Global Journal of Computer Science and Technology: E
Network, Web & Security
Volume 17 Issue 3 Version 1.0 Year 2017
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

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GJCST-E Classification: C.2.1

PERFORMANCEANALYSISOFMULTIUSERDOWNLINKMIMONOMAWIRELESSCOMMUNICATIONSYSTEMONCOLORIMAGETRANSMISSION

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Md. Humaun Kabir α & Shaikh Enayet Ullah σ

Abstract- In this paper, a comprehensive study has been made to evaluate the performance of 2 × 2 multiantenna configured MIMO NOMA wireless communication system. The simulated system incorporates various types of signal processing techniques (Channel coding: LDPC & Convolutional, Digital modulation: QPSK, DQPSK & 4-QAM, Signal detection: ML decoding based QR channel decomposition aided SIC). On considering downlink transmission of encrypted color image of each of two users in a hostile fading channel, it is noticeable from MATLAB based simulation study that the system is very much robust and effective in retrieving transmitted color images under utilization of LDPC channel coding and 4-QAM digital modulation techniques. The performance of the simulated downlink MIMO NOMA wireless communication system has been evaluated in terms of bit error rate(BER) under scenario of various receive signal to noise ratio(SNR) ranging from 0dB to 16dB.

Keywords: NOMA, MIMO, ML decoding, QR channel factorization aided SIC, LDPC.

I. Introduction

With rapid technological advancement in both mobile and wireless communications, the number of users for affordable and powerful mobile computing devices (smartphones, iPhones, netbooks, and laptops) is increasing and leading an exponential increase in the amount of data traffic that the network operators need to accommodate within their networks. It is expected that by 2020 the global IP network will carry 6.4 EB of Internet traffic per day and 21 GB per capita. In perspective of coping with this explosion of broadband data traffic, the network operators will make use of various new solutions and technologies to be integrated for network capacity enhancement in the next generation/5G mobile networks. Some of the promising solutions include the deployment of heterogeneous small cell networks which enables dynamic cooperation between different radio access technologies, MIMO/Massive MIMO(using a large number of antennas, 100 or more)for simultaneous serving a number of users in the same time frequency resource; Cloud radio access networks (C-RAN) offering a centralized, cooperative, clean and cloud computing architecture; Software-defined networks (SDN) and network function virtualization (NFV) that assist the mobile operators to reduce their capital expenditure (CAPEX) intensity by transferring their hardware-based network to software- and cloud based solutions. In view of increasing the spectral efficiency of the next generation/ 5G networks and reduction of inter cell interference levels, another promising solution can accepted to use non-orthogonal multiple access (NOMA) technique[1] . In consideration of supporting higher throughput transmission in next generation (5G) networks, there is a growing interest among the mobile operators to exploit vast amounts of available frequency spectrum in the mmwave band (30-300 GHz).The Non-orthogonal multiple access (NOMA), millimeter wave (mmWave), and massive multiple-input-multiple-output (MIMO) have been emerging as key technologies for the fifth generation (5G) mobile communications [2, 3].

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II. Literature Review

It is known from literature reviewing that many researchers of academic institutions and industries have been working since 2014 on suitability of NOMA as 5G compatible radio interface technology based on power-domain user multiplexing scheme. In this paper, few works are described briefly.

In [4],Chenet. al. proved that NOMA combined with SU-MIMO techniques achieved system performance improvement. The impact of rank optimization on the performance of NOMA with SU-MIMO in downlink were studied and 23% for cell average throughput and 33% for cell-edge user throughput were achieved as compared to other orthogonal access system. In [5], Lan et. al. investigated the system-level throughput of NOMA with closed-loop single-user multiple-input multiple-output (SU-MIMO) in the cellular downlink and clarified the potential gains as compared to OMA. In [6] Liu et. al. studied the NOMA based downlink multi-user beamforming system, where the base station (BS) tried to transmit information to multiple user clusters and each beam served one user cluster compromising of two users simultaneously. User selection algorithm was proposed to reduce the interference and improved the system information rate. The user power schedule scheme to guarantee the advantage of the proposed NOMA downlink multi-user beam forming system was also proposed in such study. In [7] Shahab et. al. proposed a novel power allocation strategy that can optimize the system ergodic sum capacity while minimizing the mutual interference between the paired users. It was shown through simulations that the proposed scheme outperformed conventional power allocation in terms of bit error rates at the user ends with negligible effect on the system ergodic sum capacity. In [8],Liu and Wang made an investigation on efficient antenna selection and user scheduling algorithms to maximize the sum rate in two MIMO-NOMA scenarios. The authors showed that the proposed antenna selection algorithm achieved near-optimal performance and joint AU contribution algorithm achieved similar performance to existing methods with reduced complexity. In [9], Zhang et. al. made investigative study on the capacity performance of NOMA-mmWave-massive-MIMO systems in noise-dominated low-SNR regime and the interference-dominated high-SNR regime. In [10], Chen and Dai made investigation on designing MED precoders for 2 user 2 × 2 downlink MIMO NOMA system through combination of previously developed methodology of MED precoding under scenarios of unicast MIMO and multicast MIMO. In [11],Zeng et.al. made comparative study on the performance of non-orthogonal multiple access (NOMA) with conventional orthogonal multiple access (OMA) under multiple-input multiple-output (MIMO) channels. The authors showed that MIMO-NOMA dominated MIMO-OMA interms of both sum rate and ergodic sum rate.

III. Signal Processing

In our present study various signal processing schemes have been used. A brief overview of these schemes is given below:

a) Convolutional Channel Coding

In Convolutional channel coding, three parameters, n, k and m(n= number of output bits; k= number of input bits and m= number of memory registers)are used to specify Convolutional codes. The quantity k/n is called the code rate and it is a measure of the efficiency of the code. In this present study, ½ rated convolutional encoders have been used so that the decoding can be performed in some structured and simplified way based on Viterbi decoding algorithm. The constraint length, L= (k (m-1)) represents the number of bits in the encoder memory that affects the generation of then output bits. With consideration of a constraint length of 7and code generator polynomials of 171 and 133 in octal numbering system, the code generator polynomials G1 and G2 can be written as [12]

G1= x0+x2+ x3+x5+ x6=1 0 1 1 0 1 1 =133 (1)
G2= x0+x1+ x2+x3+ x6=1 1 1 1 0 0 1 =171

b) LDPC Channel Coding

In 1960, Robert Gallager invented Low density parity check (LDPC) codes. The LDPC code is a linear error correction code that has a parity check matrix H, which is sparse, i.e., with less nonzero elements in each row and column. In our considered, ½ -rated irregular LDPC code with random distribution of nonzero elements within the column of its parity check matrix [H]. The parity check matrix [H] has a dimension of 64 × 128 formed from a concatenation of two 64× 64 sized matrices [A] and [P]. The columns of the parity-check matrix [H] are rearranged to produce a new parity-check matrix, $\overleftrightarrow{\mathrm{H}}$. With rearranged matrix elements of $\overleftrightarrow{\mathrm{H}}$, the matrix [A] becomes non-singular and it is further processed to undergo LU decomposition. The parity bits sequence [p] is produced from a block based input binary data sequence [u] = $[u_1\ u_2\ u_3\ u_4 \ldots\ldots u_{64}]^T$and three matrices [P] (of [$\overleftrightarrow{\mathrm{H}}$]), [L] and [U] using the following MATLAB notation:

p = mod (U\ (L\ z), 2); where, **z** = mod (P*u, 2). (2)

The LDPC encoded 128× 1 sized block based binary data sequence [c] is formulated from concatenation of parity check bit **p** and information bit **u** as: [c] = [p; u]. The first 64 bits of the codeword matrix [c] are the parity bits and the last 64 bits are the information bits. In iterative Log Domain Sum-Product LDPC decoding algorithm, the transmitted bits are retrieved [13, 14].

c) Signal Detection Scheme for MIMO NOMA Systems

In this subsection, we have tried to provide comprehensive mathematical formulations for ML decoding based QR channel factorization aided SIC scheme implementation based on the works presented in [15]. We assume a layered transmission scenario with two user (UE_1 and UE_2) case for downlink 2x2 MIMO-NOMA system, where UE_1a cell-center user (near user) and UE_2 is a cell-edge user (far user).The base station is equipped with two transmitting antennas and each individual user is equipped with two receiving antennas. The transmitted signal $\boldsymbol{X}$ is formed from summing up of simultaneous transmission of two spatially multiplexed consecutive complex symbols of each user in one time slot and can be written as:

$$\boldsymbol{X} = (\boldsymbol{X}_1 + \boldsymbol{X}_2) = \left[\begin{pmatrix} X_{1,1} \\ X_{1,2} \end{pmatrix} + \begin{pmatrix} X_{2,1} \\ X_{2,2} \end{pmatrix}\right]$$

$$\Rightarrow \boldsymbol{X} = \sqrt{P_1}\boldsymbol{S}_1 + \sqrt{P_2}\boldsymbol{S}_2 = \left[\sqrt{P_1}\begin{pmatrix} S_{1,1} \\ S_{1,2} \end{pmatrix} + \sqrt{P_2}\begin{pmatrix} S_{2,1} \\ S_{2,2} \end{pmatrix}\right] \quad (3)$$

where, $\mathbf{S}_1$ and $\mathbf{S}_2$ are the transmitted signals of unitary power for UE_1 and UE_2 prior to power allocation, signal components $x_{1,1}$of $\mathrm{UE}_1$and $x_{2,1}$of UE_2 are transmitted from first transmitting antenna and $x_{1,2}$ of $\mathrm{UE}_1$and $x_{2,2}$ of UE_2 are transmitted from second transmitting antenna. Each of two components of both $\mathbf{S}_1$ and $\mathbf{S}_2$ are needed in power scaling.The 20% of the total power P($P_1 = 0.2$ P)remaining 80% of the total power P($P_2 = 0.8$ P)are allocated to user UE_1 and to user UE_2 respectively. With consideration of 2×2 sized matrices,$[\boldsymbol{H}_1]$ and $[\boldsymbol{H}_2]$ containing complex Rayleigh fading channel coefficients for users UE_1 and UE_2,the received signals at $\mathrm{UE}_1(= \mathbf{Y}_1)$ and $\mathrm{UE}_2(= \mathbf{Y}_2)$ are given by:

$$\mathbf{Y}_1 = \mathbf{H}_1(\mathbf{X}_1 + \mathbf{X}_2) + \mathbf{n}_1 \quad (4)$$

$$\mathbf{Y}_2 = \mathbf{H}_2(\mathbf{X}_1 + \mathbf{X}_2) + \mathbf{n}_2 \quad (5)$$

where $\boldsymbol{n}_1$ and $\mathbf{n}_2$are the additive white Gaussian noises (AWGN) estimated based on the typically assumed receive SNR values at receivers of user UE_1 and user UE_2respectively.

In case of estimating transmitted signals for user UE_1, equation(4) can be written in elaborate form as:

$$\boldsymbol{Y}_1 = \begin{bmatrix} Y_{11} \\ Y_{12} \end{bmatrix} = \begin{bmatrix} H_1(1,1) & H_1(1,2) \\ H_1(2,1) & H_1(2,2) \end{bmatrix} \left[\begin{pmatrix} X_{1,1} \\ X_{1,2} \end{pmatrix} + \begin{pmatrix} X_{2,1} \\ X_{2,2} \end{pmatrix} \right] + \begin{bmatrix} n_{1,1} \\ n_{1,2} \end{bmatrix} \quad (6)$$

The signal received at first layer of user UE_1 is given by

$$Y_{11} = H_1(1,1)(X_{1,1} + X_{2,1}) + H_1(1,2)(X_{1,2} + X_{2,2}) + n_{1,1} \quad (7)$$

The signal received at second layer of userUE_1 is given by

$$Y_{12} = H_1(2,1)(X_{1,1} + X_{2,1}) + H_1(2,2)(X_{1,2} + X_{2,2}) + n_{1,2} \quad (8)$$

On performing QR matrix decomposition of $\mathbf{H}_1$as:

$$\mathbf{H}_1 = \mathbf{Q}_1\mathbf{R}_1 \quad (9)$$

where,$\mathbf{Q}_1$is a 2 × 2 unitary matrix and $\mathbf{R}_1$is an 2 × 2 upper triangular matrix and multiplying both sides of equation(6) with complex conjugate transformed of $\mathbf{Q}_1$, we get: .

$$\boldsymbol{Z}_1 = \boldsymbol{Q}_1^H\boldsymbol{Y}_1 = \boldsymbol{R}_1(\boldsymbol{X}_1 + \boldsymbol{X}_2) + \boldsymbol{n}_1$$

$$= \begin{bmatrix} R_1(1,1) & R_1(1,2) \\ 0 & R_1(2,2) \end{bmatrix} \left[\begin{pmatrix} X_{1,1} \\ X_{1,2} \end{pmatrix} + \begin{pmatrix} X_{2,1} \\ X_{2,2} \end{pmatrix} \right] + \begin{bmatrix} n_{1,1} \\ n_{1,2} \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} Z_{1,1} \\ Z_{1,2} \end{bmatrix} = \begin{bmatrix} R_1(1,1) & R_1(1,2) \\ 0 & R_1(2,2) \end{bmatrix} \left[\begin{pmatrix} X_{1,1} \\ X_{1,2} \end{pmatrix} + \begin{pmatrix} X_{2,1} \\ X_{2,2} \end{pmatrix} \right] + \begin{bmatrix} n_{1,1} \\ n_{1,2} \end{bmatrix} \quad (10)$$

From equation (10), the components of $\boldsymbol{Z}_1(Z_{1,1}$and $Z_{1,2})$ can be written as:

$$Z_{1,1} = R_1(1,1)(X_{1,1} + X_{2,1}) + R_1(1,2)\,(X_{1,2} + X_{2,2}) + n_{1,1} \quad (11)$$

$$Z_{1,2} = R_1(2,2)(X_{1,2} + X_{2,2}) + n_{1,2} \quad (12)$$

Neglecting contribution from noise in equation (12) and the estimated transmitted symbols for both users can be written as

$$(X_{1,2} + X_{2,2}) = \frac{Z_{1,2}}{R_1(2,2)} \quad (13)$$

Substituting the value of $(X_{1,2} + X_{2,2})$from equation (13) in equation (11) and neglecting the noise component, we can write

$$Z_{1,1} = R_1(1,1)(X_{1,1} + X_{2,1}) + R_1(1,2)\frac{Z_{1,2}}{R_1(2,2)} \quad (14)$$

$$(X_{1,1} + X_{2,1}) = \frac{Z_{1,1}}{R_1(1,1)} - \frac{R_1(1,2)}{R_1(1,1)}\frac{Z_{1,2}}{R_1(2,2)} \quad (15)$$

The right hand term of equation (15) is known and this equation can be written in modified form as

$$\hat{Z}_{1,1} = \frac{Z_{1,1}}{R_1(1,1)} - \frac{R_1(1,2)}{R_1(1,1)}\frac{Z_{1,2}}{R_1(2,2)}$$

$$= (X_{1,1} + X_{2,1}) = \sqrt{P_1}\boldsymbol{S}_{1,1} + \sqrt{P_2}\boldsymbol{S}_{2,1} \quad (16)$$

Dividing equation (16) by $\sqrt{P_1}$, we get

$$\hat{\hat{Z}}_{1,1} = \boldsymbol{S}_{1,1} + \sqrt{\frac{P_2}{P_1}}\boldsymbol{S}_{2,1} = \boldsymbol{S}_{1,1} + 2.0\,\mathbf{S}_{2,1} \quad (17)$$

As the modulated symbols are normalized in such that each complex symbols has unitary power. The normalized QAM modulated signal vector is denoted by $\underline{\mathbf{S}}$. Then the transmitted symbol from first transmitting antenna considered as interference component for UE_1can be estimated using ML decoding based QR channel decomposition aided SIC scheme as

$$\widehat{\boldsymbol{S}}_{2,1} = \arg\min \left\| \hat{\hat{Z}}_{1,1} - 2.0\,\widehat{\boldsymbol{S}} \right\|^2 \quad (18)$$

where, $\widehat{\boldsymbol{S}} \epsilon \underline{\boldsymbol{S}}$ and $\|.\|^2$ is indicative of Frobenius norm of matrix. Equation(13) can be written in modified form as:

$$\frac{Z_{1,2}}{R_1(2,2)} = \sqrt{P_1}\boldsymbol{S}_{1,2} + \sqrt{P_2}\boldsymbol{S}_{2,2} \quad (19)$$

Dividing equation (19)by $\sqrt{P_1}$, we get

$$\frac{Z_{1,2}}{\sqrt{P_1}\,R_1(2,2)} = \boldsymbol{S}_{1,2} + \sqrt{\frac{P_2}{P_1}}\boldsymbol{S}_{2,2}$$

$$\hat{Z}_{1,2} = \frac{Z_{1,2}}{\sqrt{P_1}\,R_1(2,2)} = \boldsymbol{S}_{1,2} + 2.0\,\boldsymbol{S}_{2,2} \quad (20)$$

The transmitted symbol from second transmitting antenna for considered as interference component for UE_1can be estimated using ML decoding based QR channel decomposition aided SICscheme as

$$\widehat{\boldsymbol{S}}_{2,2} = \arg\min \left\| \hat{Z}_{1,2} - 2.0\,\widehat{\boldsymbol{S}} \right\|^2 \quad (21)$$

where $\widehat{\boldsymbol{S}} \epsilon \underline{\boldsymbol{S}}$ and $\|.\|^2$ have already been specified.

Substituting the value of $\widehat{\boldsymbol{S}}_{2,2}$ in equation (20), the transmitted symbol from second transmitting antenna for user UE_1as desired signal component can be estimated as:

$$\widehat{\boldsymbol{S}}_{1,2} = \hat{Z}_{1,2} - 2.0\,\widehat{\boldsymbol{S}}_{2,2} \quad (22)$$

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Substituting the value of $\widehat{\boldsymbol{S}}_{2,1}$ from equation (18) in equation (17),the transmitted symbol from first transmitting antenna for user UE_1as desired signal component can be estimated as:

$$\widehat{\boldsymbol{S}}_{1,1}=\hat{\hat{Z}}_{1,1}-2.0\,\widehat{\boldsymbol{S}}_{2,1} \tag{23}$$

In case of estimating transmitted signals for userUE_2, equation(5) can be written in elaborate form as:

$$\boldsymbol{Y}_2=\begin{bmatrix}Y_{21}\\Y_{22}\end{bmatrix}=\begin{bmatrix}H_2(1,1) & H_2(1,2)\\H_2(2,1) & H_2(2,2)\end{bmatrix}\left[\begin{pmatrix}X_{1,1}\\X_{1,2}\end{pmatrix}+\begin{pmatrix}X_{2,1}\\X_{2,2}\end{pmatrix}\right]+\begin{bmatrix}n_{2,1}\\n_{2,2}\end{bmatrix} \tag{24}$$

The signal received at first layer of user UE_2 is given by

$$Y_{21}=H_2(1,1)(X_{1,1}+X_{2,1})+H_2(1,2)(X_{1,2}+X_{2,2})+n_{2,1} \tag{25}$$

The signal received at second layer of user UE_2 is given by

$$Y_{22}=H_2(2,1)(X_{1,1}+X_{2,1})+H_2(2,2)(X_{1,2}+X_{2,2})+n_{2,2} \tag{26}$$

On performing QR matrix decomposition of $\mathbf{H}_2$as:

$$\mathbf{H}_2=\mathbf{Q}_2\mathbf{R}_2 \tag{27}$$

where,$\mathbf{Q}_2$isa 2×2 unitary matrix and $\mathbf{R}_2$is an 2×2 upper triangular matrix and multiplying both sides of equation (24) with complex conjugate transformed of $\mathbf{Q}_2$, we get: .

$$\boldsymbol{Z}_2=\boldsymbol{Q}_2^H\boldsymbol{Y}_2=\boldsymbol{R}_2(\boldsymbol{X}_1+\boldsymbol{X}_2)+\boldsymbol{n}_2$$

$$=\begin{bmatrix}R_2(1,1) & R_2(1,2)\\0 & R_2(2,2)\end{bmatrix}\left[\begin{pmatrix}X_{1,1}\\X_{1,2}\end{pmatrix}+\begin{pmatrix}X_{2,1}\\X_{2,2}\end{pmatrix}\right]+\begin{bmatrix}n_{2,1}\\n_{2,,2}\end{bmatrix}$$

$$\Rightarrow\begin{bmatrix}Z_{2,1}\\Z_{2,2}\end{bmatrix}=\begin{bmatrix}R_2(1,1) & R_2(1,2)\\0 & R_2(2,2)\end{bmatrix}\left[\begin{pmatrix}X_{1,1}\\X_{1,2}\end{pmatrix}+\begin{pmatrix}X_{2,1}\\X_{2,2}\end{pmatrix}\right]+\begin{bmatrix}n_{2,1}\\n_{2,2}\end{bmatrix} \tag{28}$$

From equation (28), the components of $\boldsymbol{Z}_2(Z_{2,1}$and $Z_{2,2})$ can be written as:

$$Z_{2,1}=R_2(1,1)(X_{1,1}+X_{2,1})+R_2(1,2)\,(X_{1,2}+X_{2,2})+n_{2,1} \tag{29}$$

$$Z_{2,2}=R_2(2,2)(X_{1,2}+X_{2,2})+n_{2,2} \tag{30}$$

Neglecting contribution from noise in equation (30) and the estimated transmitted symbols for both users can be written as

$$(X_{1,2}+X_{2,2})=\frac{Z_{2,2}}{R_2(2,2)} \tag{31}$$

Substituting the value of $(X_{1,2}+X_{2,2})$from equation (31) in equation (29) and neglecting the noise component, we can write

$$Z_{2,1}=R_2(1,1)(X_{1,1}+X_{2,1})+R_2(1,2)\frac{Z_{2,2}}{R_2(2,2)} \tag{32}$$

$$(X_{1,1}+X_{2,1})=\frac{Z_{2,1}}{R_2(1,1)}-\frac{R_2(1,2)}{R_2(1,1)}\frac{Z_{2,2}}{R_2(2,2)} \tag{33}$$

The right hand term of equation (33) is known and this equation can be written in modified form as

$$\hat{Z}_{2,1}=\frac{Z_{2,1}}{R_2(1,1)}-\frac{R_2(1,2)}{R_2(1,1)}\frac{Z_{2,2}}{R_2(2,2)}$$

$$=(X_{1,1}+X_{2,1})=\sqrt{P_1}\boldsymbol{S}_{1,1}+\sqrt{P_2}\boldsymbol{S}_{2,1} \tag{34}$$

Dividing equation (34)by $\sqrt{P_2}$, we get

$$\hat{\hat{Z}}_{2,1}=\sqrt{\frac{P_1}{P_2}}S_{1,1}+S_{2,1}=0.5\,S_{1,1}+S_{2,1} \tag{35}$$

Then the transmitted symbol from first transmitting antenna considered as interference component for UE_2 can be estimated using ML decoding based QR channel decomposition aided SICscheme as

$$\widehat{\boldsymbol{S}}_{1,1}=\arg\min\left\|\hat{\hat{Z}}_{2,1}-0.5\,\widehat{\boldsymbol{S}}\right\|^2 \tag{36}$$

where,$\widehat{\boldsymbol{S}}\,\epsilon\,\underline{\boldsymbol{S}}$ and equation(31) can be written in modified form as:

$$\frac{Z_{2,2}}{R_2(2,2)}=\sqrt{P_1}S_{1,2}+\sqrt{P_2}S_{2,2} \tag{37}$$

Dividing equation (37)by $\sqrt{P_2}$, we get

$$\hat{Z}_{2,2}=\frac{Z_{2,2}}{\sqrt{P\ R}\ (2,2)}=0.5\,S_{1,2}+S_{2,2} \tag{38}$$

The transmitted symbol from second transmitting antenna considered as interference component for UE_2can be estimated using ML decoding based QR channel decomposition aided SIC scheme as

$$\hat{S}_{1,2}=\arg\min\left\|\hat{Z}_{2,2}-0.5\,\hat{S}\right\|^2 \tag{39}$$

where, $\widehat{\boldsymbol{S}}\,\epsilon\,\underline{\boldsymbol{S}}$ and substituting the value of$\widehat{S}_{1,2}$ from equation (39) in equation (38), the transmitted symbol from second transmitting antenna for user UE_2 as desired signal component can be estimated as:

$$\hat{S}_{2,2}=\hat{Z}_{2,2}-0.5\,\hat{S}_{1,2} \tag{40}$$

The transmitted symbol from first transmitting antenna for user UE_2 as desired signal component can be estimated from equation (35) as:

$$\hat{S}_{2,1}=\hat{\hat{Z}}_{2,1}-0.5\,\hat{S}_{1,1} \tag{41}$$

d) 2D Median Filtering

2D median filtering is widely used as an effective technique for removing various types of noises (salt and pepper and Gaussian) from noise contaminated image. In such filtering operation, the pixel values in the neighborhood window are generally ranked according to intensity and the middle value (the median) becomes the output value for the pixel under evaluation. In this paper, 2D Median Filtering scheme with a 3×3 neighborhood windowing mask is preferably used to make sorting of all the pixel values within the window and finding the median value and replacing the original pixel value with the median value [16].

e) Data Scrambling

Cryptography is probably the most important aspect of communications security and is becoming increasingly important as a basic building block for computer security. The binary converted data from color image of each of two users are grouped individually with each group containing 1 byte (8 bits) binary data. Each grouped binary data as plain text are encrypted with identical secret key of bit length 8 through performing XOR operation to produce encrypted/scrambled binary data[17].

IV. System Model

The simulated multiuser downlink MIMO NOMA wireless communication system is depicted in Figure 1.In such system, we assume that two users are expecting to receive two different RGB color images of identical size (height: 96 pixels and width: 96 pixels).The color images are converted into their respective three Red, Green and Blue components with each component is of 96 × 96 pixels in size. The pixel integer values are converted into 8 bits binary form and encrypted(scrambled). The scrambled binary data are channel encoded using Convolutional and LDPC scheme, interleaved and subsequently converted into digitally modulated complex signals using QPSK, DQPSK and 4-QAM [18]. The digitally modulated symbols are allocated assigned power and fed into spatial multiplexing encoder section and transmitted from each of two transmitting antennas. In receiving section of each user, signal is detected and contaminated with AWGN noise. The noise contaminated signals are processed layer wise and interference terms are cancelled out to retrieve proper signals using ML decoding based QR channel decomposition aided SIC scheme. The detected signals are fed into spatial multiplexing decoder. The decoded signals are, digitally demodulated, deinterleaved and channel decoded. The channel decoded binary data are descrambled and converted into pixel integers and filtered to recover the transmitted color images.

V. Results and Discussion

In this section, we have presented simulation results using MATLAB R2014a to illustrate the significant impact of various types of channel coding and digital modulation techniques on system performance evaluation of multiuser downlink MIMO NOMAwireless communication in terms of bit error rate (BER). It is assumed that the channel state information (CSI) of fading channel is available at the receiver with unchanged fading process throughout the whole work. The model parameters considered in our study are presented in Table 1.

Table1: Summary of the simulated model parameters

Parameters	Types
Data type	Color Image
Image Size (Both Users)	(96 x 96 x 3) Pixels
No. of user	2
Antenna configuration	2 x 2 MIMO Channel
Channel coding	½-rated Convolutional & LDPC
Digital modulation	QPSK, DQPSK and 4-QAM
Signal detection technique	ML decoding based QR channel factorization aided SIC scheme
SNR	0 to16 dB
Channel	AWGN and Rayleigh
Noise Type	Gaussian
Noise reduction image filter	2D-Median filter

The BER values of our simulated system in case of user$\#1(\mathrm{UE}_1)$ and user$\#2(\mathrm{UE}_2)$ under implementation of LDPC and convolutional channel coding schemes with QPSK digital modulation are presented in figure 2. It is noticeable in figure 2 that the estimated BER values for both users are approximately remain unchanged for convolutional channel coding but in case of LDPC channel coding BER values decrease slowly with increase in signal to noise ratio (SNR) values(0 dB to 16 dB). For user #1 and under consideration of typically assumed SNR value of 6 dB, the estimated BER values are 0.4981 and 0.4234 in case of convolutional and LDPC channel coding with QPSK digital modulation which implies a system performance improvement of 0.71 dB. In case of user #2 for identical SNR value, the estimated BER values are 0.4992 and 0.3882 which is indicative of system performance improvement of 1.09 dB. The estimated system performance for user #2 is better than the user #1 as comparatively more power(four times greater than user #1) was assigned to user #2.

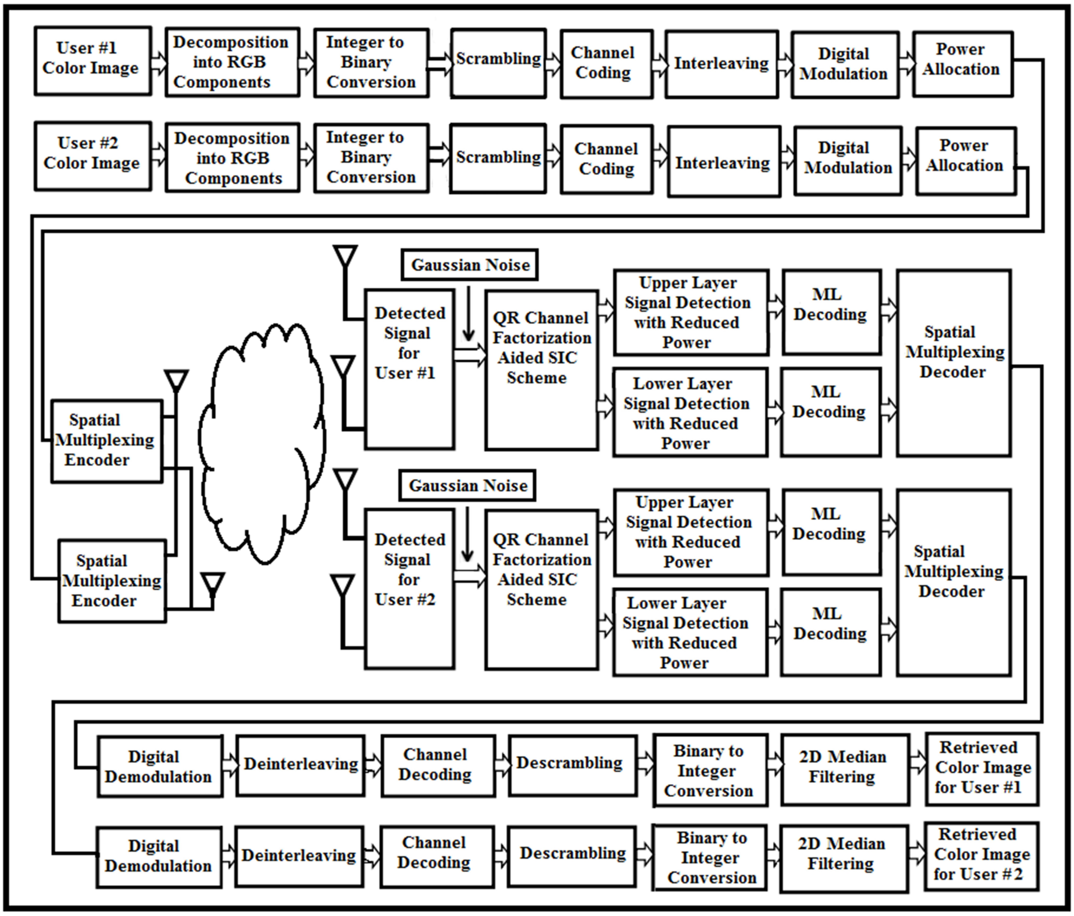

Fig.1: Block diagram of MIMO NOMA Wireless Communication System

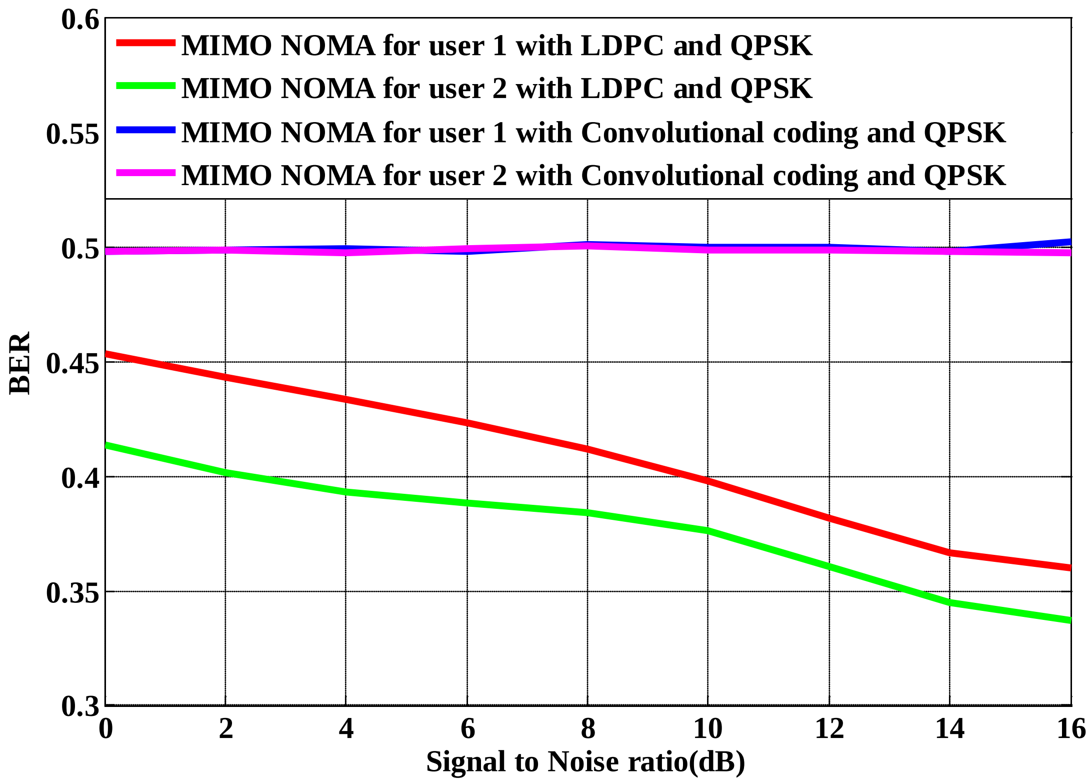

Fig. 2: BER performance of Convolutional and LDPC channel encoded MIMO NOMA wireless communication system with QPSK digital modulation scheme for image transmission

It is seen from figure 3 that the estimated BER values for both users are almost constant in convolutional channel coding. In case of LDPC channel coding, BER values decrease in higher SNR value region. Under assumption of SNR value of 10 dB in case of user#1, the estimated BER values are 0.5006 and 0.4151 in convolutional and LDPC channel coding schemes with DQPSK digital modulation which implies a system performance improvement of 0.81 dB. In case of user #2 for identical SNR value, the estimated BER values are 0.5023 and 0.4002 which is indicative of system performance improvement of 0.99 dB. For a 40%BER, a SNR improvement of around 1.8 dB is achieved in case of user #2 in comparison to user #1.

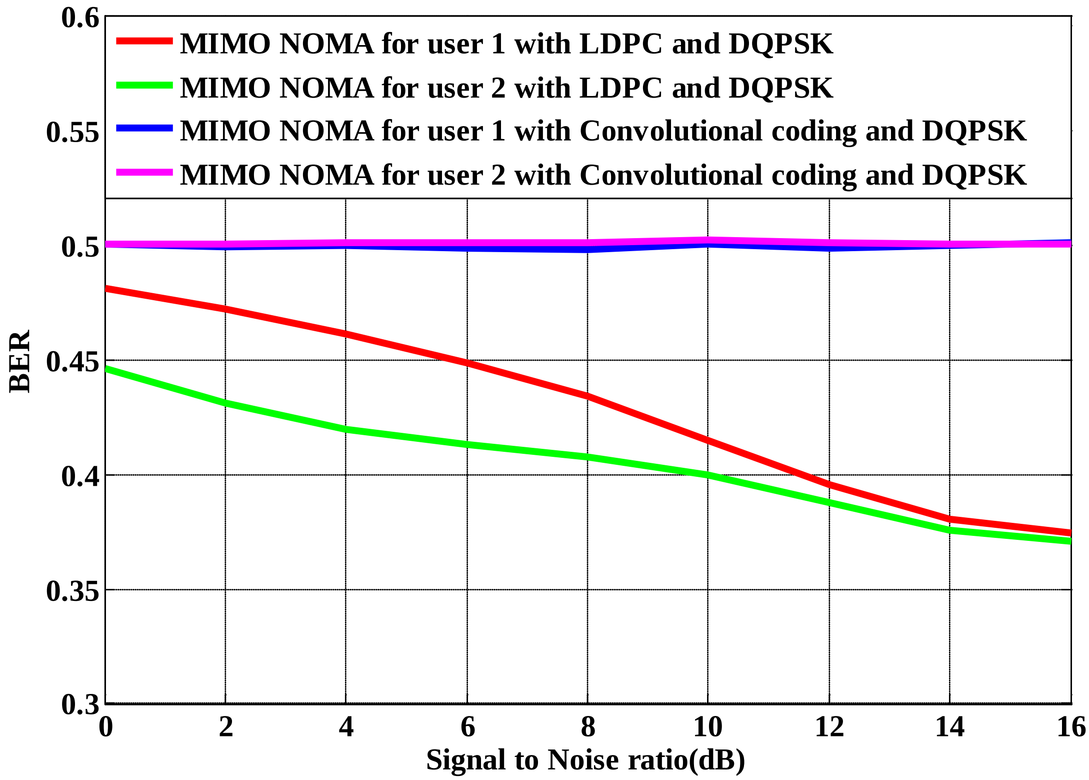

Fig. 3: BER performance of Convolutional and LDPC channel encoded MIMO NOMA wireless communication system with DQPSK digital modulation scheme for image transmission

The performance of the simulated MIMO NOMA wireless communication system in terms of estimated bit error rate (BER) in case of user #1 and user #2 under implementation of LDPC and convolutional channel coding schemes with 4-QAM digital modulation are illustrated graphically in figure 4. It is quite observable from figure 4 that the estimated BER values for both users are reasonably acceptable in both convolutional and LDPC channel coding schemes. For a typically assumed SNR value of 2 dB in case of user #1, the estimated BER values are 0.5012 and 0.3579 with the implementation of convolutional and LDPC channel coding schemes which implies a system performance improvement of 1.46 dB. In case of user #2 for identical SNR value, the estimated BER values are 0.3591 and 0.2020 which is indicative of system performance improvement of 2.50 dB. For a 20% BER, a SNR improvement of around 6 dB is achieved in case of LDPC channel coding and 4-QAM digital modulation for user #2 in comparison to user #1. At such 20% BER, a SNR improvement of around 7 dB is achieved in case of convolutional channel coding and 4-QAM digital modulation for user #2 in comparison to user #1. The transmitted and retrieved images for user #1 with white background and for user#2 with blue background under implementation of LDPC channel coding with4-QAM digital modulation at 10 dB SNR value are presented in figure 5 and figure 6 respectively. Undoubtedly, in both cases, system performance is quite satisfactory

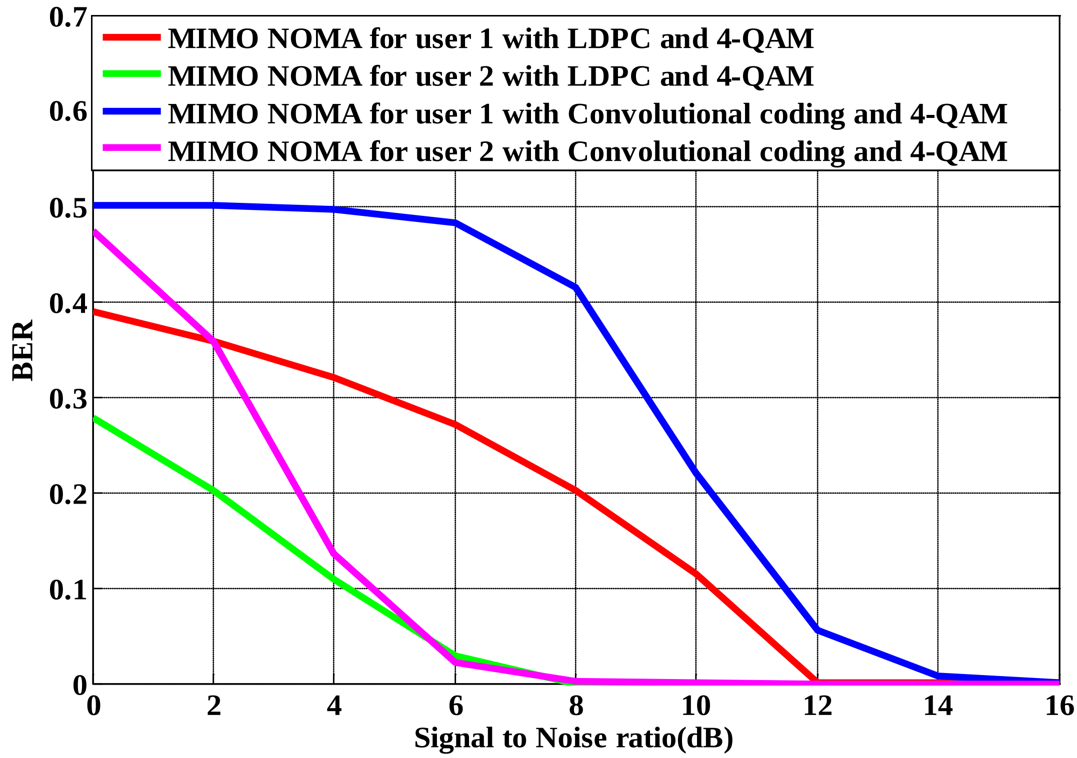

Fig. 4: BER performance of Convolutional and LDPC channel encoded MIMO NOMAWireless communication system with 4-QAM digital modulation scheme.

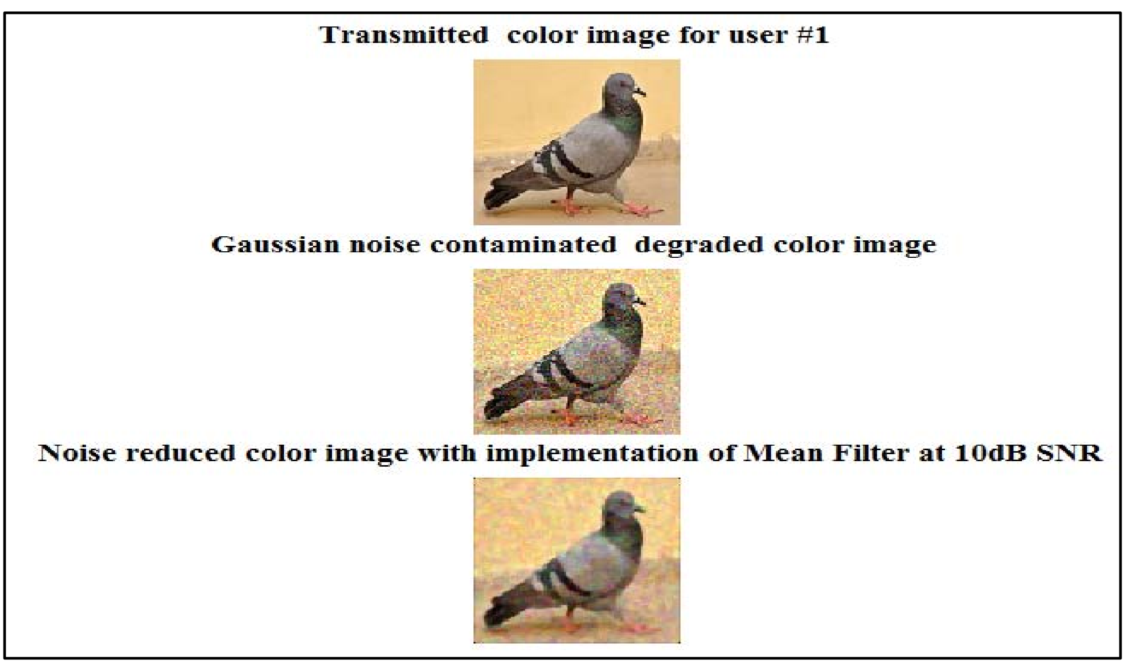

Fig. 5: Transmitted and retrieved image for user #1 of MIMO NOMA wireless communication system under implementation of LDPC channel coding with 4-QAM digital modulation at SNR value of 10 dB

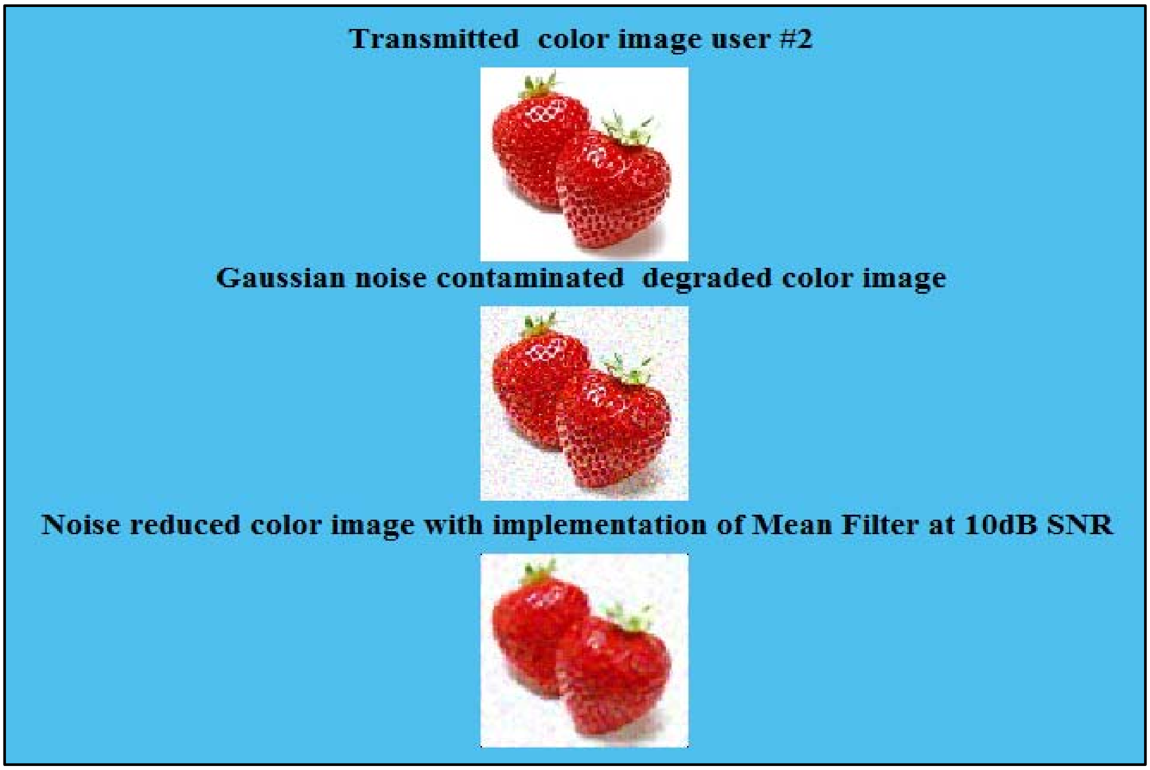

Fig. 6: Transmitted and retrieved image for user #2 of MIMO NOMA wireless communication system under implementation of LDPC channel coding with4-QAM digital modulation at SNR value of 10 dB

VI. Conclusion

In this present paper, we have made a comprehensive study on performance analysis of 5G compatible power domain user multiplexing scheme based downlink multiuser MIMO NOMA wireless communication system. Various low order digital modulation and channel coding schemes have been utilized to evaluate the system performance. On the basis of simulation results, it can beconcluded that the downlink multiuser MIMO NOMA wireless communication system is undoubtedly a robust system in perspective of signal transmission in hostile fading channel under the utilization of 4-QAM digital modulation and LDPC channel coding scheme.

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