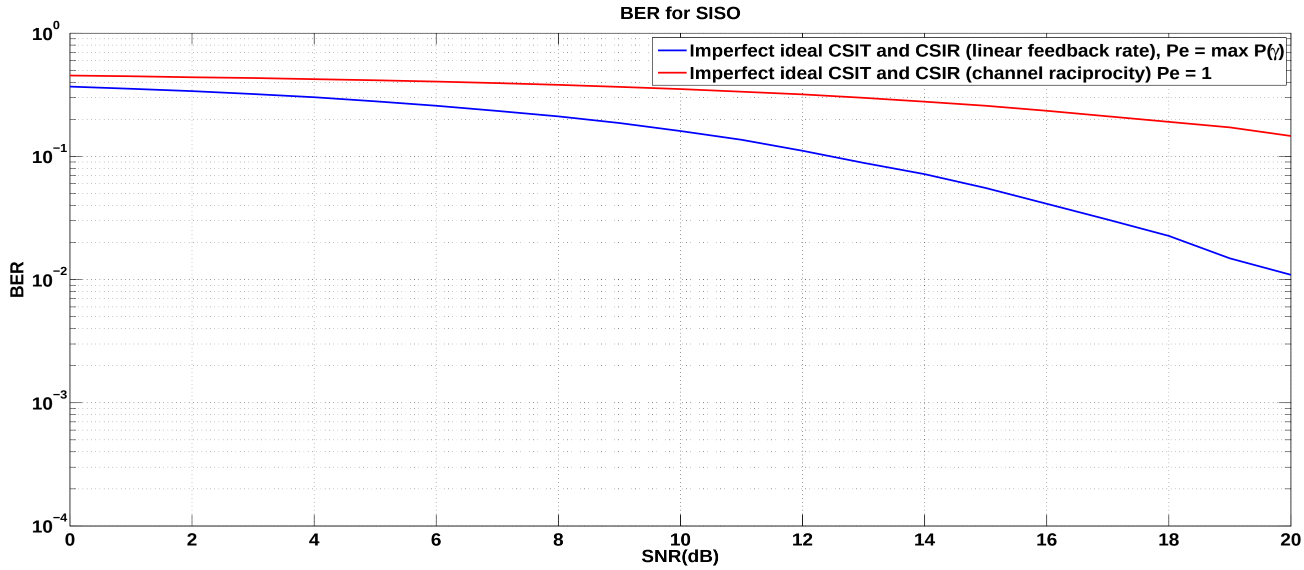

Figure 4.4: Received Signal $Y = \sqrt{(P_E)}\mathbf{H}W_T x + N$

is a maximum of power threshold.

Chapter 5

Conclusion and Future Work

In this work, we simulated various system models to achieve maximized sum-rate using power allocation techniques. Power allocation technique using limited feedback in the coordinated multipoint system in the current scenario has been estimated. Various solutions based on CoMP is available but with the cost of more number of bit overload in uplink with imperfect CSI. Few areas are still in progress where power allocation techniques need to be analyzed with non-orthogonal multiple access techniques, as CoMP is the complex structure. So, the importance of the field trials for new technologies are the key solutions for the new models coming up and to refine simulations and analytical models like Cloud RAN.

References

[1] J. Jin, Q. Wang, C. Lin, H. Yang, Y. Wang, Coordinated Multi-Point Transmission with Limited Feedback, *IEEE Globecom 2010 Workshop on Broadband Wireless Access*, pp. 850854, 2010.

[2] P. Marsch, G. Fettweis, Static Clustering for Cooperative Multi-Point (CoMP) in Mobile Communications, *IEEE Communications Society, IEEE ICC 2011 proceedings*, pp. 946-951, 2012.

[3] J. Zhao, Z. Lei, Clustering Methods for Base Station Cooperation, *2012 IEEE Wireless Communications and Networking Conference: PHY and Fundamentals*, pp. 946-951, 2012.

[4] 3GPP TS 36.211 v9.1.0, Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation, Mar. 2010.

[5] M. S. Ullah, M. J. Uddin, "Performance Analysis of Wireless MIMO System by Using Alamoutis Scheme and Maximum Ratio Combining Technique, *Int. J. of Advanced Engineering Sciences and Technologies*vol. 8, no. 1, pp. 019–024.

[6] N. Ravindran, N. Jindal, Limited Feedback-based Block Diagonalization for the MIMO Broadcast Channel, draft, Feb. 2008.

[7] L. U. Choi, R. D. Murch, A transmit preprocessing technique for multiuser MIMO systems using a decomposition approach, *IEEE Trans. on Wireless Commun.*, vol. 3, no. 1, pp. 20–24, 2004.

[8] Q. H. Spencer, A. L. Swindlehurst, M. Haardt, Zero-forcing methods for downlink spatial multiplexing in multiuser MIMO channels,*IEEE Trans. on Signal Processing*, vol. 52, no 2, pp. 461–471, Feb. 2004.

[9] F. Boccardi, H. Huang, A near-optimum technique using linear precoding for the MIMO broadcast channel,*Proc. IEEE International Conference on Acoustics, Speech and Signal Processing*, vol. 3, pp. III-17– III-20, 2007.

[10] M. Z. A. Khan, "Achieving exponential diversity with spatiotemporal power allocation with imperfect channel state information," *National Conference on Communications*, pp. 1–5, Jan. 2011.

[11] R. Bhagavatula, R. W. Heath, "Adaptive Limited Feedback for Sum-Rate Maximizing Beamforming in Cooperative Multicell Systems", *IEEE Transactions on Signal Processing*, vol. 59, no. 2, pp. 800–811, Feb. 2011.

[12] V. Sharma, K. Premkumar, R. N. Swamy, “Exponential diversity achieving spatio-temporal power allocation schemes for fading channels”,*IEEE Trans. Information Theory*, vol. 54, no. 1, pp. 188–208, Jan. 2008.

[13] D. Lee et al., Coordinated multipoint transmission and reception in lte-advanced: Deployment scenarios and operational challenges, *IEEE Commun. Mag.* , vol. 50, no. 2, pp. 148-155, Feb. 2012.