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Multi-Dimensional Multiple Access (MDMA) Scheme Provisioning in 6G Wireless Networks

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***Abstract** –To support emerging applications and communication scenarios there are requirements for more flexible and inclusive multiple access technologies to rapidly diversify the quality of service (QoS) envisaged requirements for future 6G wireless networks. To derive from, we propose a multi-dimensional multiple Access (MDMA) scheme for Individual User Equipment (UE's) unique QoS demands when using multi-dimensional Radio resource cost effectively. In detail, the proposed plan consists of two novel aspects, namely, the selection of an analogous multiple Access mode for each UE considering UE-specific Radio resource utilization cost due to non-orthogonal interference cancellation; and multidimensional radio resource allocation between UEs coexisting under dynamic network conditions. To reduce UE-specific resource usage costs, The Base station (BS) organizes the UE with different multi-domain resources. Specific to each UE's. By considering the constraints as UE alliance Resource availability, perceived quality and utilization potential. Each UE within the alliance can access their required radio resources, which leads to lower usage costs while saving Resource-sharing conflicts with the rest of the UEs. Ahead, to meet UE-specific QoS requirements and individual resources Positions on the UE side, multi-dimensional radio resources the allocation between coexisting UEs is modelled as an optimization the problem of maximizing the sum of cost-conscious utility All UE's functions. Solution to solve this NP-hard problem is developed using successive convex with less complexity Approximation and Lagrange double decomposition methods. The effectiveness of our proposed scheme is validated by numerical Simulation and performance comparison with state-of-the-art Schemes.*
In particular, the simulation results demonstrate that our proposed scheme outperforms these benchmark schemes by large margins.

***Keywords**- Unmanned 6G, Multidimensional Multiple Access, Resource Usage cost, individual QoS provision.*

I. INTRODUCTION

The continued pace of data traffic growth and dramatic expansion of diverse services and vertical applications posing many challenges to the development of the sixth generation (6G) wireless network was conceived. On the one hand, with an estimated seven-fold growth of mobile data traffic in 2022 as compared to 2017 [1], 6G networks are the future expected to support fairly high data rates. For example, smart manufacturing, augmented reality, which requires diverse, application-specific and individual service provision with reference to the data rate, Latency, reliability and power consumption [2], [3].

II. LITERATURE REVIEW

Given diversity and dynamic resource constraints of future networks and wireless devices, designing highly efficient and intelligent multiple access techniques becomes critical for 6G. As a result, personalized quality of service (QoS) provisioning, rather than current scenario-specific solutions Adopted in 5G, as well as the cost-effectiveness of User Equipment (UE) operations, envisaged as keys Features of 6G to fulfil its role as a multipurpose platform and the foundation of a connected society [4]. Current efforts for Getting individual QoS provisioning in 6G is mainly recent technological advances focused on incorporating in operations/management, for example, network slicing and mobile Edge computing [5], [6], which may not be practical due to Increase in system complexity. Meanwhile, by adopting a

Bottom-up option, we believe the next generation of design multiple access schemes that can be used efficiently multidimensional radio resource with situational awareness Competence can play an important role in personal service Provision for 6G [7], [8].

In achieving cost-effective personalized QoS provision, there are multiple next generation access protocols Miscellaneous QoS. Is expected to offer better servicing granularity for Provisioning by harnessing multi-dimensional radio resources, including frequency, time, space, power and code domain, when considering specific resource situations and Specific QoS requirements of each UE. Many for Additional factors, e.g., UE hardware capabilities, and radio resource utilization cost, must be considered to improve Effectiveness of Intelligent Multiple Access for Personal QoS provision.

Recently, several new Multiple Access technology, especially multi-input multi-output non-orthogonal multiple access (MIMO-NOMA) [9] and Rate-splitting multiple access (RSMA) [10] Proposal to detect additional degrees of freedom in spatial and power domain to improve spectral efficiency and system Multiplexing capability. However, this multiple access Plans follow existing scenario-specific practice in 5G and still face many challenges to fulfil the individual the demand and specific condition of each UE due to failure To address the following three important issues:

UE-specific resource constraints and heterogeneous the cost of resource usage in different domains. Each UE use in many is inherently limited by costs radio resource domain. Ideally, all UE are expected to be equipped with powerful processing capabilities and abundant resources. However, in practice, UEs Has odd hardware capabilities, including signal processing/computing capacity, storage limits, and power/battery supply, resulting from built-in hardware Constraints and anomalous radio resource utilization Cost in different domains [11], [12]. For example, some Low-cost devices have poor sequential interference cancellation (SIC) capacity due to limited computing capabilities and power supplies, which restrict their performance to employ power-domain NOMA.

UE-specific perceived value of radio resources in various domain, which is determined by both performance Advantages of Communication Services and Resources usage cost. Each UE feels unique resource scarcity, i.e. a different level of resource Availability and quality for multi-dimensional radio resources due to specific channel conditions of UE. Perceived value of allocated multi-dimensional will be UE -specific as radio resources vary when using UE's capabilities and induced costing: Resource. This observation provides a new intelligent Multiple access design to achieve personalized and Opportunistic Multidimensional Radio Resource Allocation coexistence between users.

UE-specific, miscellaneous, and individual QoS requirements. By broadly categorizing all services extended Mobile Broadband (eMBB), massive Machine Type Communication (mMTC), and ultra-Reliable and Low Latency Communication (uRLLC), typical scenario Multiple access schemes to be encountered in 5G networks Many Challenges to Satisfy Dramatically Increase Service diversity and variety due to wide variety of applications and devices [13]. As a result, the new 6G the design is expected to be uniquely different QoS requirements from each UE. UE-specific QoS Requirements can be translated into resource requirements Nostalgic Radio Resource Domain. It inspires us Explore intelligent radio resource allocation in various Domains for more effective multiple access and personalized Service provision design.

Inspired by these observations, we aim to create a multi-dimensional multiple access (MDMA) scheme, which can flexibly and opportunistically organize multidimensional Radio resource by integrating orthogonal multiple access (OMA), power-domain NOMA, and spatial-domain NOMA based on individual communication needs each UE. Specifically, this paper aims to achieve the following: Two technical goals: a) joint exploitation of specific situations and different constraints across multiple radio resource domains Coexistence between users to improve overall network communication Result; and b) enabling personalized service Making provision for each UE by considering it comprehensively Both benefits achieved by meeting UE-specific QoS demands and the use cost of multifunctional radio resources on the side of UE.

III. METHODOLOGY

In achieving personalized QoS provisioning in 6G, we propose in this paper a flexible MDMA scheme, which can be OMA is seen as a convergent multiple access technology, power-domain NOMA, and spatial-domain NOMA. For one looking at the UE, our proposed scheme can determine the most based on the evaluation of its specific radio resource utilization, the advantageous and suitable multiple access mode Costs, terms and constraints across multiple domains. In particular, the multidimensional resource utilization cost is defined to reflect power consumption and complexity UE side done by non-orthogonal interference cancellation Spatial- and power-domain NOMA. Core technical the contribution of this paper can be summarized as follows:

MDMA's proposal for personalized service provision when considering resource usage cost. Can be used to select newly developed MDMA scheme Multiple Access Modes (an affordable way to explore) Additional performance gains across multiple resources domain) for each UE that is. Can strike a balance between its resource utilization cost and performance benefits to meet your specific QoS demands. In detail, this includes in two steps: i.e., cost-conscious selection of many Access mode and position-aware multi-dimensional radio Resource allocation of users. First, Base Station (BS) Customizes UE with different multi-domains Resource constraints as a coalition to reduce capacity cost of use. Then, multidimensional resource allocation the utility of UE is obtained by maximizing the sum of operates under the resource constraints of the individual UE and QoS requirements.

UE alliances formed to reduce UE-specific radio Resource utilization cost while fully utilizing available resources Multifunctional radio resource. According to UE Personal preference of resource and associated use cost, BS organizes mutually beneficial UE Co-operative alliances, i.e. co-existing UEs can be multiplexing in any combination of multidimensional a resource with appropriate multiple access modes to achieve Low resource usage cost. UE Alliance Formation The algorithm is designed on the basis of a two-way multiple-A matching principle. The proposed algorithm can the exchange guarantees stability and only a. operates on coarse time granularity keeping UE alliances unchanged for a relatively longer period and thus reduces complexity. Managing the Multidisciplinary Resource to Meet UE-specific QoS requirements. Resolving resource Allocation problem for the proposed MDMA scheme is non-convex and NP-hard, which is computationally Impolite. This paper implements the gradual convex Approximation method to replace the original resource Allocation problem in concave optimization problem, for which the existing convex optimization-based approach can solve. Then, using the Lagrange double decomposition method, this problem can be decomposed into independent Sub-problems with closed form solutions. Apart from this, an iterative algorithm is proposed to be further reduced to computational complexity.

The rest of the paper is conducted as follows: Section II describes the system model employing MDMA schemes, then introduces the related problem formulation. Section III Presents several adopted strategies for solving non-convex the utility sum maximization optimization problem. Eventually, Section IV presents the simulation results and Section V This concludes the paper.

The purpose of this paper is to design a MDMA scheme that can be flexible and opportunistically organized Multi-dimensional radio resources to meet the specifics of each UE the service demands cost effectively. In this section, to capture Effect of UE's specific processing conditions on in MDMA, we will cover three essential factors: system model, i.e. unequal resource conditions, heterogeneous resource use costs, and individual Resource constraints of each UE. In detail, Section II-A (channel model) set up to reflect resource availability and hinder the multifunctional radio resource Domain Again, Volume II-B (Cost-Aware MDMA for the Personal) service provisioning) captures the impact of UE Radio resource utilization cost and hardware constraints of equipment On selecting Multidimensional Multiple Access mode. Based on the established system model, we introduce proposed MDMA scheme and related problem formulation.

I. SYSTEM MODEL AND PROBLEM FORMULATION

Consider the downlink scenario in the cellular network shown In Figure 1 [14], where a single BS is positioned. In particular, B.S. lies at the origin of a disc of radius R and BS is Equipped with a similar linear array, with Nt antennas. The total available bandwidth B is divided into M orthogonal to sub channel. Meanwhile, a set of BS serves a set K of K single antenna UE (K > M). For simplification, each UE only one sub channel is required to transmit.

Figure 1. Illustration of the proposed Multi-Dimensional Multiple Access (MDMA) scheme, which could flexibly build and utilize multi-dimensional radio resources UE Alliance. For example, UE4, UE5 and UE6 have different multi-domain resource constraints: i) UE5 and UE6 have high channel gain difference power domain but high spatial correlation; ii) UE4 has good orthogonality with UE5 and UE6 in the spatial domain. Thus, BS arranges this three UE as a User alliance for cost-effective sharing of multi-dimensional resources, with UE5 and UE6 served by power-domain NOMA while UE4 is served by beam forming [14].

Channel Model

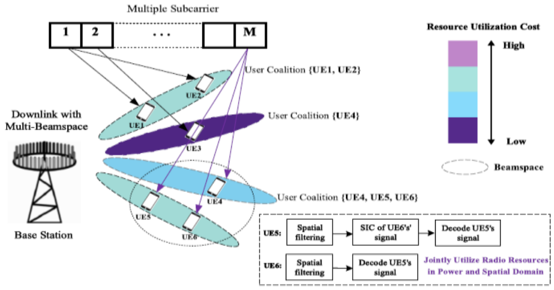

Figure 1 Illustration of proposed multi-dimensional multiple access (MDMA) scheme [14]

As shown in Figure 1, the location of UE k is characterized by (dk, θk), where dk is the distance between uk and the BS, and θk € (-π, π) is the angles of departure (AOD) of UE k, seen from the broadside direction of the transmit antenna array, i.e., the physical direction of the line-of-sight (LOS) path. The channel vector with complex coefficients between the BS and UE k in the c-th beam space on m-th sub channel is defined as

$$h_{k,m} = \sqrt{PL(d_k)} \cdot g_{k,m} \in C^{N_{t \times 1, k \in k}} , \qquad (1)$$

Where $PL(d_k)$ denotes the large-scale fading from BS to the UE k. Furthermore, this paper assumes that the LOS path exists in the intra-cell communication links, then vector $g_{k,m}$ follows uncorrelated Rician fading [15], that is,

$$g_{k,m} = \sqrt{\frac{k}{k+1}}\,.\,a(\theta k) + \sqrt{\frac{1}{k+1}}\,.\,z_{k,m\,,} \quad k \in k, \quad (1a)$$

Where vector $a(\theta k) = \left[1, e^{-j2\pi\Delta sin(\theta k)}\ , \ldots\ldots, e^{-j2\pi(N_t\ -1\Delta sin(\theta k)}\ \right]$ is accounting for the LOS component; Δ is the inter-antenna spacing in the unit of carrier wavelength, and vector $z_{k,m\,,}\sim \mathbb{C}\,\mathcal{N}(0_{N_t,}I_{N_t,})$ follows i.i.d. complex Gaussian distribution.

As a starting point, the spatial domain is coarsely divided into B beam spaces according to the AoD of UEs (i.e., θk) [16]. The set of UEs associated with the b-th beam space is denoted as $\mathcal{B}_b$, where $U_{b=1}^{\mathcal{B}}\mathcal{B}_b = k$ and $\mathcal{B}_b \cap \mathcal{B}_{b'}= \emptyset, \forall b, b' \in \mathcal{B}$. The UEs in different beam spaces have enough spatial orthogonality. In contrast, the UEs within one beam space cannot sufficiently guarantee spatial orthogonality. Dividing beam spaces can guide the formation of UE coalition through avoiding certain UEs to multiplex multi-dimensional radio resources with high utilization cost. In detail, UEs in different beam spaces can only share the same sub channel by spatial – domain NOMA (beamforming), while two UEs in the same beam space can only share the same sub cannel by power – domain NOMA.

Cost-Aware MDMA for Individualized Service Provisioning

Proposed MDMA Scheme: In this part, we design a MDMA scheme, in which BS adaptively choose a suitable multiple access mode for each UE based on their resource conditions, constraints, QoS demands, as well as utilization costs. Firstly, this paper introduces the concept of UE coalition, that is, several UEs with disparate multi-dimensional resource constraints can coordinate as resource-sharing coalitions to utilize the same sub channel in a cost-effective and less conflicting way. As shown in Figure 2, there are four multiple access modes for each UE, i.e., OMA mode, power domain NOMA mode, spatial-domain NOMA mode, and hybrid multiple access mode. For instance, spatial-domain NOMA mode would be applied in one sub channel if UEs within the coalition have large separated AOD. Meanwhile, power-domain NOMA mode could be used to serve the near-UE and the far-UE with large channel gain difference, where the number of users in each power-domain NOMA pair is limited to 2 [17]. Furthermore, in hybrid multiple access mode, UEs can share the same subcarrier by using both spatial domain and power domain NOMA at the same time.

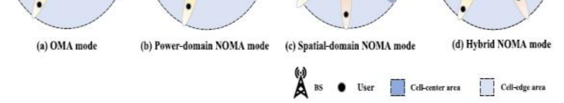

Figure 2 Candidate multiple access modes for UE coalition [14]

As shown in figure 2 Candidate multiple access modes for UE coalition: Each UE can utilize the radio resource in OMA mode with very low utilization cost and high-quality links, when the network traffic is low. With the increasing of network traffic, orthogonal radio resources are insufficient, UEs with less resource sharing conflicts can be multiplexed by spatial and power domain NOMA [14].

Definition 1 (UE Coalition): BS chooses mutually beneficial UEs into cooperative UE coalition, in which co-existing UEs will share and utilize the same sub channel by preferred multiple access mode to reduce potential radio resource utilization costs. Specifically, all UEs are partitioned into a set N of M coalitions according to the UE's resource utilization costs, hardware constraints, and perceived value of radio resources. Specifically, the n-th UE coalition is defined as a UE set $\mathcal{U}_n$, where $U_{n\in\mathcal{N}}\,\mathcal{U}_n = k$ and $\cap_{n\in\mathcal{N}}\,\mathcal{U}_n = \emptyset$. In particular, to describe the employed multiple access mode of UEs in n-th coalition, a binary variable α_n to denote if spatial-domain NOMA is defined as,

$$\alpha_n = \begin{cases} 1, & if \sum_{b=1}^{\mathcal{B}} 1\{|\mathcal{B}_b \cap\ \mathcal{U}_n| \geq 1\} > 1 \\ 0, & otherwise \end{cases}$$

Where 1 {·} is the indicator function. Meanwhile, let $\mathcal{B}_n$ = 1 denote if power-domain NOMA mode is used by UEs belonging to the same beam space; otherwise, $\mathcal{B}_n$ = 0.

$$\mathcal{B}_n = \begin{cases} 1, & if\ \exists\ b\colon |\mathcal{B}_b \cap\ \mathcal{U}_n| = 2,\ \ 1 \leq b \leq B \\ 0, & otherwise \end{cases}$$

Hence, there are four candidate multiple access modes for n-th UE coalition to multiplex the same sub channel,

$$\alpha_{n,}, \mathcal{B}_n = \begin{cases} (0,0), \text{if OMA is set} \\ (1,0)\ , \text{if spatial domain NOMA is set} \\ (0,1)\ , \text{if power domain NOMA is set} \\ (1,1)\ , \text{if if hybrid NOMA mode is set} \end{cases}$$

Signal Transmission Model: Let $s_{n,m} = 1$ denote the sub channel allocation indicator, where $s_{n,m} = 1$, when m-th sub channel is utilized by UE coalition $n \in \mathcal{N}$; otherwise, $s_{n,m} = 0.$ Furthermore, each UE is assigned with a beamforming vector to exploit the gain in the spatial domain. Let $\mathcal{U}_k \in \mathbb{C}^{N_t\times 1}$ denotes the beamforming vector from BS to UE k. Herein, zero-forcing beamforming is used to serve UEs associated with different beam spaces, while UEs in the same beam space will share by the same beamforming vector. Then, the signal-to-interference-plus-noise rate (SINR) of UE k $\in \mathcal{U}_n$ on m-th sub channel is expressed as:

$$\gamma_{k,m} = \frac{p_{k}|h_{k,m}^{H}\mathcal{U}_k|^2}{I_{k,m} + N_0} \text{if} s_{n,m} = 1 \ (2)$$

where $p_k$denotes the downlink transmission power of k-th UE, term N0 is the additive Gaussian noise on each sub channel, and term $I_{k,m}$ in the denominator of the SINR represents the non-orthogonal interference. As illustrated in Figure 2, there are four kinds of interference situations,

$$I_{k,m} = \begin{cases} 0, \text{if OMA is set}, \\ I^{SD}_{k,m}, \text{if spatial domain NOMA is set}, \\ I^{PD}_{k,m}, \text{if power domain NOMA is set}, \\ I^{PD}_{k,m}, \text{if if hybrid NOMA mode is set}, \end{cases}$$

In the case of the OMA mode, there is no additional interferences, i.e., $I_{k,m} = 0$. In the case of power-domain NOMA mode, the SIC receiver of "near-UE" k can cancel the interference from "far-UE" with lower channel gain. Then, the interference in power-domain (PD), $I^{PD}_{k,m}$ is

$I^{PD}_{k,m} = \sum_{b=1}^{\mathcal{B}} 1\{k \in \mathcal{B}_b\}. \sum_{i \in S_K} p_{i|h^H_{k,m}\mathcal{U}_i|}2$ (2a)

Where 1 $\{\cdot\}$ is the indicator function and $S_K = \{i|i \in \mathcal{U}_n \cap \mathcal{B}_b, ||h_{k,m}|2\}$ is the UE who has better channel gain than UE k. In the case of spatial-domain NOMA mode, $I^{SD}_{k,m}$ is the non-orthogonal interference in the spatial-domain (SD), caused by the UEs in other beam spaces,

$I^{SD}_{k,m} = \sum_{b=1}^{\mathcal{B}} 1\{k \in \mathcal{B}_b\}. \sum_{i \in \mathcal{U}_n \cap \mathcal{B}_b} p_{i|h^H_{k,m}\mathcal{U}_i|}2$(2b)

Moreover, in the case of the hybrid NOMA mode, it will cause the non-orthogonal interferences in both spatial and power domains. Therefore, the data rate of UE k in n-th UE coalition can be expressed as,

$\gamma_k = \sum_{m=1}^{M} s_{n,m} \ . \frac{B}{M} \log_2(1 + \gamma_{k,m}), \ k \in \mathcal{U}_n$ (3)

Divergent Recourse Constraints Experienced by Each UE: The proposed MDMA scheme aims to encourage UEs to explore multi-dimensional radio resources through the selection of multiple access modes. However, the utilization of radio resources in different dimensions comes at different costs of computational complexity, subject to heterogeneous hardware constraints. Specifically, in NOMA modes, UE will suffer from the non-orthogonal interference caused by the partially overlapped signal in the spatial-domain, the power domain, or both, which inevitably induces additional power consumption of UEs for interference mitigation. Therefore, we have the following definitions of the utilization costs and resource constraints at the UE side.

Radio resource utilization cost of UE. Firstly, the power-domain NOMA requires the SIC processing at the "near-UE" (with strong channel gain), which leads to extra complexity and power consumption at the receiver [18]. The utilization cost to the power-domain NOMA for the "near-UE" is inversely proportional to the experienced SINR in the SIC procedure [11]. For UE $k \in \mathcal{U}_n$ on m-th sub channel, if UE k has strong channel gain in the power-domain NOMA pair, its utilization cost for SIC is defined as

$$\psi^{PD}_{k,m} = \sum_{b=1}^{\mathcal{B}} 1\{k \in \mathcal{B}_b\}. \sum_{i \in \chi_k} [\rho_0 - \rho_1 Lg(\gamma^{Sic}_{k,m}],$$

if$s_{n,m} = 1 \ and \ \mathcal{B}_n = 1$ (4)

Where term ρ_0 denotes the constant cost of SIC processing, $\chi_k = \{i|i \in \mathcal{U}_n \cap \mathcal{B}_b, ||h_{k,m}||2 > ||h_{i,m}||2\}$ is the UE who has worse channel gain than UE k, ρ_1 is the positive scalar, and $\gamma^{Sic}_{k,m}$ denotes the SINR experienced by UE k, when UE k detects the signal of UE i, i.e., "far-UE," in presence of interference from its desired signal, that is,

$$\gamma^{Sic}_{k,m} = \frac{p_{i|h^H_{k,m}\mathcal{U}_i|}2}{p_{i|h^H_{k,m}\mathcal{U}_i|}2 + I^{SD}_{k,m} + N_0}$$

As we can see, $\psi^{PD}_{k,m}$ is an increasing function of the inverse SINR, i.e., $(\gamma^{Sic}_{k,m})-1$. Besides, only the UE with strong channel gain has the additional cost by the SIC processing. Thus, the far-UE, which does not perform SIC, has no additional utilization cost in the power domain.

Secondly, for the case of spatial-domain NOMA, the high spatial correlation between desired signal and interference signal makes it costly for the UE side to distinguish the overlapped signals in the spatial domain [19]. The utilization cost of the spatial domain is determined by the spatial correlation among UEs in different beam spaces sharing the same sub channel. For UE $k \in \mathcal{U}_n$ on on m-th sub channel, the spatial domain non-orthogonality of this UE is defined as

$$\psi^{SD}_{k,m} = \sum_{b=1}^{\mathcal{B}} 1\{k \notin \mathcal{B}_b\}. \sum_{i \in \mathcal{U}_n \cap \mathcal{B}_b} \rho_2 \cdot \frac{|h^H_{k,m} h_{i,m}|}{|| h_{k,m}||.||h_{i,m}||2},$$

if$s_{n,m} = 1 \ and \ \alpha_n = 1$ (5)Type equation here.

Where term ρ_2 is a positive scalar related to the additional costs of using spatial domain NOMA at the receiver. Then, we quantify the utilization costs of radio resource with respect to the non-orthogonality in both power and spatial domain,

Definition 2 (Multi-Dimensional Radio Resource Utilization Cost at UE Side): In UE coalition $n \in \mathcal{N}$, the corresponding utilization cost of UE $k \in \mathcal{U}_n$ is defined as

$$g_k = \sum_{m=1}^{M} s_{n,m} \ .(\alpha g_m)$$

$$g_k = \sum_{m=1}^{M} s_{n,m} \ .(\alpha_m \psi^{PD}_{k,m} + \beta_m \psi^{SD}_{k,m}) \ (6)$$

If coalition n utilizes m-th sub channel by OMA mode, the utilization cost of UE $k \in \mathcal{U}_n$ is zero.

ii). Hardware Constraints of UE. Ideally, all UEs are expected to be equipped with compatible processing capabilities and functionalities for different multiple access modes. However, in practice, different UE has diversified processing capabilities and limitations, which may restrict UE's selection on specific multiple access modes. Particularly, power-domain NOMA requires "near-UE" (i.e. UE with strong channel gain) to perform SIC. However, the SIC capability is not universally exist considering the heterogeneity of device type.

In this paper, assume that the UEs with SIC capability as set K_{sic} and the UEs without SIC capability asK_{no-sic}, where $K_{sic} \cup K_{no-sic} = k$, $K_{sic} \cap K_{no-sic} = \phi$. If UE k in n-th UE coalition does not possess SIC ability, it cannot be selected as the "near-UE" in the power-domain NOMAM pair. This hardware constraint can be mathematically in C1, as shown at the bottom of the next page.

II. Problem Formulation

UE's perceived Value of Radio Resource: In principle, we aim at optimizing the UE's perceived value of radio resources, which are balancing two conflicting metrics for each UE, that is, a) performance gain of communication service (i.e., user's satisfaction of QoS performance) and b) utilization costs of multi-dimensional radio resources. For UE $k \in \mathcal{U}_n$, its cost-aware utility function is defined as

$$\mathcal{U}_k = , \frac{r_k}{R_{max}} - w_k\, g_k\, , k \in (7)$$

Where R_{max} is the ideal data rate of UE k that experiencing no inter-user interference with given SNR 30 dB. We use the fraction of r_k and R_{max} to reflect the performance gain of communication service, that is, the level of user satisfaction. On the other hand, w_k is the weighting factor to the radio resource utilization cost g_k. For instance, if UE k is energy sensitive (e.g., limited battery), w_k will be set to a high value to restrict the energy consumption at the receiver. In this case, UE k will prefer OMA mode than NOMA modes to avoid high resource utilization costs.

Remark: It should be noted that the same sub channel might worth different utility values, i.e., formula (7), to different UE of different coalitions. By exploiting this feature, we can utilize multi-dimensional radio resources more efficiently and opportunistically for individualized QoS provisioning.

Target Problem: From the service-provisioning perspective, the proposed MDMA scheme should satisfy the distinctive recourse constraints and QoS requirements from each UE. In this paper, the overall objective is to maximize the total sum of UE's utility function subject to the hardware and resource constraints of UE. Thus, it can be formulated as a maximization optimization problem,

$$\mathcal{P}: \max_{\Omega} \left\{ \sum_{n \in \mathcal{N}} \sum_{k \in \mathcal{U}_n} \mathcal{U}_k \right\}$$

$$s.t.: C1: \sum_{k \in \mathcal{U}_n} \sum_{b=1}^{\mathcal{B}} \sum_{i \in \mathcal{U}_n \cap \mathcal{B}_b} 1\ \{k \in K_{no-sic}, \}.\ 1\{\| h_{k,m} \|2 > \|h_{i,m}\|2\} = 0, \forall n \in \mathcal{N},$$

$$C2:$$

IV- RESULT & CONCLUSION

This paper has proposed a mathematical approach for new multidimensional multiple Access (MDMA) planning to meet specific QoS demands and the resource conditions of each user in the 6G wireless network cost effectively. In our proposed scheme, the QoS of each UE Performance and resource constraints are considered combined In UE's cost-aware utility function. To the max the sum of the utility functions of all UE's coexisting UE's with There can be diverse QoS diversity and resource diversity efficiently served. Formulated problem is different Two-stage, that is, cost-conscious multiple access mode selection and multidimensional radio resource allocation. based on Two-way many-to-one matching principle, user-specific Multiple access modes are selected to fully utilize the available Multifunctional resource with acceptable utilization cost for users. Multidimensional Radio Resource Allocation The problem is then solved on the basis of medium complexity on the convex optimization principle.

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