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Millimeter Wave Communication for Massive MIMO HETNET to Achieve High Spectral and Energy Efficiency

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Abstract:
The latest concept of beam-space and Non orthogonal multiple access (NOMA) can improve the performance of mmwave Massive MIMO HETNET by enabling the efficient usage of RF chains. However in the existing system the RF chains is equal to the number of beam space signal, that is the number of users cannot be more when compared to RF chains. To overcome the existing problem, new spectrum with energy efficient mmWave transmission scheme that integrates the concept of non-orthogonal multiple access (NOMA) with beam-space MIMO and analysing the fading effects, i.e., beam-space MIMO-NOMA HET NET. By using NOMA in beam-space MIMO systems, the number of supported users can be larger than the number of RF chains at the same time-frequency resources. And as users with good channel conditions and power level can serve as relays to enhance the system performance by using successive interference cancellation (SIC), the integration of NOMA and cooperative relaying has recently attracted increasing interests. And in multi cell massive mimo system pilot contamination occurs in reuse of pilots in adjacent cells. In Edge weighted interference graph (WIG) by denoting each color as a pilot and each vertex as a user which is able to mitigate PC by assigning different pilots to connected users with a large weight system. A NOMA-based cooperative relaying system is studied, and an analytical framework is developed to evaluate its performance. The performances of NOMA in massive MIMO are simulated with different fading models such as Raleigh fading and Rician fading. In order to obtain the expected data rate model the system with the Gauss–Chebyshev Integration. Our proposed model, the het net with massive MIMO equipped works with mm wave signals with the support of NOMA and SIC which help to improve the performance of the network.

Index terms: NOMA, mmwave, fading, massive MIMO, SIC

I. INTRODUCTION

Mobile data traffic has just started exploding: the amount of traffic usage has been doubling each year during the last few years with the increasing popularity of smart phones and new types of mobile computing devices. Now the wireless industry is preparing for an even bigger challenge, an astounding 1000-fold increase in data traffic expected in this decade Higher utilization of spectrum (bits per second per Hertz per cell) in given frequency resources per cell is quite saturated; recent results show that at least point-to-point link throughput is very close to the theoretical limits. Utilization of more bandwidth (Hertz) is a very costly solution, unless devices can utilize additional radio access technologies for unlicensed bands with seamless aggregation and offloading. The final and probably one of the most promising frontiers to achieve the goal is to increase cells per square kilometer by deploying more cells of different types/technologies in a given area. Heterogeneous and small cell networks (HeteroNets), whose goal is to maximize the utilization of existing spectrum by deploying more cells, are thus expected to be important to challenge the future of cellular networks. HeteroNets are networks deployed with a mix of traditional high-power macrocells and lowpower smaller cells such as pico, femto, and/or relay nodes. We assume that HetSNets include wireless local area network (WLAN) and wireless personal area network (WPAN) technologies as well, so HetSNets are networks consisting of multiple radio technologies. In theory, the overall capacity scales with the number of small cells deployed in a unit area: shrinking the radius of each cell and packing more cells in a given area would actually offer more capacity and more spectrum reuse. In reality, however, as cells get closer, the hyper-densification of HetSNets is challenged in many ways. In a hyperdense deployment, not only desired signal strength but also interference from other cells increase. Increasing other-cell interference needs to be mitigated, and a better mobility management mechanism is required as the mobile users see cell edges more frequently.

SECTION II: LITERATURE SURVEY

The network consists of a macro cell with a number of small cells embedded in it. The small cells' base stations (BSs) are equipped with a few antennas, while the macro BS is equipped with a massive number of antennas. To maximize the aggregated Mean Opinion Score (MOS) of the users under constraints on the BSs' powers and the required quality of service (QoS) of the users, also consider extra constraints on the QoE of users to more strongly enforce the QoE in the beam forming design, to reduce the complexity of the optimization problem, suboptimal and computationally efficient solutions [2]. Practical cross-layer QoE-aware radio resource allocation (RRA) algorithms for the downlink of a heterogeneous orthogonal frequency division multiple access (OFDMA) system, the algorithms is to assure the appropriate level of QoE for each user of the system by incorporating application-layer parameters and subjective human perception of quality into the RRA process [3]. Multiple Input Multiple Output (MIMO) adds a new dimension, the spatial one, to be optimized in Cognitive Radio (CR) by offering service simultaneously to more than one user, statistical optimization techniques are applied to assess the performance of the Quality of Experience (QoE) in CR systems, where each user has different demands. A Multiuser scenario is considered where the transmitter can accomplish either a random or an opportunistic scheduling approach. Closed form expressions are derived for different scenarios and obtained for three QoE indicators in the system [4]. Relay-assisted cellular network is one of the most promising architectures for the next- generation mobile cellular system, which is envisaged to support high-rate multimedia services in a wide variety of environments: indoors, outdoors, low-mobility, high-mobility, etc. A genetic- algorithm based approach is employed for joint multi-cell optimization of system parameters including locations of relay stations, path selection, reuse pattern and resource allocation to maximize the system spectral efficiency. Two types of quality of end-user experience (QoE) (fixed-bandwidth allocation and fixed-throughput allocation) are investigated along with two path selection schemes that is spectral efficiency-based and SINR-based [5]. Assuming user can only transmit on one channel and the optimization goal is the network throughput without considering users' QoE demands. QoE demands and the individual QoE losses of MUs, a joint matching coalitional game theoretical scheme to solve such a QoE based multichannel allocation problem with individual cross-tiered interference constraint in each channel. Concretely, according to the different interference and competition relationships among users, dividing the complicated problem into two subproblems, i.e., Q1: intra-cell channel allocation for SUs, and Q2: inter-cell channel allocation for small-cell base stations (SBSs), formulating the intra-cell channel allocation as a many-to-one selfish matching game and formulate the inter-cell channel allocation subproblem as an altruistical coalitional game separately. Then, the complicated problem can be solved based on the two proposed games iteratively, a joint channel allocation algorithm for the matching-coalitional game theoretical scheme [6].

SECTION III: PROPOSED MODEL

By using NOMA in beam-space MIMO systems, the number of supported users can be larger than the number of RF chains at the same time-frequency resources. Efficient mmWave transmission scheme that integrates the concept of non-orthogonal multiple access (NOMA) with beam-space MIMO

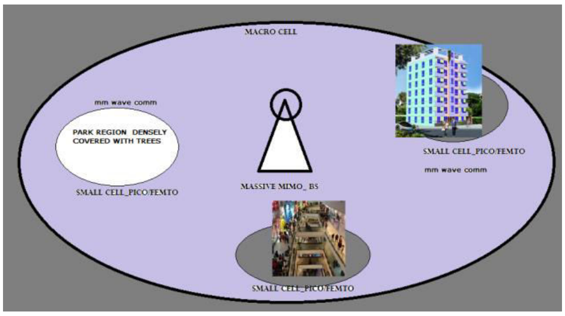

Figure.1. Architecture of proposed system: mmWave Communication

Figure 1: depicts the proposed system design with the massive MIMO as the base station. Precoding scheme based on the principle of zero forcing is designed to reduce the inter-beam interferences in the beamspace MIMO-NOMA system. To maximize the achievable sum rate, a dynamic power allocation is proposed by solving the joint power optimization problem. In addition to realizing massive connectivity, the use of NOMA can also improve the capacity bound of beamspace MIMO. In multi cell massive MIMO system pilot contamination occurs in reuse of pilots in adjacent cells. In Edge weighted interference graph (WIG) by denoting each colour as a pilot and each vertex as a user which is able to mitigate PC by assigning different pilots to connected users with a large weight system.

SECTION IV: PERFORMANCE ANALYSIS

The MATLAB Tool Version 2017a is used for implementing the design and simulation of HETNET with RF chains performance improvements.

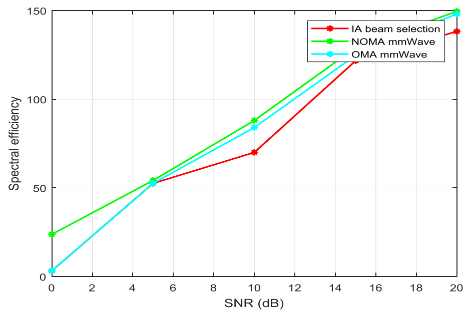

Figure.2. SNR vs Spectral efficiency

Figure 2 depicts the spectrum efficiency against SNR of the considered 4 schemes mentioned above. Where the number of users K=32.The proposed beam space MIMO-NOMA scheme can achieve high spectrum efficiency then the beam space MIMO-OMA particularly, the proposed beam space NOMA has about 3db, SNR gain compared to the beam space MIMO, which benefits from the use of NOMA to serve multiple users in each beam. Since NOMA can achieve high spectrum efficiency then that of OMA it is indicated that the fully digital MIMO can achieve best spectrum efficiency.

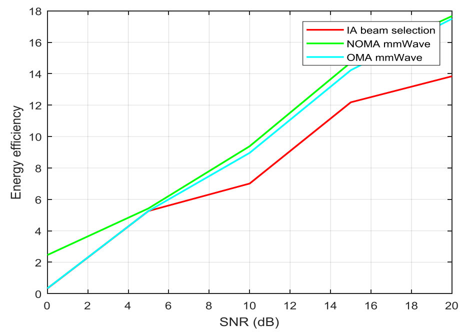

Figure.3. SNR in db Verses Energy efficiency

Figure 3depicts that SNR vs Energy efficiency for the following 4 schemes such as (Fully digital system, IA beam selection, NOMA mmWave, OMA mmWave).Where the number of users K=32, proposed beam space NOMA can achieve high energy efficiency improvement compared to others(number of RF chains=number of base station antennas.

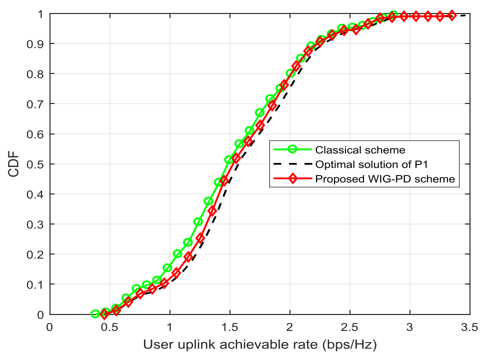

Figure.4. User uplink with respect to CDF

Figure 4 depicts the cumulative distribution function (CDF) curve of the users' uplink achievable rate, where the system parameters L = 3, S = K = 4, ρ = 10 dB, and M = 32 (M = 256) are considered.

The proposed WGC-PD scheme is compared with following existing solutions:

The classical pilot assignment scheme randomly assigns pilots to users without cooperation among cells. The time-shifted pilot scheme cancels pilot contamination by using asynchronous transmission among adjacent cells at cost of introducing mutual interferences between data and pilots; the smart pilot assignment scheme optimizes pilot assignment for each cell in a sequential way; the optimal solutions to P1 and P2 are obtained through exhaustive search. As mentioned in Section III-C, the optimal solution to P2 is able to approach the optimal solution to P1 when BS is equipped with a large number of antennas, which is verified with two cases as M = 32 and M = 256. Moreover, we can find that the proposed WGC-PD scheme outperforms time shifted pilot scheme and smart pilot assignment scheme, and the performance gap between the proposed scheme and the optimal solution to P1 is about 0.3 bps/Hz.

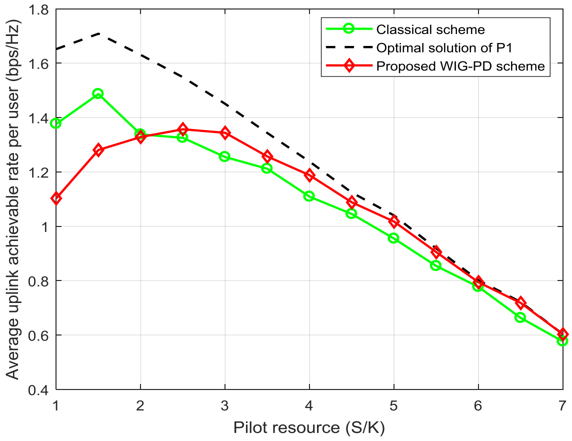

Figure.5. Pilot resources with respect to Average uplink achievable rate per user.

Figure 5 depicts shows the average uplink achievable rate per user against the number of pilot resource S, where the system parameters L = 7, K = 16, ρ = 10 dB, and M = 128 are considered. For the time-shifted pilot scheme, more pilots, i.e., S > K, actually makes no performance improvement, since adjacent cells asynchronously transmit uplink pilots. Hence, we assume fixed S = K = 16 pilots are utilized in the time-shifted pilot scheme. Considering pilot resource $1 \leq S/K \leq 4$, it is clear that the proposed WGC-PD scheme significantly outperforms the time-shifted pilot scheme. For the classical random pilot assignment scheme, the smart pilot assignment scheme, and the proposed WGC-PD scheme, the performance can be improved by increasing the pilot resource when $S/K \leq 3$. However, by continually increasing pilot resource, their performances drop fast due to the increasing loss of spectral efficiency.

V. CONCLUSION

A new transmission scheme, i.e., beamspace MIMO-NOMA, to integrate NOMA and beamspace MIMO to break the fundamental limit of existing beamspace MIMO that only one user can be served in each beam at the same time-frequency resources. Particularly, the number of users can be larger than the number of RF chains in the proposed beamspace MIMO-NOMA scheme.

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