

Energy Efficient Resource Allocation Strategy for Multi-Cell NOMA Networks Using Hungarian Algorithm

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ABSTRACT: This paper investigates the resource allocation strategy for multi-cell NOM Networks to enhance the users' quality of experience (QoE) for multi-cell non orthogonal multiple access (NOMA) networks. An optimization problem is formulated with the objective of maximizing the sum mean opinion score (MOS) of users in the network. To solve the challenged mixed integer programming problem, we first decompose it into two sub-problems. A three-dimensional (3D) matching problem is proposed for modelling the relation between the users, BSs and sub-channels. Then, a two-step approach is put forward to attain a suboptimal solution. Furthermore, a low complexity suboptimal approach based on successive convex approximation (SCA) techniques is developed for optimizing power allocation among users. A simulation results reveal that the proposed NOMA networks is capable of outperforming the conventional orthogonal multiple access (OMA) networks in terms of QoE(Quality of Experience); moreover, the proposed algorithms for sum-MOS maximization can achieve the significant fairness improvement against the sum-rate maximization scheme.

KEYWORDS: Attack-pattern discovery, IIoT, mobile ad-hoc networks, packets, sensitivity, routing.

I. INTRODUCTION

Multicarrier transmission techniques such as orthogonal frequency division multiple access (OFDMA), have been widely adopted in broadband wireless communication systems such as LTE and LTE-Advanced. Non-orthogonal multiple access (NOMA) is recognized as a promising candidate that provides an effective solution to address the challenging requirements of the fifth generation (5G) mobile networks, such as massive connectivity, high data speed and low latency. Compared to the conventional orthogonal multiple access (OMA), NOMA allows multiple users complexed in the same orthogonal resources (e.g., time/frequency) by exploiting superposition coding in the power domain at transmitters and successive interference cancellation (SIC) techniques at receivers. The advantages behind this approach lies in the fact NOMA can opportunistically exploit users' channel conditions.

Driven by the requirements of high quality video services such as embedded video contents in the webpages, video calls, online TVs, etc, an appropriate level of quality of experience (QoE) in 5G mobile networks is desired. QoE is a subjective assessment of media quality of users and has recently become an essential indicator in 5G wireless communication systems. Due to the various video characteristics, the users may experience different QoE even if the data rates are same, which implies that effective QoE-based resource allocation is essential to provide better user satisfaction with limited radio resources. By taking advantage of NOMA features, this paper establishes the potential of QoE-based resource allocation in multicell NOMA networks. We model the problem of resource allocation for multi-carrier NOMA (MC-NOMA) in multi-cell networks to improve the user QoE instead of throughput, which can provide potential performance gains satisfying the user demands. Specifically, we employ BS cooperation to solve the QoE-

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based resource allocation problem in the multicell MC-NOMA networks, which consists of user-BS association, subchannel assignment and power allocation. We solve the formulated optimization problem by two steps: 1) An three dimensional (3D) matching problem is invoked to model the allocation among users, BSs and subchannels. Then, a two step approach is proposed to find a suboptimal solution. 2) For the non-convex power allocation problem, we propose a low complexity suboptimal solution based on successive convex approximation (SCA) techniques.

II. RELATED WORK

Haoyang Zhai ; Qiang Liu ; Athanasios V. Vasilakos and Kun Yang has proposed a detection technique for demodulating signals, the increase detection algorithm (IDA), to improve the reliability of concentration-encoded diffusion-based molecular communication. The proposed IDA detects an increase (i.e., a relative concentration value) in the molecule concentration to extract the information instead of detecting an absolute concentration value. To validate the availability of IDA, we establish the real physical tabletop test bed.

Molecular communications (MC) is a promising paradigm which utilizes molecules to implement communication among nano-machines. Cooperative relaying strategies can be used to extend communication distance and achieve reliable remote communications. In this paper, a two-hop diffusion-based molecular communication with three nano-machine nodes is considered. To mitigate the drawback of traditional cooperative relay strategies in diffusion-based MC, such as decode-and-forward and amplify-and-forward, an opportunistic cooperative relaying strategy is proposed. An ion channel based modulator for DMC is proposed which controls the rate of molecule release from the transmitter by modulating a gating parameter signal. Exploiting the capabilities of the proposed modulator, an on-off keying modulation technique is introduced and the corresponding average modulated signal, i.e., the average release rate of the molecules from the transmitter, is analysed.

III.NETWORK MODEL

SYSTEM DESCRIPTION

Consider a multi-cell downlink NOMA transmission scenario, where multiple T base stations (BSs) communicate with K cellular users, denoted by $\mathcal{T} = \{1, \dots, T\}$ and $\mathcal{K} = \{1, \dots, K\}$, respectively. We assume that each cell is served by a BS and BSs are temporally synchronized. Both BSs and users equip with one transmit and one receive antenna. The entire bandwidth W is partitioned into N sub-channels, each with W/N . The index set of all sub-channels is denoted by $\mathcal{N} = \{1, \dots, N\}$. We consider the universal frequency reuse deployment in which every cell is available to the whole bandwidth. Invoked by the NOMA protocol, each sub-channel can be shared by multiple users associated to the same BS.

Considering the detection complexity of SIC receiver, we assume that the maximum number of users allocated in the n -th sub-channel, denoted by SCn , of BS t , denoted by BS_t , is Lt . Moreover, we assume that the BSs cooperate to jointly serve the users where the CSI of the direct link and the cross link channels are available at the BSs.

MOS Model for Web Browsing

Inspired by the widely used QoE metric, MOS model is used as a measure of the user's QoE for the services like video streaming, file download, or web browsing. As one of the most popular application in wireless networks, we focus on web browsing applications in this paper. It maps the subjective human perception of quality for web browsing applications to the objective metrics. The proposed method is capable of being extended to other applications with necessary modifications. It is shown in Figure.2.

IV. USER –BS ASSOCIATION AND SUBCHANNEL ASSIGNMENT USING 3D MATCHING

It is proved that three-dimensional matching is NP-hard and there is no polynomial-complexity algorithm to find the optimal solution. Thus, we decompose the three-matching problem into two two-dimensional matching sub-problems- UEBS matching problems and (UE,BS)-SC matching problems. Specifically, the first sub-problem is to select a served BS for each user to transmit desired signals, which is a many-to-one matching problem between users and BSs, i.e., multiple users can be served by one BS using the NOMA protocol.

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User-BS Association Problem

As discussed above, the user-BS association problem is a many-to-one matching problem. Due to the interference in the SINR of user $UE_t n, k$ over each sub-channel is related to the set of users sharing with the same sub-channels. Furthermore, each BS not only considers which users to match with, but also that the inner-relationship among the subset of users due to the power domain multiplexing.

Sub-channel Assignment

As discussed above, the problem to assign sub-channels to (UE, BS) units is a many-to-many matching problem. Due to one sub-channel can assign multiple BSs, the rate of each (UE, BS) unit over each sub-channel is related to the other BSs sharing with the same sub-channels. Thus, the formulated sub-channel assignment problem is a many-to-many matching problem with externalities.

V.METHODOLOGY

HUNGARIAN ALGORITHM

The Hungarian algorithm defines, that it is a combinatorial optimization algorithm that solves the assignment problem in polynomial time and which anticipated later primal-dual methods. It was developed by Harold Kuhn and published in 1955, who gave the name "Hungarian method" because the algorithm was largely based on the earlier works of two Hungarian mathematicians: Dénes König and Jenő Egerváry.

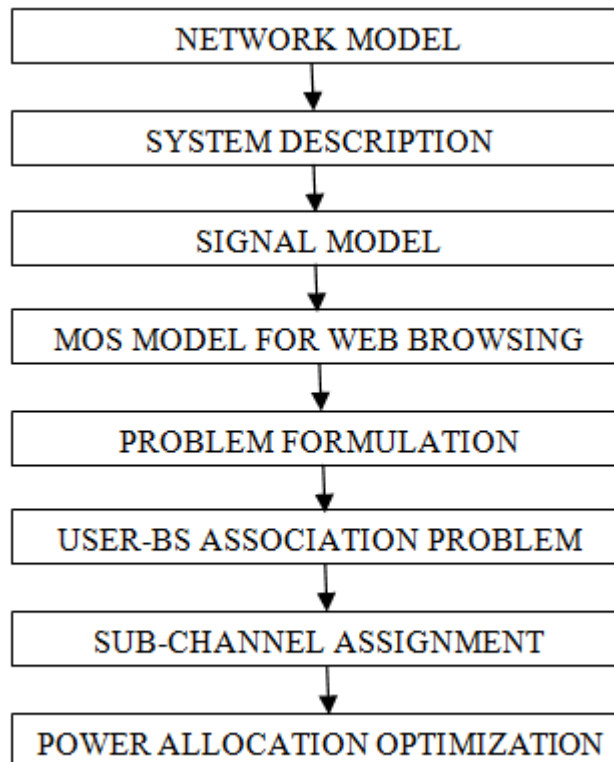


Figure:1 Proposed System Block Diagram

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NETWORK MODEL

It is a database model formulate as a flexible way of representing an object and their relationships. It distinguish the features in that the schema, viewed as a graph in which the object types are arcs and relationship types are nodes, is not restricted to being a hierarchy or lattice.

SYSTEM DESCRIPTION

System Description will describes in various platforms. Many of them may exist at this time, while others are fictional and may someday be manufactured. The purpose is to show the diversity of potential system topologies. The systems description will be described in this document include in the below:

- A typical SMP system.
- The Alpha Wildfire system.
- The IBM Numa-Q system.
- The SGI Mips64 system.
- A system in which CPUs and Memory are connected in aring.
-

SIGNAL MODEL

The signal model is a function that "conveys information about the attributes of some events. It is most commonly employed in the electronics and telecommunication, this is a time varying voltage, current or electromagnetic wave used to carry information. It is also defined in the "visible change in a quantifiable operation". In the physical world, any quantity of exhibiting variation in time or space is potentially a signal that might be provide in the information on the status of a physical system.

MOS MODEL FOR WEB BROWSING

A capability to scan the follower quality of experience for web browsing is essential to determining when and where network conditions are contributing to an impaired customer experience. An comprehension in the relationship between the web browsing of QoE and the network factors helps in the communications service providers (CSPs) to identify the difficulties, to understand the causes and the contributing factors, and to evaluate potential solutions.

PROBLEM FORMULATION

It is the process of determining the component parts of a difficult and its important factors and variables, and the inter-relationships between them. Communication system inventors of earthly microwave radios have highest priority for good bandwidth efficiency with low BER(Bit Error Rate). They have a lot of power available and are not anxious with power efficiency in such earthly communication.

USER- BS ASSOCIATION PROBLEM

The difficulty of user association to small-cell base stations (SBSs) in a heterogeneous and small-cell network (HetSNet). The two optimization problems are explored, which are maximizing the set of associated users to the SBSs (the unweighted problem) and maximizing the set of weighted associated users to the SBSs (the weighted problem), under signal-to-interference-pulse noise ratio (SINR) constraints. Both problems are formulated as linear integer programs.

SUB-CHANNEL ASSIGNMENT

In user scheduling problem of a downlink non-orthogonal multiple access network, where the base station assigns spectrum and power resources to a set of users. We aim to jointly optimize the sub-channel assignment and power allocation to maximize the weighted total sum-rate while taking into account user fairness. The sub-channel allocation problem as a equivalent to an many-to-many two-sided user-sub-channel co-ordinate distraction in which the set of users and sub-channels are considered as a two sets of players pursuing their own interests. We then propose a equal algorithm which converges to a two-side exchange stable matching after a limited number of emphasis. A link compound is thus provided to solve the sub-channel assignment and power allocation problems iteratively.

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POWER ALLOCATION OPTIMIZATION

An difficulty of optimal power allocation among the multiple heterogeneous servers, i.e., reducing the average function response time of a multiple heterogeneous computer systems restriction. Each server is behave as a queuing system and the average function response time in a data centre with many servers is composed as a function of power allocations to the servers. The average function response time is reduced as subjected to the restriction that the total effective power consumption of all the servers does not exceed a given power limit.

STEPS OF THE ALGORITHM

The Hungarian algorithm consists of the four steps they are discussed below. The first two steps are implemented once, while Steps 3 and 4 are repeated until an optimal assignment is found. The input of the algorithm is an m by m square matrix with only non-negative elements.

Step 1: Subtract the row minima

For each row, finding the lowest element and subtract it from the each element in that row.

Step 2: Subtract the column minima

Similarly, for each column, finding the lowest element and subtract it from the each element in that column.

Step 3: Cover all zeros with a minimum number of lines

Cover all zeros in the resulting matrix using a minimum number of horizontal lines and vertical lines. If m lines are required, an optimal assignment exists among the zeros. The algorithm stops.

If it is less than m lines are required, and then continue with Step 4.

Step 4: Create additional zeros

Find the smallest element (call it l) that is not covered by a line in Step 3. Subtract k from all are uncovered elements, and add l to all elements that are covered twice.

VI. EXPERIMENTAL RESULTS

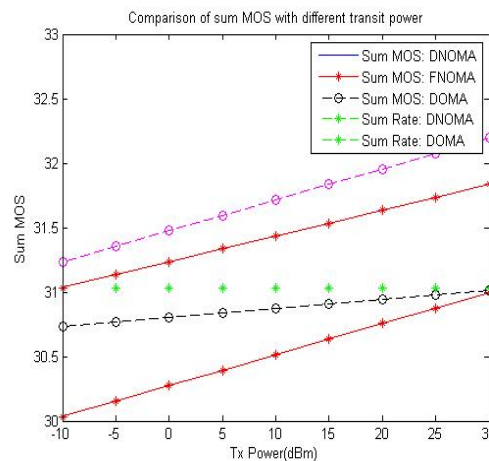


Figure:2 Comparisons of sum MOS and sum rate with different transmit power, where $K = 6$, $T = 3$, $N = 3$, $L_t = 2$, $T_n = 2$, $S_n = 2$ and $[p_t, p_t] T = [1/4, 3/4]T$.

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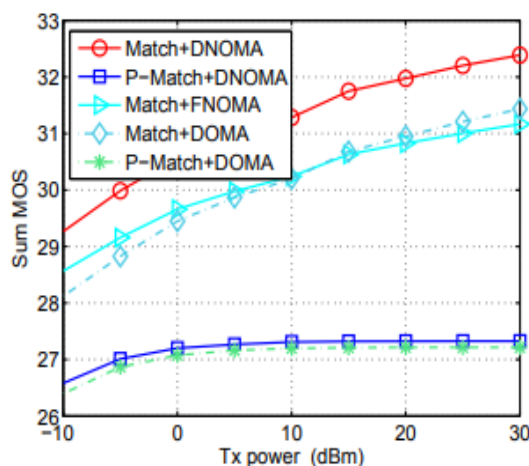


Figure:3 Comparisons of sum MOS with different matching schemes, where $K = 6$, $T = 3$, $N = 4$, $L_t = 2$, $T_n = 2$, and $S_n = 2$.

VII.CONCLUSION

In this paper, we studied the QoE-based resource allocation algorithm design of an multi-cell MC-NOMA system in terms of user-BS association, subchannel assignment and power allocation. The problem was formulated as a mixed combinatorial non-convex optimization problem of maximizing the sum MOS of the system. By formulating the user-BS association and subchannel assignment as a 3D matching problem, we proposed a low-complexity two-step approach based one two-dimensional matching. Then, a power allocation approach based on SCA was developed. Simulation results has revealed that a substantial improvement of the sum MOS can be achieved by employing the proposed MC-NOMA scheme in multi-cell networks over the conventional multi-cell OMA systems. Furthermore, the proposed QoE-based multi-cell MCNOMA scheme was shown to provide a good balance between improving the sum MOS and maintaining fairness among users.

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