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A New Optimization Approach for Hybrid LDM-NOMA and FeMBMS-OMA in 5G Cellular Broadcasting

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ABSTRACT

In this paper, a new approach for 5G broadcast optimization deployment is considered. We propose a novel hybrid of layered division multiplexing with non-orthogonal multiple access (LDM-NOMA) and further evolved multimedia broadcast multicast service with orthogonal multiple access (FeMBMS-OMA). The multi-user transceiver architecture of the broadcast service provider (BSP) works in such a way that the former LDM uses the latter FeMBMS as a cooperation layer. Jointly power and sub-carrier allocation are investigated to maximize system performance. We will define a new utility function to optimize resource allocation depending on the sum rate and bit error rate (BER). This utility function can depict the trade-off between FeMBMS-OMA and LDM-NOMA. Service selection is done using binary factor radio access technology. A framework is proposed that jointly maximizes the weighted sum rate and minimizes the total BER for iterative resource allocation problems. The proposed scheme provides the minimum required outage probability rate for low-layer (LL), upper-layer (UL), and middle-layer (ML) users. To solve the power allocation, the broadcast water-filling algorithm (BWA) is localized. Simulation results show that the proposed hybrid method provides better performance than individual OMA and NOMA in terms of achievable sum rate and BER.

INDEX TERMS LDM, FeMBMS, BER-sum rate Optimization, 5G Cellular Broadcast,Outage,Coverage technology selection

I. INTRODUCTION

For years, the existing technical literature has merged broadcast-broadband technologies to mingle their benefits. The need for an alternative cellular broadcast system for the fifth generation is clear. It is widely accepted that broadband cellular technological changes occur once every decade, while television broadcast service provider (BSP) technology is changed over time, such as fifth and sixth generation (5G, 6G) and digital video broadcasting (DVB) [1], [2]. Technology compatibility and support capability after transitioning between current and next broadcast/broadband technologies are always one of the concerns of users and broadcast owners. Absolute dependence on IP, creating coverage gaps, system diversity, spectrum efficiency, and access technology selection are the main issues of the transition period [3]. To meet the growing demands of audiences broadcast/broadband technology, hybrid NOMA with OFDMA has been recognized to perform better than the conventional orthogonal multiple access (OMA) as well as pure NOMA or OMA schemes [4], [5].Further enhanced/evolved multimedia broadcast multicast service (FeMBMS) is released by the 3rd generation partnership project (3GPP) demands new frequencies for repeaters in indoor or outdoor areas. It is a derivative from OMA and an upcoming candidate solution for the beyond LTE-based approach known as 5G-Xcast or broadcast/multicast FeMBMS. It involves supplementing a cellular network with an overlaid high-power high-tower (HPHT) network [6], [7]. Noteworthy is the fact that, for the first time, it lets 100% of transmission, capacity be dedicated to broadcasting services. Accordingly, a power-based non-

orthogonal multiplexing (P-NOM) technology, also called the layered division multiplexing (LDM) as a baseline physical layer structure is introduced using advanced television system committee (ATSC) 3.0 for multi-service based on power level strength [5]. The advantages of combining LDM-NOMA and FeMBMS-OMA are concerning to conventional systems which can be summarized in enhanced service flexibility, selection technology, and larger spectral efficiency [3], [8].

A. BACKGROUND RESEARCH

Extensive studies have already been accomplished on the aforementioned technologies (NOMA, OMA, Hybrid technology) individually [9]. Investigations show that the type of network in the past works has been based on pairs of users, while the new works are based on cooperative users or multiple users Jain *et al.* [8]. Baghani *et al.* [3] introduced a suitable technology that is dynamically based on the instantaneous channel state information (CSI) and the proposed resource allocation problem.

Zhang *et al.* [10] applied power-based non-orthogonal multiplexing technology for next-generation 5G-MBMS to present integration broadcast/unicast.

Rezvani *et al.* [11] proposed globally optimal power allocation strategies to maximize the users sum rate in the downlink of single-cell multicarrier non-orthogonal multiple access (MC-NOMA) systems.

Boya Di *et al.* [12] introduced jointly optimize the subchannel assignment and power allocation to maximize the weighted total sum rate while taking into account user fairness.

L. Zhang *et al.* [13] characterized the mobile service delivery of the LDM-NOMA system over various challenging wireless propagation environments, with both analysis and extensive simulations.

Alemu Jorgi *et al.* [14] showed NOMA can be combined with OMA as a result it better performance using adaptive resource joint bandwidth and power allocation.

Tusha *et al.* [15] illustrated a hybrid power domain employing an orthogonal/non-orthogonal framework for downlink transmission with two user devices (UDs).

Al-Abbasi *et al.* [16] proposed the hybrid schemes technology, which is outperformed the separate method due to its flexibility in adapting the transmission approach.

Authors in [17]–[20] have worked on the optimization of hybrid with/without imperfect channel state Information OMA/NOMA systems.

Anderws *et al.* [21] optimized user rate in OFDM using a water-filling algorithm. Rohde & Schwarz in [6] and [7] reports shows that the use of HPHT will be a solution for the future of cellular broadcasting in the fifth and sixth generations.

B. CONTRIBUTIONS

- We derive optimal power and sub-carrier allocation that maximizes the sum rate and minimizes BER for multi-user collecting through a utility function and in turn, maximizes the overall system throughput.
- Despite of the difference between FeMBMS-OMA and LDM-NOMA in terms of orthogonality between users, their combination results in non-orthogonality and thus increase their capacity.
- In addition, this paper discusses the idea of hybrid multiple access, which represents a combination between LDM-NOMA and FeMBMS-OFDMA technologies, as a good candidate for the next generation wireless networks.
- Specifically, the user data rate requirement-based selection scheme is proposed as a sub-optimal solution to solve the resource allocation problem.
- We offer an intermediate method of multi-rate which can select technology for hybrid or individual service. Therefore it is used to complete coverage of regions between the two BSPs.
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C. ORGANIZATION

The rest of the article is organized as follows. In section II, system model descriptions are introduced. In section III, problem formulation are presented. In section IV, system design features are performed. In section V, the resource allocation algorithm is presented. In section VI, the performance analysis is brought. In section VII, the simulation results are given. Finally, in section VIII, conclude and futures directions are given.

II. SYSTEM MODEL DESCRIPTIONS

A. SIGNAL MODEL

Figure 1 shows three users in a single-cell BS, two users are multiplexed into one sub-carrier and the third user exists in another sub-carrier. which stands for BSP technology. Three users are superposed together in the frequency domain. The lower layer (LL) user is closer to the BS than the upper layer (UL) user, which means that the LL user has better channel status than the UL user. The FeMBMS user is placed between two users. The BS optimizes transmission resource allocation for each user on each sub-carrier. Specifically, instead of allocating all the power to a user, the LL user with stronger channel conditions is allocated less transmission power, and more transmission power is allocated to the UL user with weak channel conditions. In comparison with conventional OMA, FeMBMS is allocated to the medium power user, the UL user is the weakest advantage of the high-level power allocated channel, which provides asset fairness in resource allocation. Assigning LL with less power to a user will slightly reduce its capacity, but will have a significant impact on the user's UL. Transmitted signal are defined with M RBS and m sub-carriers and K users as below

$$X_m[n] = \alpha_m X_{LDM,n}[n] + \beta_m \sqrt{p_{FeMBMS}} X_{Fe.n}[n] \quad \text{for } m = 1, 2, ..., M \text{ and } n = 1, 2...., N_n \quad (1)$$

The hybrid signal broadcasted can choose a suitable technology based on the instantaneous CSI,which is defined as $CSI = \frac{h_{k,m}}{\sigma^2}$. Therefore, the beamforming BSP powers for transmission over mth RBs will be determined by

$$X_m[n] = \alpha_m\left(\sqrt{P_{UL}}X_{UL,n}[n] + \sqrt{P_{LL}}X_{LL,n}[n]\right) + \beta_m X_{FeMBMS}[n]. \quad (2)$$

Where β_m is dedicating indexes to mth RB for LDM and FeMBMS systems respectively.To select the mth from LDM symbols we assign $\alpha_m = 1$ and $\beta_m = 0$. To select the RB from FeMBMS symbols, we allocate binary factor as $\beta_m = 1$ and $\alpha_m = 0$. The $X_{LDM,m}[k]$, is the token transported in the kth sub-carrier of mth RB in LDM section, that is equal to summation of UL symbol $X_{UL,m}[k]$ and LL symbol $X_{LL,m}[k]$. The $P_{UL,m}[k]$ and $P_{LL,m}[k]$ notations are called LDM transmitted powers. The channel condition gains for three service and two operators downlink LDM/FeMBMS system defines as h_{LL}, h_{UL}, and h_{FeMBMS} of UD1, UD2, and UD3, respectively.

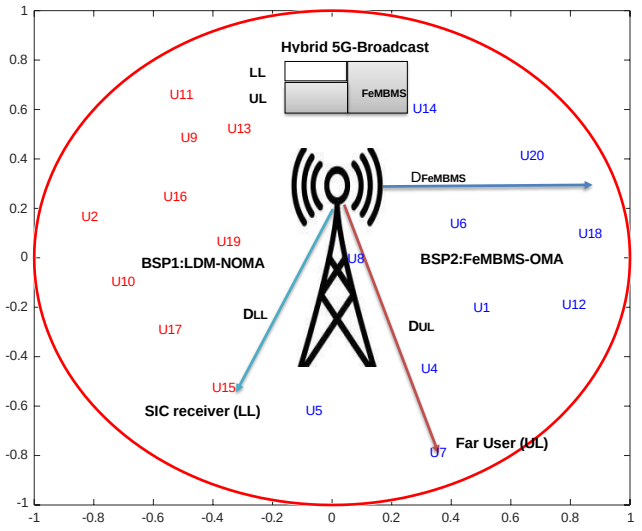

FIGURE 1. General overview space of two BSPs proposed system model.

B. UTILITY DEFINITION

In our proposed hybrid framework, the utility function can be defined as follows

$$U_m(p,\alpha,\beta) = R_m(p,\alpha,\beta) - \omega\beta_m F_m(p,\alpha,\beta) \quad (3)$$

where the $R_m(p,\alpha,\beta)$ is the downlink sum rate requirement system function and m is the sub-carrier and w is a normalization factor to harmonize the cost and rate functions to the desired priority levels of these two parameters in designing the system and $Fm(\alpha,\beta,p)$ represents the total SIC processing cost of LDM. The achievable BER is corresponding to the detection of a user with a strong received signal in the LL which has a lesser transmission power, a superior-level modulation, and a greater signal constellation that transports fixed services. The UL is the farthest user with a weak received signal equipped with a low-level modulation, superior transmission power, and a briefer signal constellation that carries mobile services. Access technology service selection for LDM and FeMBMS is defined as binary β_m factor for each subscriber. Also, we define three-dimensional matrix $\alpha_{k,k,m}$ and $\alpha_{k,k_2,m}$ binary variable is given for FeMBMS-OMA and LDM-NOMA respectively.

$$U_m(p,\alpha,\beta) = R_m(p,\alpha,\beta) - \beta_m\sum_{k=0}^{K-1}\alpha_{k,k,m} Q\log_2(1+BER) \quad (4)$$

where β_m and $\alpha_{k,k_2,m}$ with set $\in$ $0,1$ and $p_{k,m} \geq 0$ We first design an evaluation model to analyze several key constraints for optimization objectives, and then we derive the optimal power allocation coefficients.The second term of utility function in Equation (3) is $Q\log_2(1+BER)$ which is expressed as our considered LDM-NOMA cost will also include a component that is an increasing function of the inverse SINR. Where the Q is positive scalar. In addition, $Fm(\alpha,\beta,p)$ is the relationship between BER and SINR generally follow complementary error function, SINR is inverse logarithmic function suitable candidate with similar characteristics according to (3) and (4), the final utility function is

$$F_m(p,\alpha,\beta) = \frac{\sigma^2}{p_{LL,m}h_{LL,m}} + \frac{p_{LL,m}h_{UL,m}+\sigma^2}{p_{UL,m}h_{UL,m}} + \frac{p_{UL,m}h_{Fe,m}+\sigma^2}{p_{Fe,m}h_{Fe,m}} \quad (5)$$

Figure 2, illustrates the block diagram of the transceiver which is equipped with an M resource block sub-carriers that includes K users. Moreover, there are two types of RBs, the LDM denotes ψ and the FeMBMS resource blocks denotes Ω and each group includes several sub-carriers. The UD and BS are equipped with SISO antennas. The hybrid framework shows a downlink gNB station LDM non-orthogonal signal. Moreover, the FeMBMS orthogonal signal is superimposed on the same frequency and time slot architecture.

C. THE INSTANTANEOUS SUM RATE DOWNLINK

Figure 3, illustrates two BSPs in which LDM-NOMA can expand the feasibility region as two users can be supported in each sub-carrier and FeMBMS-OMA sub-carrier assignment instant per user. We have three states in Figure 3, as 1)The BSP1 uses FeMBMS-OMA service in a sub-carrier broadcast belongs of one user. 2)The BSP1 and BSP2 use LDM-NOMA service of one sub-carrier broadcast for both k_1 and k_2 users. 3)The BSP1 and BSP2 using LDM-NOMA service in a sub-carrier broadcast to identical both k_1,k_2 users. So, this scenario is repeated for every BSP. There will be reviews for three modes in each BSPs. The sub-carrier allocation

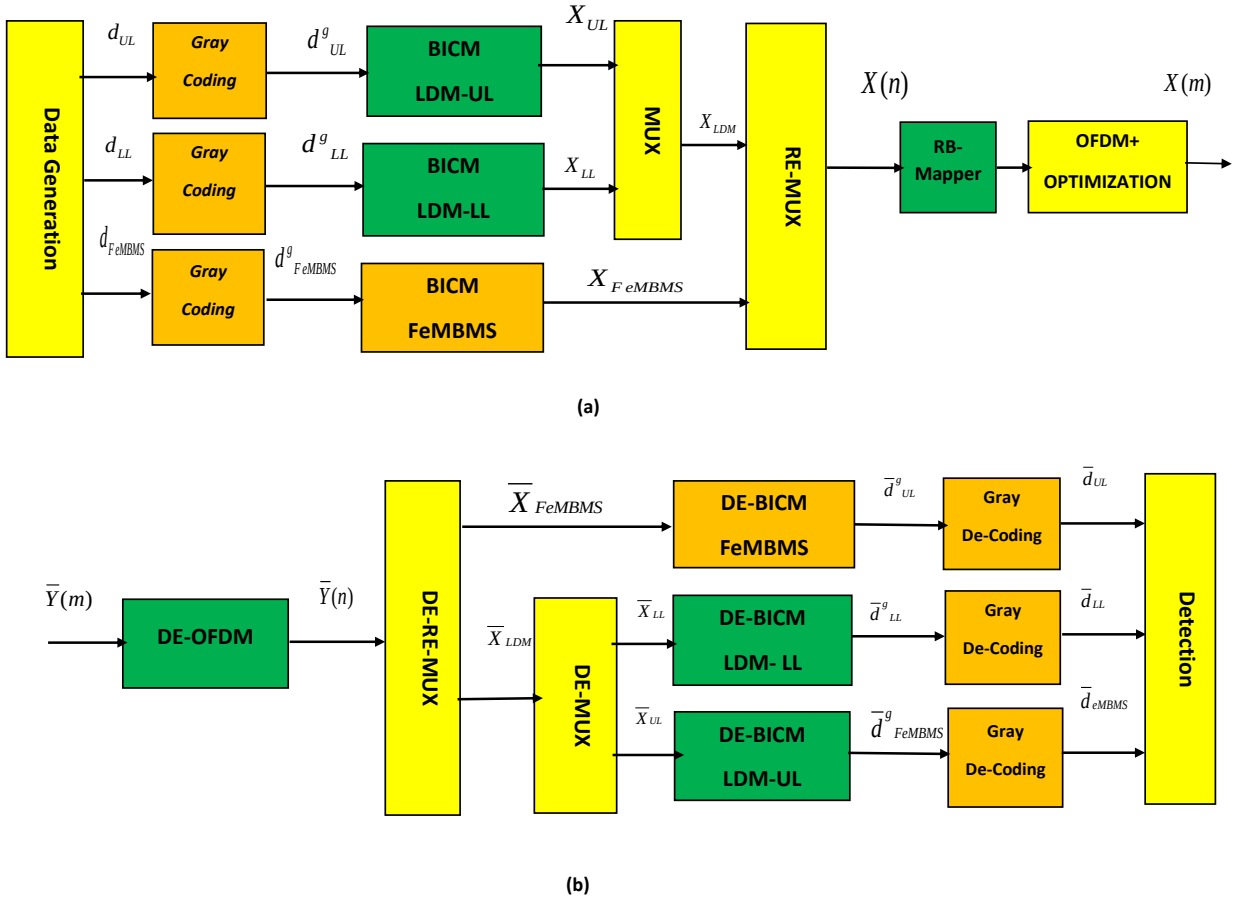

FIGURE 2. Optimized proposed LDM-NOMA/FeMBMS-OMA transceiver architecture (a)TX (b)RX

indicator is a binary variable that is given by β_m=1 if user k_1, and user k_2 are multiplexed on identical sub-carrier mth and β_m= 0 if user k_1, user k_2 are multiplexed on different sub-carrier m. Throughput is the rate of effective transmission of a signal in a wireless communication system, which is measured in bits per second (bps) [22]. Therefore, the instantaneous weighted throughput transmission downlink sum rate over m sub-carrier will be expressed as follows

$$R_m(\alpha,\beta,p) = \sum_{k=0}^{K-1} \beta_m \left[\alpha_{k1}, \alpha_{k2} \log_2 \left(1 + \frac{p_{LL,n} h_{LL,m}}{\sigma^2}\right) + \alpha_{k2} \sum_{k=0}^{K-1} \log_2 \left(1 + \frac{p_{UL,m} h_{UL,m}}{p_{LL,m} h_{UL,m} + \sigma^2}\right) \right] + \alpha_{Fe} \sum_{k=0}^{K-1} \log_2 \left(1 + \frac{p_{Fe,m} h_{Fe,m}}{p_{LL,m} h_{Fe,m} + p_{UL,m} h_{Fe,m} + \sigma^2}\right) \quad (6)$$

Where in (6) the first term is LDM-LL rate without interference, the second term is LDM-UL rate with LDM-LL interference and the third term is FeMBMS with both LDM-LL and LDM-UL interferences.

D. DC PROGRAMMING

The DC programming can be applied to solve non-convex optimization if the cost function (5) can be written as a minimization of a difference of two convex functions,we can solve (5) using DC programming to convex sub-problems by successive convex approximations [23].

$$minBER(\alpha,\beta,p) = maxF_m(\alpha,\beta,p) \quad (7)$$

Where F_m is represented as an inversely of BER function.

III. PROBLEM FORMULATION

A. OPTIMIZATION PROBLEM FORMULATION

In this article, we want to maximize the sum rate and minimize the BER equal to the utility function Equation (3). We implement this task from the optimization method of the joint power and sub-carrier allocation. We formulate this approach as a common optimization problem

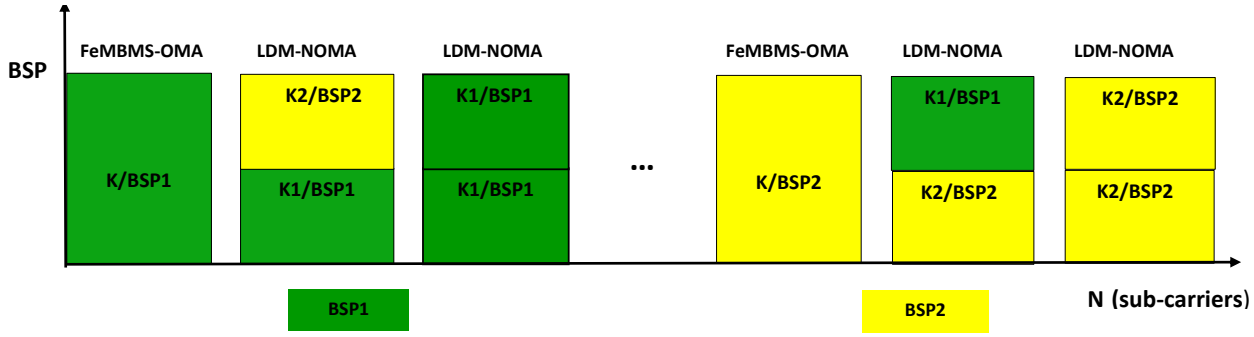

FIGURE 3. An illustrative optimized proposed system model for the broadcast service providers versus N sub-carriers.

$$\max_{p,\beta,\alpha} \sum_{m=0}^{M} R_m(\alpha,\beta,p) - \beta_m \alpha_{k_1,k_2,m} \omega \sum_{m=0}^{M} F_m(\alpha,\beta,p) \tag{8a}$$

subject to:

$$C1: \sum_{m=0}^{M}\sum_{k=0}^{K} \beta_m \alpha_{k_1,k_2,m}(p_{k1,m} + p_{k2,m} + p_{Fe,m}) \leq P_T \tag{8b}$$

$$C2: \sum_{k=0}^{K-1} B\beta_m \log_2\left(1 + \frac{p_{k,m}h_{k,m}}{\sum_{j=0}^{j-1} p_{j,m}h_{j,m} + \sigma^2}\right) \geq R_m \tag{8c}$$

$$C3: p_{LL} \geq 0, p_{UL} \geq 0, p_{FeMBMS} \geq 0 \tag{8d}$$

$$C4: \sum_{k1=0}^{K_1-1}\sum_{k2=0}^{K_2-1} \alpha_{k1,k2,m} \leq 1 \tag{8e}$$

$$C5: \left(\sum_{m=0}^{M}\sum_{k=0}^{K} \alpha_{k_1,k_2,n}(p_{k_1,m} + \alpha_{k_1,k_2,n}\sum_{k2=0}^{K2} p_{k2,m})\right) \leq P_T \tag{8f}$$

$$C6: \left(\sum_{k1=0}^{K1} \alpha_{k_1,k_2,m}(\sum_{k2=0}^{K2} p_{k_1,m} - p_{k_2,m})\right) \geq \beta_m P_d \tag{8g}$$

$$C7: \alpha_{k_1,k_2,m}, \beta_m \in 0,1 \tag{8h}$$

Whereas in (8), **C1** constraints the total power of the base station for three users.Where **C2** implies R_m which is the minimum data rate requirement for k^{th} user. Constraint **C3** represents the non-negative nature of powers for selected users, by assuming $p_{k,m} = p_{LL,m} + p_{FeMBMS,m} + p_{UL,m}$. **C4** implies at least one user can be assigned to sub-carrier and imposed to guarantee that each sub-carrier is allocated at most two users.The constraint **C5** The transmit power limitation of BS is controlled between two LDM users. Constraint **C6** provides the SIC limitation necessary power,the difference in power levels of NOMA users should be larger than a specific lower bound, where P_d represents the minimum required difference of the received power levels and **C7** which is the binary factor values are limited.

In fact, the objective function Equations (8) is a non-convex optimization problem. It is NP-hard linear integer programming, which uses the interior-point method. It is expressed as a trade off between the achievable rate and the processing cost of using each access technology. Solving the formulated problem in (8) requires an iterative algorithm for a sub-optimal solution. The optimization problem of Equations (8a) to (8h) is a joint optimization problem that combines user coupling and power allocation on sub-carriers, which are obviously non-convex, and it is difficult to directly obtain an optimal solution [24], [25].

We solve the optimization problem using the CVX modeling MOSEK version via MATLAB [3]. To do so, we define the auxiliary function. Various channel conditions in LDM-NOMA users are caused, the UL fair user should have lower channel condition gain compared to the LL strong user which has better channel condition. We should have $\alpha_{k_1,k,m} = 0$,when $h_{k_1,m} > h_{k_2,m}$ indicates channel response normalized by noise which can be represented as CRNN. The annotations symbol definitions associated with joint LDM/FeMBMS technologies are summarized in Table 1 .

IV. SYSTEM DESIGN FEATURES

A. RESOURCE ALLOCATION VIA USER COUPLING

The performances of LDM-NOMA and FeMBMS-OMA mostly depend on power allocation and user coupling, which are common optimization problems. To solve the resource allocation problem a user coupling algorithm, namely a user data rate requirement-based selection scheme, is defined as an optimal solution. The user coupling and power allocation can balance system performance and fair resource allocation [22]. The user coupling algorithm sorts users by channel condition so that the most powerful user is placed first. The first half of the proposed scheme classifies the users who are placed in the front of strong user groups in the system, and the rest of the users are considered weak users introduced as below

TABLE 1. Definitions of symbols and system parameters

Parameter	Definition
P_T	Total transmission power from the gNB site
P_{LDM}	Total power of LDM technology
P_{UL}	Total power of LDM upper layer
P_{LL}	Total power of LDM lower layer
P_{FeMBMS}	Total power of FeMBMS technology
ps	Per Subcarrier
g	Injection power factor
B	Total Bandwidth
RB	Resource Block
U	Total number of Users
M	Total number of resource blocks
Ψ	Total number of LDM resource blocks
Ω	Total number of FeMBMS resource blocks
γ	Signal to Noise Ratio (SNR)
K	Total number of sub-carriers
m	Resource block index
S	A subset of broadcast service providers
n	Time-domain sample index
ω	Normalization factor optimization problem
K_{LDM}	Total number of LDM sub-carriers
K_{FeMBMS}	Total number of FeMBMS sub-carriers
N	Fast Fourier Transform (FFT) points
T	Useful time duration of multi-carrier symbol
α_m	The binary index for mth RB illustrates where LDM is allocated
$\alpha_{k_1,k_2,m}$	The three-dimensional optimization variables that capture of resource allocation
β_m	The binary index for mth RB illustrates where FeMBMS is allocated
$N0$	Additive White Gaussian Noise
Pr_{out}	The outage probability based on capacity
$\bar{\gamma}_{FeMBMS}$	The FeMBMS average SNR
C_{PTP}	Total point-to-point channel capacity
$P_{Hybrid}(e)$	Total hybrid power error probability
$G_{UL}[k]$	The LDM UL frequency channel gain
$G_{LL}[k]$	The LDM LL frequency channel gain
$G_{FeMBMS}[k]$	The FeMBMS frequency channel gain
$x(t)$	Time-domain transmit signal
$y(t)$	Time-domain received signal
$x(n)$	The discrete transmit signal
X_{LDM}	The LDM transmit signal
X_{FeMBMS}	The FeMBMS transmit signal
$X_m[k]$	The discrete transmission signal in the frequency domain
$\mathbf{Y}$	The total vector of the received discrete signal after the FFT block in the frequency domain
$Y_m[k]$	The discrete signal recipient at kth sub-carrier, which belongs to mth RB
$y(n)$	Overall discrete signal recipient
$H[k]$	The base-band discrete channel frequency response
$\hat{X}_m[k]$	Estimated and equalized signal transmitted in the mth RB
$\overline{P}_{UL}(e)$	Average error probability of LDM-UL
$\overline{P}_{LL}(e)$	Average error probability of LDM-LL
$H_{LL}[k]$	Channel frequency response of the LL at kth sub-carrier
$H_{UL}[k]$	Channel frequency response of the UL at kth sub-carrier
$H_{FeMBMS}[k]$	Channel frequency response of the FeMBMS at kth sub-carrier
$\overline{P}_{FeMBMS}(e)$	The average error probability of the FeMBMS
$U_m(p,\alpha,\beta)$	The utility function
$R_m(p,\alpha,\beta)$	The downlink sum rate requirement
$F_m(p,\alpha,\beta)$	The total SIC processing cost of LDM
$L(p,\lambda,\gamma,\eta)$	Lagrangian Multipliers
$R_m(p,\lambda,\gamma,\eta)$	Maximum Sum rate Multipliers
$d^g_{LL}, d^g_{UL}, d^g_{FeMBMS}$	Data after LL,UL,FeMBMS gray coding

$$\underbrace{h_{LL1} \geq h_{FeMBMS2} \geq h_{UL3}}_{\text{Strong channel gain users}} > \overbrace{h_{LL4} \geq h_{FeMBMS5} \geq h_{UL6}}^{\text{Weak channel gain users}}$$

B. POWER ALLOCATION ALGORITHM

One of the conventional sub-optimal power allocation solutions is equal to power allocation. Specifically, the transmit power of the base station is equally distributed to each sub-carrier, which can be easily implemented in practice. Therefore, we first propose a low complexity sub-optimal approach that allocates the power equally among all the RBs [27].

1) Equal RB Power Allocation Using FTPA

The effect of fractional transmit power allocation (FTPA) over FeMBMS/LDM resource assignment is assessed. Due to its low computational complexity, it is widely adopted in services with multiple radio access technology. By applying the FTPA algorithm [28], [29], the transmit power of LDM, RBs on sub-carrier kth (SCk) is assigned pursuant to the channel profits are $\left\{|H_{LL}|^2, |H_{FeMBMS}|^2, |H_{UL}|^2\right\}$ of all the multiplexed users on SCk, which is given as

$$P_{UL} = P_{K,M} \frac{E\left\{|H_{UL}|^2\right\}^{-\xi}}{E\left\{|H_{UL}|^2\right\}^{-\xi} + E\left\{|H_{Fe}|^2\right\}^{-\xi} + E\left\{|H_{LL}|^2\right\}^{-\xi}} \tag{9}$$

$$P_{LL} = P_{K,M} - (P_{UL} + P_{FeMBMS}) \tag{10}$$

Where ξ $(0 \leq \xi \leq 1)$ is a decline factor and in the case of $\xi = 0$, it is put through identical power. In this article, we suppose identical power allocation to the RBs, hence, the power of the LDM part can be computed. In other words, the total transmission power in each RB is set to be

$$p_{RB} = p_{LL,m} + p_{UL,m} + p_{FeMBMS} = \frac{P_t}{M} \tag{11}$$

C. POWER ALLOCATION PER SUB-CARRIER

The main direction of solving the power allocation problem in the designed work is convex optimization approach. The proposed power allocation algorithm has two convex optimization approaches, which targets on optimizing both the allocated power to each maximum two user in each sub-carrier and the transmit power that distributed to each sub-carrier [30].

Using Equation (6) achievable simplify the total sum rate of the weakest user $p_{UL,m}$ with high power and the strongest user $p_{LL,m}$ with low power is as bellow

$$R_m(p,\lambda,\gamma,\eta) = \alpha_{k,k,m}\Big[U_{LL,m}\log_2(1+p_{LL,m}h_{LL,m}) + U_{FeMBMS,m}\log_2(1+p_{Fe,m}h_{Fe,m}) + \beta_m\alpha_{LL,UL,m} U_{UL,m}\log_2(1+p_{k_2,m}h_{k,m}) - U_{UL,m}\log_2(1+p_{LL,m}h_{UL,m})\Big] \tag{12}$$

Then to find the max point, the lagrangian method derivative of R_m with respect to $p_{k,m}$ in LDM-NOMA is as follows

$$\frac{dR_m(p)}{dp_{k,m}} = \frac{U_{k1,m}h_{k_2,m}}{(1+p_{k,m})Ln2} + 2 \times \frac{U_{k2,m}h_{k_2,m}}{(1+p_{k,m}+\sigma^2)Ln2} \quad (13)$$

In this method, the primal (maximizing $L(P)$ to find P and dual (minimizing $L(p,\lambda,\gamma,\eta)$ to find Lagrange multipliers) problems are solved interactively until changes in the variables are negligible and the iterative algorithm converges to a fixed point [31]. Since the optimization problem (11) is convex, this fixed point will be the optimal.The LDM-NOMA framework tends to gives weak user high priority in power allocation in each sub-carrier, which implies $U_{LL} > U_{UL}$, should be fulfilled. Additionally, the non-negative power constraint should be satisfied as well. As a result, the zero point of $\frac{dp_{k,m}}{dp_{k,m}}$ is given by

$$p_{k,m} = \frac{U_{UL,m}h_{LL,m} - U_{LL,m}h_{UL,m}}{(U_{LL,m} - U_{UL,m})h_{LL,m}h_{UL,m}} \quad (14)$$

Therefore, the maximum value of R_m is achieved under the conditions of LDM-NOMA. In mth sub-carrier, $p_{k1,m}$ denotes the power that is assigned to the near LL strong user. For a fixed $p_{k1,m}$, the increment in achievable data rate on general sub-carrier mth corresponds to the increment in power allocated to the weak user, which is $p_{UL,m}$.

$$p_{UL,m} = p_{max,m} - (p_{LL,m} + p_{FeMBMS,m}) \quad (15)$$

D. CLOSED-FORM OPTIMAL POWER ALLOCATION

In the current water-filling algorithm to calculate one sub-carriers allocated power, we need eta. To find optimum eta we need all sub-carriers CSI values and total power budget and OMA technology for all sub-carriers [32]–[35]. Hence, the objective function and the constraints multipliers can be the Lagrange equation for maximization is given by

$$\begin{aligned} \underset{\lambda,\gamma,\eta}{L}(p,\lambda,\gamma,\eta) = \sum_{k=0}^{K_1-1} \alpha_{k,k,n} \log_2\left(1+\frac{p_{LL,n}h_{LL,n}}{\sigma^2}\right) \\ + \log_2\left(1+\frac{p_{UL,m}h_{UL,n}}{p_{LL,n}h_{UL,n}+\sigma^2}\right) - \lambda(p_{k1,m} - p_{k2,n} - R_s) \\ -\gamma\left(\frac{h_{k,n}}{\sigma^2}\sum_{k=0}^{K}\alpha_{k_1,k,n}p_{k_1,n} - p_{k,n} + p_{FeMBMS,n}\right) \\ \geq \beta_m P_d - \eta(U_{LL,UL,n}p_{k2,n} - P_{max}) \end{aligned} \quad (16)$$

According to the method of Lagrange coefficients, when the constraints are satisfied by the inequality, the corresponding Lagrange coefficients will be zero. In this scenario, Lagrange multipliers index λ, γ become zero. Thus, the Lagrange dual function is given by

$$\begin{aligned} L(p,\lambda,\gamma,\eta) = \sum_{k=0}^{K_1-1} \alpha_{k,k,m} \log_2\left(1+\frac{p_{LL,m}h_{LL,m}}{\sigma^2}\right) \\ + \log_2\left(1+\frac{p_{UL,m}h_{UL,n}}{p_{LL,m}h_{UL,m}+\sigma^2}\right) \\ -\eta(U_{LL,UL,m}p_{k2,m} - P_{max}) \end{aligned} \quad (17)$$

To solve (16), using the Karush–Kuhn–Tucker (KKT) approach to nonlinear programming generalizes the method of Lagrange multipliers, which allows only equality constraints. Similar to the Lagrange approach maximum point is given by

$$\frac{dL}{dp_{max,m}} = \frac{-U_{UL,m}h_{UL,m}}{(1+p_{LL,m}h_{UL,m}+...)Ln2} + \eta = 0 \quad (18)$$

By taking the answer from equation (18)

$$\eta = \frac{U_{UL,m}h_{UL,m}}{(1+p_{LL,m}h_{UL,m}+p_{UL,m}h_{UL,m})Ln2} \quad (19)$$

We will have the response as follows

$$p_{max,m} = \left[\frac{1}{\eta Ln2} - \frac{p_{LL,m}h_{UL,m}+\sigma^2}{h_{UL,m}}\right]^+ \quad (20)$$

Where (20) plus indicates only positive values are acceptable. Due to the compatibility of the water-filling algorithm in OMA, and we localized it in this scenario. We generalized the different modes for FeMBMS-OMA and LDM-NOMA corresponding to the SNR ratio and binary factors, which is called the broadcast water-filling algorithm (BWA). In this framework, the allocated power to the OMA users will be which is exactly the same as the broadcast water-filling algorithm [36].

E. BROADCAST WATER-FILLING ALGORITHM

BWA:Water-filling algorithm 1.

1: **Initialization**:Set **N** = 3*rand(1,16); **P**= 8;
2:$[B, I] = sort(N)$, n = length(B);
3:$\mu = (1/length(B)) * (P + sum(B))$ Optimization level
4:$SS = \mu - B$;
5:**if** FeMBMS-OMA
6:Allocated power to an OMA user
7:find $p_{k,m}$ from (14-16)
8: $D_{k,n} = \xi_{k,n} - \eta$ difference of two multipliers
9:**else**
10:**if** LDM-NOMA
11:for high SNRs, the allocated power to the LDM-NOMA users
12:find p_{max} from (20)
13:$D_{k2,n} = \gamma\frac{h_{k1,m}}{\sigma^2} - \xi_{k2,n} - \eta$
14:**else**

15:for low SNRs, the allocated power to LDM-NOMA users
16:**end if**
17:**end if**
18:**while** $SS(end) \leq 0$
19: B(end)=[];
20: $\mu = (1/length(B)) * (P + sum(B))$
21: $SS = \mu - B$;
22: **end**
23:$S + N = \mu$;
24:**if** $S + N \geq \mu$
25: S(S<0)=0
26: **else**
27:**Sum(S)**
28: **end if**
29: **end while**

By assuming $p_m = p_{LL,m} + p_{UL,m}$ we can allocate power to LDM-UL.

$$p_{UL,m} = \left[-\frac{1}{\eta} - \frac{\sigma^2}{h_{UL,m}} \right]^+ \tag{21}$$

Using (20) and BWA algorithm if $\beta_m = 0$ and $\alpha_{k,k,m} = 1$, As a result, we achieve the power of users $k1$ and $k2$ on the sub-carrier m are obtained as follows

$$p_{k,m} = \left[-\frac{1+\lambda_s}{D_{k,n}} - \frac{\sigma^2}{h_{k1,m}} \right]^+ \tag{22}$$

where $D_{k,n}$ is the difference of multipliers.

$$D_{k,n} = \xi_{k,n} - \eta \tag{23}$$

If $\beta_m = 1$ and $\alpha_{k,k,m} = 1$and $\alpha_{k1,k2,m} = 1$

$$p_{k,m} = \left[-\frac{1+\lambda_s}{D_{k,n}} - \frac{\sigma^2}{h_{k2,m}} \right]^+ \tag{24}$$

However, for high SNRs, the allocated power to LDM-NOMA users is given

$$p_m = \left[\frac{1}{V\frac{h_{k2,m}}{\sigma^2} + \eta} - \frac{\sigma^2}{h_{k2,m}} \right]^+ \tag{25}$$

Where V is a positive scalar. However, for low SNRs, the allocated power to LDM-NOMA users is as below

$$p_m = \left[\frac{1}{\eta} - \frac{\sigma^2}{h_{k2,m}} \right]^+ \tag{26}$$

When Pmax is high, according to the Lagrangian multiplier method, when the constraints are satisfied by inequality, the associated Lagrange multipliers will be equal to zero. As a result, the Lagrange multipliers λ_s, γ, ξ are equal to zero. The coordinates of the obtained optimal point are η and $p_{max,m}$ as (19, 20). Our proposed hybrid system allocates power to FeMBMS users computed using the water-filling algorithm is as below

$$p_{max,m} = \left[\frac{1}{\eta} - \frac{\sigma^2}{h_{FeMBMS,m}} \right]^+ \tag{27}$$

Power allocation of users in the NOMA-LDM system, multiple users perform power multiplexing at the transmitting end and share the same sub-channel, which forms a user group. Accordingly in an LDM RB, there can be two group users and for FeMBMS RB, the first group user will be assigned. The LL sub-carriers power is changed by the injection level of g and the summation, power is normalized to P_{LDM}. Hence, the transmit powers of LL and UL can be written in terms of P_{LDM} as follows

$$P_{LL} = \frac{g}{1+g} P_{LDM} \text{ and } P_{UL} = \frac{1}{1+g} P_{LDM}. \tag{28}$$

V. RESOURCE ALLOCATION ALGORITHM

The variables are divided into two parts: The first part is discrete variables, including technology selection $(\beta_m, m \in M)$and sub-carrier allocation or user pairing for FeMBMS-OMA or LDM-NOMA $(\alpha_{k,k2,m}, k, k2 \in K, m \in M)$ parameters. The second part of variables, which includes the power levels $(p_{k,m}, k \in K, m \in M)$ is continuous. The proposed power allocation algorithm has two convex optimization approaches, which target optimizing both the allocated power to each paired user in each sub-carrier and the transmit power that is distributed to each sub-carrier.The resource allocation algorithm 2 is presented.

A. RESOURCE ALLOCATION ALGORITHM

Algorithm 2: Resource Allocation

1: **Initialization**:Set *t*:=1
2:$P^*(t=0) = \frac{P}{2M}$,*K* user,*M* sub-carrier
3: **Repeat**
4:**Step1**: Derive α, β, U
5: maximize using Eqs.8 with fixed value $P^*(t-1)$
6:**Step2**:Set $t_2 := 1$ and $P^*(t_2 - 1) = P^*(t-1)$
7: **Repeat**
8:**Step1**
9: **for** k=1:i$_c$
10: **Repeat**
11:**Step A**: $p_{i,j}^{t_2}$, i ∈ K, and j ∈ M
12: **for** m ∈ M
13: **if** $\beta_n = 0$, and $\alpha_{k,k_2,m} = 1$
14: **for** k ∈ K
15: **if** $\beta_n = 1$, and $\alpha^*_{k,k_1,m} = 1$, and $\alpha_{k,k_2,m} = 1$
16: find $p_{k,m}$ from Eq.24.
17:find p_m from water-filling Eq.26.
18: **else** $p_{k,m}$= 0
19: **end**
20: **else** $p_{i,m}$= 0 ,i ∈ K

21: **for** k ∈ K, and n ∈ M
22: **if** $\alpha^*_{k,k_1,m} = 1$ and $\alpha^*_{k,k_2,m} = 1$
23: find $p_{k1,m}$ from Eq.22 and $p_{k2,m}$from Eq.24.
24: **end if**
25: **end for**
26: Update λ, γ, η
27: $p^{t_2}_{i,j}$, i ∈ K, and j ∈ M
variation of lagrangian multipliers are higher than ϵ
28: Go to **step A**
29: else
30:Stop reprat
31:**if** $p^*(t) - p^*(t-1) \leq \epsilon$
32: Set $p^*(t) = p^*(t2)$ and Stop Repeat
33: else
34: Set $t := t2 + 1$
35: **end if**
36: End of update
37: **Step 3**: **if** $p^*(t) - p^*(t-1) \leq \epsilon$
38: Stop reprat
39: else
40: Set *t*:= t + 1 and go to **Step1**

VI. PERFORMANCE ANALYSIS

A. BER

We will evaluate performance analysis in the main hybrid framework, we understand that with an increment Ψ in LDM RBs, it expected sum rate increment and BER increment, which increasing the sum rate is favorite and increasing the BER is not desirable. With an increase in Ω in FeMBMS RBs and $Eb/N0$, the sum rate is decreased and BER is decreased, which decreasing the sum rate is not favorite and decreasing the total BER is desirable.

$$BER = \frac{\sigma^2}{p_{LL,m}h_{UL,m}} + \frac{p_{LL,m}h_{UL,m} + \sigma^2}{p_{UL,m}h_{UL,m}} + \frac{p_{UL,m}h_{Fe,m} + \sigma^2}{p_{Fe,m}h_{Fe,m}} \tag{29}$$

where $BER = \frac{1}{SINR}$, the solution of a constrained optimization problem can often be found by using the so-called Lagrangian method.We use the technique of Lagrange multipliers.

B. SUM RATE

For diverse BSPs transmitting simultaneously, a multiple access rate region is characterized by all the upper bound on the rates based on Shannon's rate law. Since there are LDM and FeMBMS layers in the hybrid system, the total sum rate is a summation over the rate of RBs for each layer, is as below

$$R_T = R_{LDM} + R_{FeMBMS} \tag{30}$$

Where R_{LDM} and R_{FeMBMS} denote the sum rate of LDM and FeMBMS parts, respectively. We assume $(\overline{C}_{PTM} \leq R_T)$ inequality threshold rate value, which R_T is concerning to γ_R. Outage probability is defined as the average of instantaneous PTM capacity that is less than the threshold rate value that follows

$$Pr_{out} = p_r(\overline{C}_{PTM} < R_0) \tag{31}$$

The sum rate of the FeMBMS part can be written based on Shannon's rate formula as

$$R_{FeMBMS} = \frac{B}{M} \sum_{m=1}^{M_{FeMBMS}} R_{FeMBMS}[n] \tag{32}$$

The inequality for outage probability that satisfies this condition is given by

$$R_{FeMBMS}[n] < R_0 \tag{33}$$

Therefore, the outage probability for the total number of FeMBMS sub-carriers for each RBs can be expressed as

$$Pr^{FeMBMS}_{out} = \frac{1}{M_{FeMBMS}} \sum_{n=1}^{M_{Fe.}} Pr\{R_{FeMBMS}[n] < R_0\} \tag{34}$$

where

$$\gamma_{FeMBMS}[n] = \frac{p_{FeMBMS}G_{FeMBMS}[n]}{N_0^{ps}} \tag{35}$$

Eq.(34) is the signal to noise ratio per sub-carrier of FeMBMS received power and received noise. Also, $p_{FeMBMS} = P_T \frac{\Omega}{M} \frac{1}{M_{FeMBMS}}$, $forall$ k∈ $\{1, 2, \ldots, M_{FeMBMS}\}$ denotes the transmit power per FeMBMS sub-carrier, $M_{FeMBMS} = \Omega N_m$ denotes the total number of FeMBMS sub-carriers, and $N_0^{ps} = N_0 \frac{1}{M}$ denotes the noise power per sub-carrier. The sum rate of the LDM part can be written as

$$R_{LDM} = \frac{B}{M} \sum_{k=1}^{N_{LDM}} \Big[\log_2(1 + \gamma_{LL}[n]) + \log_2(1 + \gamma_{UL}[n])\Big] \tag{36}$$

$$\gamma_{LL}[m] = \frac{p_{LL}G_{LL}[n]}{N_0^{ps}} \tag{37}$$

where $\gamma_{LL}[n]$is the SNR per subcarrier for LL of LDM received power $p_{LL}E\{|H_{LL}[n]|^2\}$or power density spectrum multiply input signal and received noise N_0^{ps} and $\gamma_{UL}[n]$ is the SINR per subcarrier for UL of LDM received power and LL interference plus received noise is given by

$$\gamma_{UL}[m] = \frac{p_{UL}G_{UL}[m]}{p_{LL}G_{UL}[n] + N_0^{ps}} \tag{38}$$

TABLE 2. Related study hybrid NOMA-OMA optimization different technologies in comparison with the proposed scheme in the last six years

References	Algorithm Description	Hybrid System Type	Optimized/Evaluation Criteria	Network
[29], [37], **2016**	5G NOMA with fixed power allocation (F-NOMA) and cognitive-radio-inspired NOMA (CR-NOMA), algorithms are characterized.	Hybrid F-NOMA/CR-NOMA system	Optimization/ F-NOMA can offer a larger sum rate/power allocation	Two-user
[16], [20], [47], [48], **2017**	Optimization/User paring Power allocation across sub-channels maximize energy efficiency/ DC programming	Hybrid Multiple Access OMA/NOMA	Coverage probability, Maximize sum rate/Power allocation across sub-channels/Energy Efficiency	Two-user
[3], [24],**2018**	Optimization using iterative/DC programming	Hybrid NOMA/OMA in 5G Dynamicly	Achivable utility/sum rate, Outage probability	Two users
[38], **2020**	Utilize available resources efficiently using jointly allocating transmit power time- slots framework	Hybrid hybrid TDMA-NOMA system	Maximize and Minimum sum rate of the users in the system.	Two-user
[17], [39], **2021**	Power allocation algorithm	Hybrid NOMA/OMA 5G Networks	Average sum rate, EE, PA	Multi-user
[18], [19], [40] , **2022**	E-greedy-based user User Pairing in NOMA Using Chaos Decision-Maker	Hybrid Unified Channel Gain Difference pairing scheme (UCGD-NOMA)	BER Minimization	Multi-user
This work	Optimization for 5G broadcast/broadband Approach	Hybrid LDM-NOMA and FeMBMS-OMA	BER, sum rate, Outage/Coverage	Multi-user

Moreover, $p_{LL} = P_{LL}\frac{1}{N_{LDM}}$ and $p_{UL} = P_{UL}\frac{1}{M_{LDM}}$, $\forall k \in \{1, 2, \ldots, M_{LDM}\}$ denotes the transmit powers per sub-carrier for LL and UL, and $N_{LDM} = \Psi N_m$ denotes the total number of LDM subcarriers. Moreover in the second part $P_{UL}E\left\{|H_{UL}[n]|^2\right\}$as a receiving power and N_0^{ps} is a receiving noise power from upper layer,$P_{LL}E\left\{|H_{UL}[n]|^2\right\}$ as an interference noise to UL from LL for decoding in SIC receiver.

$$\begin{aligned} R_{LDM}[n] &= log_2\left(1+\frac{p_{LL}G_{LL}[n]}{N_0^{ps}}\right) \\ &+log_2\left(1+\frac{p_{UL}G_{UL}[n]}{p_{LL}G_{UL}[n]+N_0^{ps}}\right) \quad (39) \\ & n = 1, 2, 3, ..., M_{LDM} \end{aligned}$$

where $G_{LL}[n]$= $E\left\{|H_{LL}[n]|^2\right\}$ and $G_{UL}[n]$= $E\left\{|H_{UL}[n]|^2\right\}$. The outage probability for the total number of LDM subcarriers can be expressed as

$$Pr_{out}^{LDM} = \frac{1}{M_{LDMS}}\sum_{m=1}^{M_{LDM}} Pr\left\{R_{LDM}[n] < R_0\right\} \quad (40)$$

For the overall proposed system, outage probability can be expressed using the (33) and (39) Equations which satisfy as below

$$\begin{aligned} Pr_{out}^{overall} &= \frac{1}{M}\left[\sum_{n=1}^{M_{FeMBMS}} Pr\left\{R_{FeMBMS}[n] < R_0\right\}\right. \\ &\left.+\sum_{m=1}^{M_{LDM}} Pr\left\{R_{LDM}[n] < R_0\right\}\right] \quad (41) \end{aligned}$$

Which $\forall n \epsilon \{1, 2, 3, ...K\}$ is a number of sub-carriers. R_0 is a minimum threshold required data for outage performance. A two-step iterative algorithm that includes technology selection and power allocation are proposed to allocate the variables.

C. OUTAGE PROBABILITY ANALYSIS

In this sub-section, the outage probability is a pertinent yardstick for the evaluation of the quality of service. It measures the probability of losing out to arrive at an output signal to noise ratio (SNR) threshold value required for the desired service.

$$Pr_{out} = p_r(\gamma_{SNR} \leq \gamma_{min}) \quad (42)$$

Where the γ_{min} is a threshold SNR criterion, for received SNR below the γ_{min}, the received symbols cannot be successfully decoded with probability one, and the system declares an outage. We define the outage probability in (36) as the probability that the rate of at least one BSP is lower than its minimum required rate . For the SNR above γ_{min}, the received symbols can be successfully decoded with probability one [32]. For a single user, the channel capacity for BSP that normalized capacity using Shannon's law is given as,

$$C_{PTP} = B\log_2\left(1+\frac{P_T G^2}{N_0}\right) \tag{43}$$

Where C_{PTP} is the point to point channel capacity in bits per second per Hz (bps/Hz), B is channel bandwidth in Hz and G is the channel gain response, and P_T is the transmitted total power and the noise is assumed to be additive Gaussian with a variance N_0. For two users, taking into account the interference caused by using another user, and can be modeled as Gaussian, its power will appear and it is added to N_0 in the denominator. Each BSP in a multiple access channel can transmit at a rate $(C \leq R)$ inequality. A PTM channel distribution BSP is composed of one transmit point and $(j > 1)$ receive points. In such a network, collaboration among the received points may improve the power gain and thus the capacity gain. Denote G_j as the channel coefficient of receive point j with unit variance, and all the $G_j(j = 1, 2, 3..J)$ follow the same distribution. Total capacity for a PTM framework based on Shannon's law is written as follows

$$C_{PTM} = \frac{B}{N}\log_2\left(1+\sum_{j=1}^{J}\frac{P_T G_j^2}{N_0}\right) \tag{44}$$

The total capacity now can be described as $C \sim N(\overline{C}, \sigma_c^2)$, mean $\overline{C}$ and σ_c^2 is noise variance. Hence,outage probability based on capacity [41]–[43] , it could be defined as follows

$$Pr_{out} = p_r(C < \gamma_R) = 1 - Q\left(\frac{\gamma - \overline{C}}{\sigma_c}\right) \tag{45}$$

$$\overline{C} = \frac{1}{N}\sum_{i=1}^{M} C_i \tag{46}$$

Where in γ_R is the threshold rate value, and $Q(\cdot)$ is the standard Q function. C_i denotes the total capacity as a summation over each M RBs capacities, which are identical. The $\overline{C}$ is the average total capacity.

D. COVERAGE PROBABILITY ANALYSIS

In this section, our goal is to obtain the coverage probability for a random user in a cell. It is defined as the probability that the user can achieve a target rate. The probability of coverage can be seen as a complement to the probability of outage in Equation (40) and the coverage probability is described as the probability that a typical mobile UDs could reach the SINR threshold. We change this definition a bit and say that a typical user might reach the target rate of the threshold R_0 [44]. The coverage probability is done as a supplement to outage probability with a simple calculation as follows

$$Pr_{cov}^{LDM} = 1 - Pr_{out}^{LDM}, \tag{47}$$

$$P_{cov}^{FeMBMS} = 1 - Pr_{out}^{FeMBMS} \tag{48}$$

$$Pr_{cov}^{overall} = 1 - Pr_{out}^{overall} \tag{49}$$

VII. SIMULATION RESULTS

Simulation parameters are listed in Table 3..To illustrate the performance gains, The BER and achievable sum rate and outage/coverage performance are considered.

TABLE 3. Simulation Parameters

Parameter	Value
System Bandwidth	5 MHz
Transmitter P_{Tmax}	$46dBm$
Number of total Resource blocks: M	16
FFT size : N	8192
Center frequency f_0	2.1GHz
Total number of users U for equal LDM/FeMBMS allocation	24
Modulation LDM two layers and FeMBMS	QPSK/BPSK/QPSK
ACCP =Attenuation Path Loss(APL)	$E\left\{\lvert H_{LL}\rvert^2\right\} = 0\,dB$
$(ACCP)_{UL}$= Attenuation Path Loss (APL)	$E\left\{\lvert H_{UL}\rvert^2\right\} = 0, -3, -5, -7\,dB$
$(ACCP)_{FeMBMS}$=Attenuation Path Loss (APL)	$E\left\{\lvert H_{FeMBMS}\rvert^2\right\} = 0\,dB$
Sub carriers separation $\triangle f$	$0.97\,KHz$
Channel model/fading	Rayleigh small scale frequency selective fading
Recipient	General Multi-carrier + SIC
Gain amplitude (g) for LDM	between 0 and 1
Number of sub carriers per RBs: K_m	512

A. BER AND SUM RATE

Figure 4, shows the BER performance of QPSK-BPSK/QPSK modulation schemes for LDM and FeMBMS are considered with the hybrid proposed framework against the $Eb/N0$ (dB). When $Eb/N0$ (dB) is increased, the FeMBMS BER performance improves than the LDM and the proposed hybrid framework considerably. It is obvious that The simulation, and theory for LDM-LL, LDM-UL, FeMBMS layers, and the overall system are matched exactly.

As illustrated in Figure 5. Although we use SIC for LDM users, residual interference causes BER performance degradation. As can be seen from the proposed method, there is a curve between both technologies, and the efficiency is better than LDM, and also for FeMBMS. The strongest user LDM-LL has a minimum BER versus a strong user as FeMBMS and the weakest user. The weakest user LDM-UL has a maximum BER versus both users. simulation shows performance BER against transmission power.

Figure 6 depicts the results for the overall system as well as various numbers of FeMBMS RBs allocations. In this simulation, the number of engaged RBs is $M = 16$ for

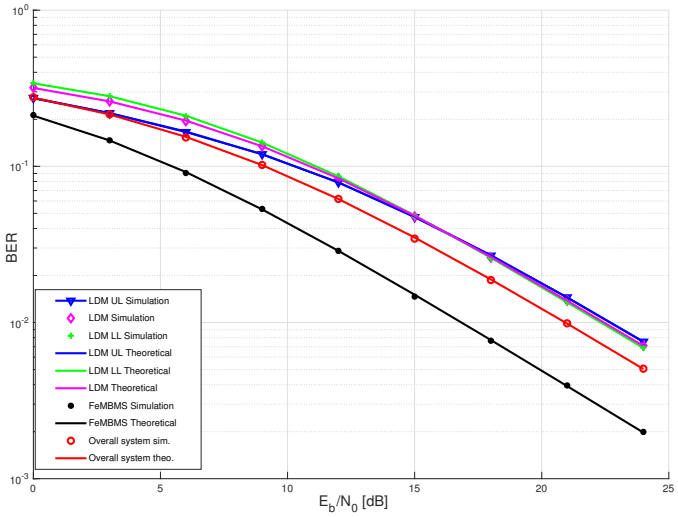

FIGURE 4. Multi-user BER proficiency LDM/FeMBMS hybrid layers for QPSK-BPSK Modulation versus E_b/N_0.

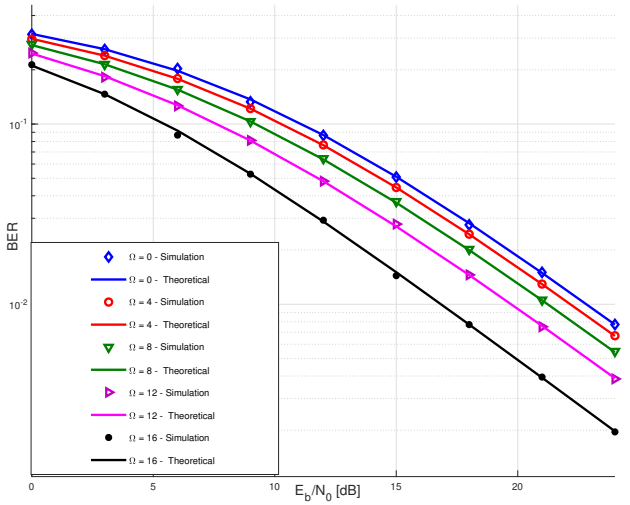

FIGURE 6. BER proficiency of offering service against E_b/N_0 with different number of FeMBMS RBs .

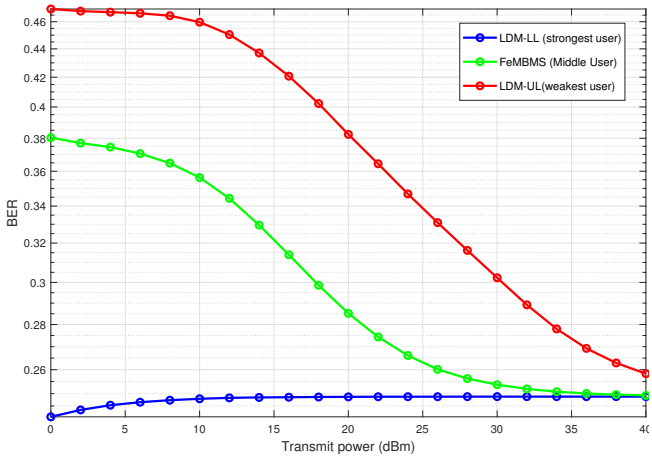

FIGURE 5. Multi-user BER proficiency of offering service compared with LDM-NOMA separately versus power transmission $dB(m)$.

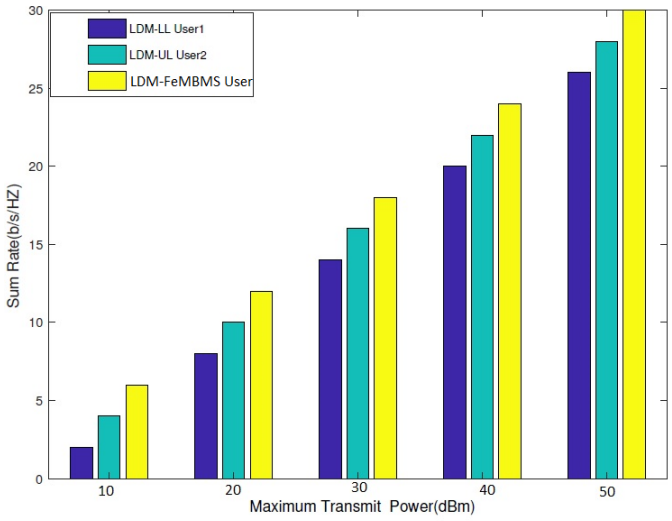

FIGURE 7. Multi-user Sum rate versus maximum transmit power $dB(m)$.

every scenario, but the number of FeMBMS RBs, Ω, is continuously derived $\{0, 4, 8, 12, 16\}$. Thus, the number of LDM RBs, Ψ , is obtained as $\{16, 12, 8, 4, 0\}$. It is evident that when the number of FeMBMS RBs, Ω increases, the proposed hybrid system improves BER performance. However, a decrease in the number of LDM RBs, Ψ, outperforms the BER performance of the proposed hybrid framework.

Figure 7, shows the sum rate bar-graph for three users by distance from BS versus power transmission.The LDM-LL has a smallest sum rate. By increasing transmit power up to 30(dbm), the FeMBMS achievable sum rate in the simulated system based on the proposed algorithm is improved remarkably. The reason that the proposed scheme has a better outcome on improving the LDM-UL achievable sum rate is that it has a high level of Maximum transmit power. So,the LDM-FeMBMS with the highest sum rate requirement in proposed algorithm flexibility for exploiting the use of the degree of freedom compared to the conventional user selection scheme.

B. OUTAGE AND COVERAGE PROBABILITY

Figure 8 indicates that the outage probability against sum rate. It is illustrated that LDM-LL has a more efficient sum rate. Hence, the two layers of LDM were accompanied by an increment in their efficiency in comparison with the FeMBMS single-layer mobile system.Therefore, it is concluded that the performance of LDM-LL outage probability is better than that of the LDM-UL outage probability system.

Figure 9 compares outage probability for LDM and FeMBMS and hybrid both versus the maximum transmitted power.This figure shows that the proposed scheme provides the median outage probability owing to the flexibility in the radio access technology selection. The LDM outage outperforms while the FeMBMS outage has increased since FeMBMS and LDM concurrently carry one user and two users

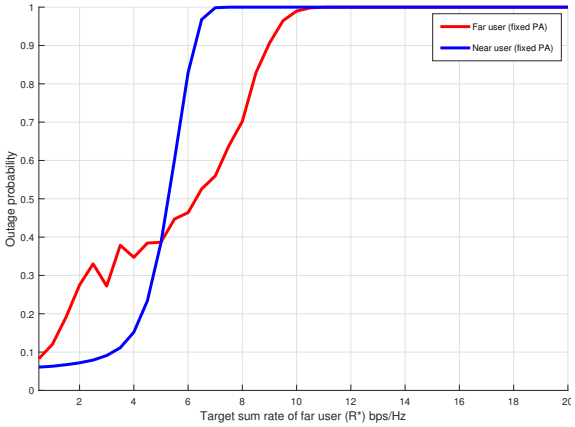

FIGURE 8. Achievable outage probability versus Sum rate $R_m ax$

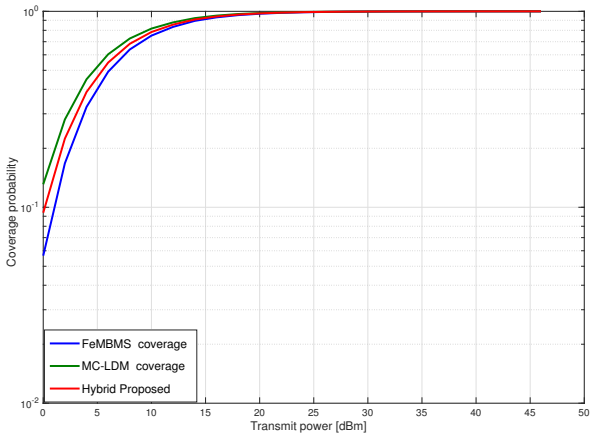

FIGURE 10. Achievable coverage probability for LDM/eMBMS as individually and hybrid proposed system versus $P_T max$

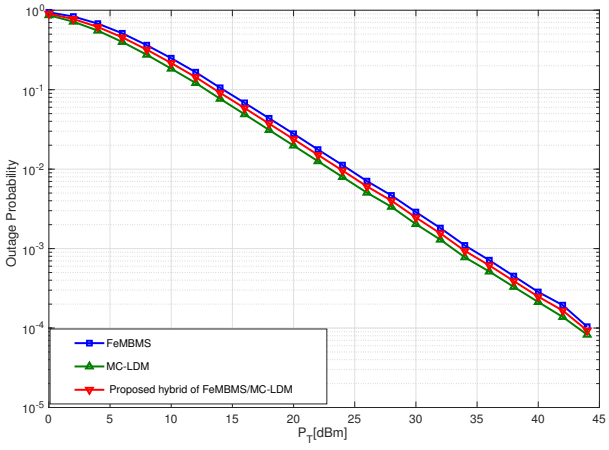

FIGURE 9. Outage probability for LDM/ FeMBMS as individually and hybrid proposed system versus $P_T max$

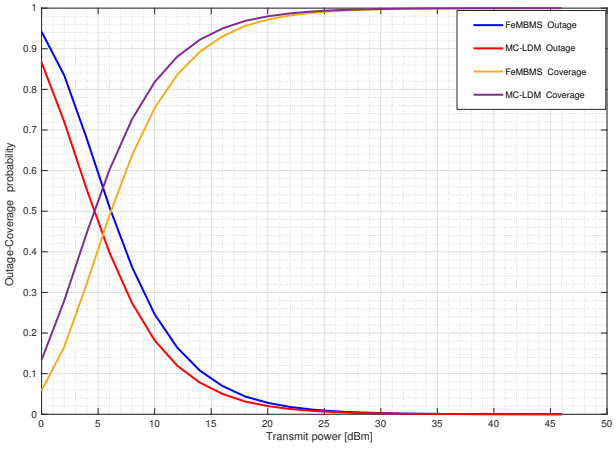

FIGURE 11. Outage-coverage probability for LDM/FeMBMS as individually versus $P_T max$

on the sub-carrier, respectively. Outage efficiency suggested combination service was demonstrated over the multi-path Rayleigh channel for multi-service, improving outage intermediate framework improves performance compared with the LDM and FeMBMS, individually. The proposed hybrid framework improved performance compared with FeMBMS and LDM, individually. Figure 10 illustrates Coverage probability for LDM/eMBMS as individually and hybrid proposed system versus PT max is illustrated , which shows LDM coverage performance is increased compared to the other FeMBMS and the hybrid proposed system.

Figure 11 compares the outage-coverage probability for LDM and FeMBMS versus total transmitted power which is LDM and FeMBMS coverage are inverse with outage probability. It is concluded that LDM coverage performance is better than the FeMBMS and also FeMBMS outage performance is better than the LDM technology.

Figure 12 demonstrates four sub-picture BER versus transmit power. Bar-graph strongest user versus power is reduced. Whereby the weakest user is approximately constant also for the strong user, whiles FeMBMS user as a middle user is reduced averagely. From sub-Fig. 12-c and 12-d, it is clear that the BER does not decrease much when the user moves away. While sub-Fig. 12-a and 12-b have a great effect on the performance and reduce the BER.

VIII. CONCLUSION

In this paper, we proposed a novel combination of LDM-NOMA and FeMBMS-OMA for broadcast multimedia services. The joint power and sub-carrier allocation problems for LDM-FeMBMS hybrid cooperative link systems were investigated. Therefore, power and sub-carrier allocation were jointly determined to maximize system performance. We defined a new utility function to optimize resource allocation depending on the sum rate and bit error rate (BER).This utility function can depict service selection between FeMBMS-OMA and LDM-NOMA using radio access technology with a binary factor. Accordingly, a framework that jointly maximizes the weighted sum rate and minimizes the total BER by the iterative resource allocation problem algorithm design for future 5G-Broadcast applications is considered. The proposed scheme provided the minimum required outage prob-

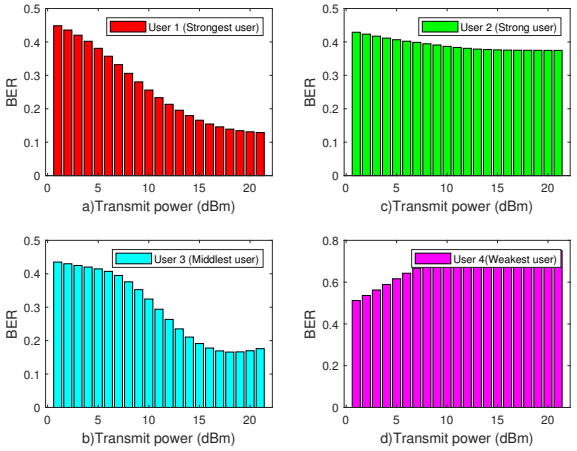

FIGURE 12. Achievable BER proficiency of offering service versus P_T power transmission .

ability rate for LL, UL, and ML users. To solve the power allocation, the BWA and resource allocation algorithms are localized. The simulation results show that the proposed hybrid method performs better than OMA and NOMA alone in terms of achievable aggregation rate and BER, outage, and coverage probability.

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