A STUDY OF FREQUENCY REUSE IN MIMO CELLULAR NETWORKS FOR SCALABLE SOURCE TRANSMISSION

Akshay Bochare
M. Tech. Scholar
Digital Communication
PIES, Bhopal MP

Mukesh Saini
Asst. Professor
Department of Electronics & Communication
PIES, Bhopal MP

Abstract

The large scale multi user MIMO technique is introduced as a promising technique for the fifth generation (5G) radio systems. Where recent researches validate that BSs, deploy an order of magnitude more antennas than scheduled users, have great capability to enhance the spectral efficiency (SE) in cellular systems and consequently, meet the fast growth in wireless-traffic of various multimedia applications. It is worth noting that, feedback burden of channel state reporting can be avoided by exploiting the channel reciprocity in time division duplex transmission mode. Moreover, in order to minimize training overhead in channel estimation, massive MIMO system exploits the reuse of frequency sequences. However, the major challenge is the contamination of channel-estimate due to reusing the same frequency's in nearby cells and this impairment is termed as frequency-contamination.

Keywords: - MIMO, Cellular Network, OFDM, AFR, number of Packet.

INTRODUCTION

In MIMO systems, when there is only one user in a BS coverage, they refer to the scenario as a single user-MIMO (SU-MIMO) system as shown in figure (b). An SU-MIMO system suffers from a high channel correlation since multiple antennas are spaced apart by a short distance both at a BS and a UE. Further, the capacity of a SU-MIMO system is limited by the number of antennas of a UE[1, 2]. This is because the capacity of a MIMO system varies proportionally with spatial multiplexing gain of the link between a BS and a UE, where the gain is directly proportional to the lesser between the numbers of antennas of a transmitter (BS) and a receiver (UE) in downlink, and a UE usually has fewer antennas than a BS. To overcome this problem, a high diversity in spatial channels needs to be achieved. One way to do this is to employ MIMO principles to more than one UE by exploiting randomness of UE distributions in the coverage of a BS, and the resulting system is called multi-user-MIMO (MU-MIMO) as shown in figure (c). However, the inter-cell interference experienced by UEs, particularly cell-edge UEs, from nearby BSs and UEs is the major bottleneck to an improvement in the overall system capacity[4, 6].

A cooperation between nearby BSs can be exploited to keep this interference at a minimal or zero level. By introducing a coordination between BSs, a higher degree of freedom can be achieved. This configuration is called networked MIMO where a group of BSs coordinate with each other to form a virtual massive multi-antenna system for downlink transmission as shown in figure (d). In a networked MIMO system, data streams from multiple BSs are simultaneously transmitted to multiple UEs within or beyond their cell coverages by cancelling cross-talk interferences. This results in achieving a spatial multiplexing gain that scales system capacity with cluster size (i.e., the density of cooperating BSs)[3, 7]. However, it requires a tight synchronization in terms of transmission time, carrier frequency, sampling clock-rate, and sharing of user data between cooperating BSs for cancelling cross-talk interferences. Since overheads from cooperating BSs increase with cluster size, a networked MIMO system is feasible for small networks[8]. CoMPs with MU-MIMO can also be exploited to improve capacity by taking advantages from both the spatial multiplexing gain of MU-MIMO systems and the interference avoidance (nullification) of CoMP systems[4].
The rest of paper organized as in section II discuss the literature survey and problem domain in section III. In section IV discuss the frequency reuse and finally in section IV discuss the conclusion.

II. LITERATURE SURVEY

Et al.	Author	Title - Publication	Approach
[1]	Seok-Ho Chang, Hee-Gul Park, Jun Won Choi and Jihwan P. Choi	Scalable Source Transmission with Unequal Frequency Reuse in MIMO Cellular Networks, IEEE, 2017	They prove that they can find a crossover of the outage probability curves for a data rate lower than a given threshold, which is a function of the parameters such as the partial frequency reuse factor and the user location in the cell.
[2]	Renaud-Alexandre Pitaval, Olav Tirkkonen, Risto Wichman, Kari Pajukoski, Eeva Lähetkangas and Esa Tiirola	Full-duplex self-backhauling for small-cell 5g networks", IEEE, 2015	They consider in-band self-backhauling for small cell 5G systems. In-band self-backhauling enables efficient usage of frequency resources. When coupled with a flexible frame format, it also enables efficient time-division duplexing of uplink, downlink, and backhaul transmissions.
[3]	Naveen Jacob and U. Sripati	Bit Error Rate Analysis of Coded OFDM for Digital Audio Broadcasting System, Employing Parallel Concatenated Convolutional Turbo Codes, IEEE, 2015	A comparative study on the computational complexity is also done by applying an audio signal and measuring the data processing time per frame, on computers with different processor speeds. It is shown that a coding gain of approximately 6 dB is achieved using turbo coding when compared to convolutional coding, at a cost of higher computational complexity.
[4]	Rony Kumer Saha, Poompat Saengudomlert and Chaodit Aswakul	Evolution Toward 5G Mobile Networks – A Survey on Enabling Technologies, Engineering Journal, 2016	They have addressed this issue by developing an evolution framework for 5G networks that consists of three evolutionary directions, specifically, radio access network node and performance enabler, network control programming platform, and backhaul network platform and synchronization

[5]	Ekram Hossain and Monowar Hasan	5G Cellular: Key Enabling Technologies and Research Challenges, IEEE, 2015	] the evolving fifth generation (5G) cellular wireless networks are envisioned to provide higher data rates, enhanced end-user quality-of-experience (QoE), reduced end-to-end latency, and lower energy consumption. They have provided an overview of several emerging technologies for 5G cellular wireless networks.
[6]	Hossein Shokri-Ghadikolaei, Carlo Fischione, Gabor Fodor, Petar Popovski and Michele Zorzi	Millimeter Wave Cellular Networks: A MAC Layer Perspective, arXiv, 2015	Discusses key MAC layer issues, such as synchronization, random access, handover, channelization, interference management, scheduling, and association. The paper provides an integrated view on MAC layer issues for cellular networks, identifies new challenges and tradeoffs, and provides novel insights and solution approaches.
[7]	Mohammad Vahid Jamali and Jawad A. Salehi	On the BER of Multiple-Input Multiple-Output Underwater Wireless Optical Communication Systems, arXiv, 2015	Their simulation results show that MIMO technique can mitigate the channel turbulence-induced fading and consequently, can partially extend the viable communication range, especially for channels with stronger turbulence.
[8]	Yifei Huang, Ali A. Nasir, Salman Durrani and Xiangyun Zhou	Mode Selection, Resource Allocation and Power Control for D2D-Enabled Two-Tier Cellular Network, arXiv, 2016	They consider a D2D pair in the presence of an MBS and a femto access point, each serving a user, with quality of service constraints for all users. their discussed solution encompasses mode selection (choosing between cellular or reuse or dedicated mode), resource allocation and power control within a single framework. The framework

			prioritizes D2D dedicated mode if the D2D pair are close to each other and orthogonal resources are available.
[9]	Ertugrul Basar	Multiple-Input Multiple-Output OFDM with Index Modulation, IEEE, 2015	They discussed multiple-input multiple-output OFDM-IM (MIMO-OFDM-IM) scheme by combining OFDM-IM and MIMO transmission techniques. The low complexity transceiver structure of the MIMO-OFDM-IM scheme is developed and it is shown via computer simulations that the discussed MIMO-OFDM-IM scheme achieves significantly better error performance than classical MIMO-OFDM for several different system configurations.
[10]	Ertugrul Basar	On Multiple-Input Multiple-Output OFDM with Index Modulation for Next Generation Wireless Networks, IEEE, 2016	they shed light on the implementation and error performance analysis of the MIMO-OFDM-IM scheme for next generation 5G wireless networks. Maximum likelihood (ML), near-ML, simple minimum mean square error (MMSE) and ordered successive interference cancellation (OSIC) based MMSE detectors of MIMO-OFDM-IM are discussed and their theoretical performance is investigated.
[11]	Pimmy Gandotra and Rakesh Kumar Jha	Device-to-Device Communication in Cellular Networks: A Survey, IEEE, 2016	An extensive survey on device-to-device (D2D) communication has been performed. This emerging technology is expected to solve the various tribulations of the mobile network operators (MNOs), efficiently satisfying all the demands of the

			subscribers. A complete overview about the different types of D2D communication and the supported architectures has been brought up. A number of features can be used in conjunction with D2D communication, to enhance the functionality of cellular networks.
[12]	Martin Taranetz, Thomas Blazek, Thomas Kropfreiter, Martin Klaus Müller, Stefan Schwarz and Markus Rupp	Runtime Precoding: Enabling Multipoint Transmission in LTE-Advanced System-Level Simulations, IEEE, 2015	This paper introduces the concept of runtime-precoding, which allows to accurately abstract many coherent transmission schemes while keeping additional complexity at a minimum. they explain its implementation and advantages. They measure simulation run times and compare them against the legacy approach as well as link-level simulations. Furthermore, they present multiple

			application examples in the context of intra-site and inter-site CoMP for train communications and MBSFN.
[13]	Akhil Gupta and Rakesh Kumar Jha	A Survey of 5G Network: Architecture and Emerging Technologies, IEEE, 2015	the prime focus is on the 5G cellular network architecture, massive multiple input multiple output technology, and device-to-device communication (D2D). Along with this, some of the emerging technologies that are addressed in this paper include interference management, spectrum sharing with cognitive radio, ultra-dense networks, multi-radio access technology association, full duplex radios, millimeter wave solutions for 5G cellular networks, and cloud technologies for 5G radio access

			networks and software defined networks.
[14]	Navid Tadayon, Georges Kaddoum and Rita Noumeir	Inflight Broadband Connectivity Using Cellular Networks, IEEE, 2016	They discuss the technical possibilities of enhancing the existing LTE infrastructure for air to ground communications. they identify the major challenges and obstacles in this path, such as uplink/downlink interferences, frequent roaming, large Doppler effect, and channel degradation. they also discuss appropriate solutions to counteract them using some of the emerging antenna, signal processing, beamforming, and multi-beaming ideas.

III. PROBLEM DOMAIN

The concept of frequency reuse and optimization of partial frequency improve the performance of MU-MIMO system for the cellular network. In frequency reuse the major issue is interference and increase the value of SNR[9]. The increase value of SNR increases the value of bit error rate. The increased error rate degraded the performance of transmission of scalable source transmission such as image, video and many more online streaming multi-media data over the cellular network. Some common problem discusses here[2-7].

1. The primary source of interference is inter-cell interference.
2. Transmission rate lower than a given threshold rate
3. The crossover point of user frequency degraded the rate of data.
4. The larger distance of users creates the position of non-orthogonal system and degraded the gain value of cellular network.

IV. FREQUENCY REUSE

Frequency Reuse is achieved when the users of one network cell are only allowed to operate on a fraction of the available frequency band. The fraction of the frequency band is allocated in such a way that adjacent cells are operating on different sets of sub-channels. FR3 mitigates inter-cell interference quite effectively due to the large distance between sectors using the same frequency band. However, the resulting higher signal-to-interference plus noise values are achieved on behalf of a loss in resources: only one third can be utilized. With Frequency Reuse 1 (FR1) all resources can be theoretically used since the frequency band is universally reused in every cell in the network. However, in practice, high inter-cell interference leads to outage and unfairness at the cell edges. Therefore, FFR schemes constitute a combination of these two schemes, i.e. allow for whole resource utilization at the cell center while interference is mitigated at the cell edge for avoiding outage. FFR comes in two major variants: Static FFR and adaptive FFR. Static FFR includes pre-planned FR1 or FR3 schemes, or a mixture of them. Commonly, this is achieved with restricting the power of frequency resources. Further improvement can be achieved by dynamically adapting the FFR assignments according to the channel quality measurements (CQI) or the path loss of the users. Such adaptive FFR systems can be classified into Partial Frequency Reuse (PFR) and Soft Frequency Reuse (SFR) schemes. PFR provides a separate frequency reuse zone for cell edge and inner cell users. At the cell center FR1 is used and FR3 is used at the cell edge. In contrast, SFR does not rely on several certain reuse zones. The transmit power of mobiles in particular frequency bands is restricted in such a way that cell edge users of different sectors operate in different frequency bands. Cell center users utilize the whole frequency band. Hence, cell edge users operate in a FR3 zone together with cell center users which do not generate much interference. For trisector zed cell networks, the reserved part for cell edge users is 1/3 of the total band and is chosen orthogonal among neighbor cells. Hence, the reuse scheme factor is 3. Cell center users can use all frequency bands but with lower priority than the cell edge users. Thus, the effective overall frequency reuse factor is still close to one which guarantees a high spectral efficiency.

V. CONCLUSION

The rapid growth in wireless communications has led to unprecedented demand for the radio frequency (RF) spectrum. This issue motivates the search for modern techniques that will use more efficiently the available radio resources. To this end, we need some alternative technologies to improve the spectral efficiency, either by suppression the co-channels interference or by providing more orthogonal channels within the same spectrum. A set of new technologies is proposed such as dense deployment of BSs and aggressive frequency reuse to efficiently manage the data-traffic demands.

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Mukesh Saini received the BE degree in Electronics and Communication and Master of Technology degree in Digital Communication. Currently he is an associate professor with head of department electronics and communication engineering from PIES, Bhopal India. His research interests are Digital Signal Processing, Antenna Designing, Wireless Communication and Digital Image Processing.

Akshay A. Bochare received the Bachelor of Engineering Degree in Electronics and Communication from Gujarat Technological University, Ahmedabad, Gujarat. At present he is pursuing Master of Technology in Digital Communication in Patel Institute of Engineering & Science, Bhopal, under RGPV University, Madhya Pradesh.