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Performance Evaluation of Encrypted Text Message Transmission in 5G Compatible Frequency-domain Subband Superposed Scheme Implemented MIMO OFDM Wireless Communication System

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GJCST-E Classification: C.2.1

PERFORMANCEEVALUATIONOFENCRYPTEDTEXTMESSAGETRANSMISSIONIN5GCOMPATIBLEFREQUENCY-DOMAINSUBBANDSUPERPOSEDSCHEMEIMPLEMENTEDMIMOOFDMWIRELESSCOMMUNICATIONSYSTEM

Strictly as per the compliance and regulations of:

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I. Introduction

In scenario of high out-of-band emission (OOBE) with relatively low spectrum efficiency and little flexibility, Orthogonal frequency division multiplexing (OFDM) cannot meet up the diverse layouts of the future fifth generation (5G) networks.

In 2017, Wang and et al., proposed a non-uniform subband superposed OFDM (NSS-OFDM) scheme based on a variable granularity (VG) spectrum allocation technique with the utilization of a multistage poly-phase sub-filtering architecture.

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In their works, the authors demanded significant reduction of OOBE with enhanced spectral efficiency in terms of spectrum utilization rate and minimization of the frequency guard intervals between subbands[1]. At[2], the authors made a comprehensive study on significant performance degradation of the traditional OFDM system in high-speed mobile scenarios. They proposed a subband superposed oversampled OFDM (SS-OOFDM) scheme for accommodating the diverse synopsis with the inclusion of the scenarios with high mobility and development of the time-domain channel estimation method to track the fast-varying mobile channel. In their work, a subband decision feedback and feed forward equalizer for exploiting the Doppler and multipath diversity gains was designed, and the simulation results showed that the SS-OOFDM, especially in high-speed mobile channels outperformed the traditional OFDM receiver in terms of the bit-error-rate (BER) performance.

The enhanced multicarrier transmission scheme implemented subband superposed OFDM(SS-OFDM) system achieves narrower guard bands and flexible subband division through subband partitioning and filtering. Allowing for the multiple accesses, the superposition schemes of the signal from the users sharing the transmission channel in both frequency and time domains are considered at[3].

In our study, we have considered Frequency-domain subband superposed scheme aided the OFDM system to study its system performance on encrypted text message transmission.

II. Review of Signal Processing Techniques

In this sub-section, various channel coding and signal detection techniques are implemented. A brief observation of each technique has been outlined below:

a) LDPC Channel Coding

In 1962, Gallager invented low-density parity-check (LDPC) code. Such LDPC code is a linear block code and its generated parity-check matrix H_o contains only a little 1's with the comparison of 0's (i.e., sparse matrix). The LDPC codes have been graphically represented by the bilateral Tanner graph, and their nodes have been grouped into first set of n bit nodes (or variable nodes) and another set of m check nodes (or parity nodes). Check node i has been connected to bit node j in case of any elemental value of unity in the parity matrix. The decoding is operated alternatively on the bit nodes and the check nodes to find the most similar codeword c which is satisfy the condition $cH_o^T=0$. In the iterative Log Domain Sum-Product LDPC decoding under the consideration of AWGN noise channel of variance σ^2 and the received signal vector r, LLR (log-likelihood ratios) instead of probability have been defined as:

$$L(c_i) \triangleq \ln[P(c_i=0|r_i)/P(c_i=1|r_i)]$$
$$L(P_{ij}) \triangleq \ln[P_{ij}^{\,0}/P_{ij}^{\,1}] \tag{1}$$
$$L(Q_{ij}) \triangleq \ln[Q_{ij}^{\,0}/Q_{ij}^{\,1}] \quad L(P_j) \triangleq \ln[Pj^0/Pj^1]$$

Where in equation(1), (ln) illustrates the natural logarithm operation. The bit node j is initially set with an edge to check node i:

$$L(P_{ij}) = L(c_i) = 2r_i/\sigma^2 \tag{2}$$

In message passing from the check nodes to the bit nodes for each check node i with an edge to bit node j; L(Q ij) has been updated as:

$$L(Qij) = \prod_{j'} \alpha_{ij'} \phi[\sum_{j'} \phi(\beta_{ij'})] \quad (j'=1,2...............n \text{ and } j' \neq j) \tag{3}$$
$$\text{where, } \alpha_{ij} \triangleq \text{sign}[L(P_{ij})] \text{ and } \beta_{ij} \triangleq [L(P_{ij})].$$

The ϕ function has been defined as:

$$\phi(x) = -\ln[\tanh(x/2)] = \ln[(e^x+1)/(e^x-1)] \tag{4}$$

From bit nodes to check nodes for each bit node j with an edge to check node i; L(Pj) has been updated as:

$$L(Pij) = L(c_i) + \sum_{i'} L(Qij) \quad (i'=1,2...............m \text{ and } i' \neq i) \tag{5}$$

Decoding and soft outputs: for j=1,2,3…,n; L(Pj) is updated as:

$$L(Pj) = L(c_i) + \sum_i L(Pij) \qquad (i=1,2.........m) \tag{6}$$

$$c_i = \begin{cases} 1 \text{ if } L(P_j) < 0 \\ 0 \quad \text{else} \end{cases} \tag{7}$$

If $cH_o^T=0$ or the number of iterations reaches the maximum limit [4]

b) Repeat and Accumulate (RA) Channel Coding

The RA is a mighty advance error-correcting channel coding scheme. In this type of channel coding scheme, all the extracted binary bits from the text message are arranged into a one block and the binary bits of such block has been repeated 2 times and reorganized into a single block with contains binary data which is double of the number of input binary data [5].

c) Cholesky Decomposition based ZF Signal detection(CDSD)

In $N_R \times N_T$ MIMO system, the signal model can be represented by

$$y=Hx+n \tag{8}$$

Where, H is a channel matrix with its $(j,i)^{th}$ entry h_{ij} for the channel gain between the j^{th} receive antenna and the i^{th} transmit antenna, $j=1,2,\ldots\ldots N_R$ and $i=1,2,\ldots\ldots N_T$, $x=[x_1, x_2, \ldots\ldots\ldots\ldots x_{N_T}]^T$ and $y=[y_1, y_2, \ldots\ldots\ldots\ldots y_{N_R}]^T$ are the transmitted and received signals and $n=[n_1, n_2, \ldots\ldots\ldots\ldots n_{N_R}]^T$ is the white Gaussian noise with a variance of $\sigma^2{}_n$. By Using the Equation (8), the matched filtering (MF) based detected signal is given by

$$\hat{x}_{MF} = H^H y = H^H H x + H^H n \tag{9}$$

Where, H^H is the Hermitian conjugate of the estimated channel. In the interference limit scheme, the more advanced ZF detector has been required which operates on the MF data by

$$\hat{x}_{ZF} = (H^H H)^{-1} \hat{x}_{MF} \tag{10}$$

In Cholesky Decomposition (CD) base ZF detection, Equation (10) has been written in modified form as:

$$\hat{x}_{ZF} = (H^H H)^{-1} \hat{x}_{MF} = (LL^H)^{-1} \hat{x}_{MF} \tag{11}$$

With forward and backward substitution, the detected signal in CD-based ZF detection would be[6].

$$\hat{x}_{ZF} = L^{-H} L^{-1} \hat{x}_{MF} \tag{12}$$

d) Group Detection approach aided Efficient Zero-Forcing (GDEZF)

Group Detection (GD) approach based Efficient Zero-Forcing (ZF) detectors reduce the computational cost of the conventional linear detectors. In such a technique,

Equation (8) can be rearranged as:

$$y = [\bar{H}_1 \ \bar{H}_2] \begin{bmatrix} s_1 \\ s_2 \end{bmatrix} + n = \bar{H}_1 s_1 + \bar{H}_2 s_2 + n \tag{13}$$

Where, $\bar{H}_1 \in C^{N_R \times L}$ and $\bar{H}_2 \in C^{N_R \times (N-L)}$ are composed of first L and the remaining (N-L) columns of

H respectively, where the total number of columns of H is N. Similarly, $s_1 \in C^{L\times 1}$ and $s_2 \in C^{(N-L)\times 1}$ are the two sub-symbol vectors that have been made by taking the first L rows and the remaining rows of x. A weight matrix can be defined, $W_1 = (\overline{H}_1^H \overline{H}_1)^{-1}\overline{H}_1^H$, where (•) H denotes Hermitian transpose operation. Multiplying each side of the equation (13) by W_1, we obtain

$$W_1 y = s_1 + W_1\overline{H}_2 s_2 + W_1 n \tag{14}$$

Or equivalently, we can write

$$s_1 = W_1 y - W_1\overline{H}_2 s_2 - W_1 n \tag{15}$$

Substituting equation (15) into equation (13) and after some small manipulation, we get

$$y_2 = \widetilde{H}_2 s_2 + n_2 \tag{16}$$

Where, $y_2 \in C^{N_R\times 1}$, $\widetilde{H}_2 \in C^{N_R\times(N-L)}$, and $n_2 \in C^{N_R\times 1}$. The y_2, $\widetilde{H}_2$ and n_2 can be rewritten as:

$$y_2 = (I - \overline{H}_1 W_1)y \tag{17}$$

$$\widetilde{H}_2 = (I - \overline{H}_1 W_1)\overline{H}_2 \tag{18}$$

$$n_2 = (I - \overline{H}_1 W_1)n \tag{19}$$

Where I is the identity matrix. By estimated $\widetilde{H}_2$, another weight matrix W_2 can be defined as

$$W_2 = (\widetilde{H}_2^H \widetilde{H}_2)^{-1}\widetilde{H}_2^H \tag{20}$$

The sub-symbol vector s_2 is estimated using $\hat{s}_2 = Q(W_1 y_1)$, where the symbol Q is indicative of quantization. The effect of s_2 is canceled out from y to get $y_1 = y - \overline{H}_2\hat{s}_2$. The sub-symbol vector s_1 is estimated using $\hat{s}_1 = Q(W_1 y_1)$. Here x is transmitted signal vector, which has been approximated as [7]:

$$\hat{x} = \left[\hat{s}_1^T \ \hat{s}_2^T\right]^T \tag{21}$$

e) Lanczos method based efficient signal detection

The signal model is presented in Equation (8), the Minimum mean square error (MMSE) weight matrix can be represented as:

$$W_{MMSE} = (H^H H + \sigma_n^2 I)^{-1} H^H \tag{22}$$

and the detected desired signal from the transmitting antenna is given by[8]

$$\widetilde{X}_{MMSE} = W_{MMSE}\, y \tag{23}$$

In the Lanczos method based efficient signal detection technique; Equation (22) and Equation (23) are considered to write down a new signal model as:

$$b = A\vec{x} \tag{24}$$

Where, $\vec{x} = W_{MMSE}\,y$, $b = H^T y$ and $A = H^H H + \sigma_n^2 I$

From Equation (24), a quadratic function can be considered as

$$\phi(\vec{x}) = \frac{1}{2}\vec{x}^T A\vec{x} - \vec{x}^T b \tag{25}$$

Where A∈ $\mathbb{C}^{k\times k}$ is a symmetric positive definite matrix, b∈ $\mathbb{C}^{k}$ is a non-zero vector. Taking partial derivatives of $\vec{x}$, we obtain that $\nabla\phi\left(\vec{x}\right) = A\vec{x} - b$. Therefore $\vec{x} = A^{-1}b$ is the unique minimum value of function presented in Equation (25).

Assuming $Q_k = [q_1, q_2, q_3, \ldots, q_k]$ is a group of a standard orthogonal basis of Krylov subspace $\mathcal{K}(A, B, k)$, we can overwrite solution $\vec{x}$ as:

$$\vec{x}_k = \vec{x}_0 + Q_k y_k \tag{26}$$

Substitute equation (26) into the function of the Equation (25) and take the partial derivative of y_k, we can acquire that y_n is the minimum solution to the equation set:

$$Q_k^T A Q_k y_k = Q_k^T (b - A\vec{x}_0) \tag{27}$$

Which lead $\vec{x}_n = \vec{x}_0 + Q_n y_n$ as the approximated minimum point of function Equation (25). It is obvious that equation (27) is not easy to solve, and the computation of $\vec{x}_k$ would be storage inefficient if $[q_1, q_2, q_3, \ldots, q_k]$ was used at the last iteration. Here, Lanczos vector was adopted to overcome these two problems instead of q_k. The tri-diagonal matrix as T_k can be written as:

$$T_k = Q_k^T A Q_k = \begin{bmatrix} \alpha_1 & \beta_1 & \ldots\ldots\ldots\ldots 0 & \\ \beta_1 & \alpha_2 & & \\ & & & \beta_{k-1} \\ . & & & \\ 0 & & \beta_{k-1} & \alpha_k \end{bmatrix} \tag{28}$$

Lanczos method is an iteration method to convert symmetric definite positive matrix A into tri-diagonal matrix T as a function (28). At the k[th] step of the iteration, we have

$AQ_k = Q_k \boldsymbol{T_k} + \boldsymbol{r_k} e_k^T$ w here $\boldsymbol{r_k}$ is the residual error vector and e_k is the unit vector with the k[th] element equals 1. Decomposing the tri-diagonal matrix as $\mathbf{T_k}=\mathbf{L_k D_k L_k^T}$, where:

$$L_k = \begin{bmatrix} 1 & 0 & \ldots\ldots\ldots\ldots 0 & \\ \mu_1 & 1 & 0 & 0 \\ & & & \\ 0 & & \mu_{k-1} & 1 \end{bmatrix},$$

$$D_k = \begin{bmatrix} d_1 & 0 & \ldots\ldots\ldots\ldots 0 & \\ 0 & d_2 & 0 & 0 \\ & & & \\ 0 & & 0 & d_k \end{bmatrix}$$

Compared $\boldsymbol{T_k}$with $\boldsymbol{L_k D_k L_k^T}$, we can easily get:

$$\begin{cases} \mu_{k-1} = \beta_{k-1}/d_{k-1} \\ d_k = \alpha_k - \beta_{k-1}\mu_{k-1} \end{cases} \tag{29}$$

Combine equation (26), (27) and (28), and assume that $\mathbf{r_0} = \mathbf{b} - \mathbf{A}\,\ddot{x}_{\mathbf{0}}$, we can derive Equation (26) as

$$\ddot{x}_k = \ddot{x}_0 + Q_k T_k^{-1} Q_k^T r_0$$

$$= \ddot{x}_0 + Q_k (L_k D_k L_k^T)^{-1} Q_k^T r_0 \tag{30}$$

matrix $\mathbf{C}_k \in \mathbb{C}^{N\times k}$and vector $\mathbf{p_k} \in \mathbb{C}^{\boldsymbol{k}}$ which satisfy:

$$\begin{cases} C_k L_k^T = Q_k \\ L_k D_k p_k = Q_k^T (b - A\,\ddot{x}_0) \end{cases} \tag{31}$$

From (31) we can deduce that $\mathbf{C}_k = [\mathbf{C}_{k-1}, \mathbf{c}_k]$ and

$\mathbf{p}_k=[\mathbf{p}_{k-1}, \boldsymbol{\rho_k}]^T$,, where

$\mathbf{c}_k = \boldsymbol{q}_k - \mu_{k-1}\mathbf{c}_{k-1}$ and, $\boldsymbol{\rho_k} = (\boldsymbol{q}_k^T \boldsymbol{r}_0 - \mu_{k-1} d_{k-1} \rho_{k-1})/d_k$

Finally we can obtain the iteration function as[9]

$$= \ddot{x}_{\mathbf{0}} + \mathbf{C_{k-1}} \mathbf{p_{k-1}} + \boldsymbol{\rho_k} \mathbf{c}_k$$

$$= \ddot{x}_{\boldsymbol{k-1}} + \boldsymbol{\rho_k} \mathbf{c}_k \tag{32}$$

III. System Model

The conceptual block diagram of 5G compatible frequency-domain subband superposed (FDSS) scheme implemented MIMO OFDM wireless communication system has been shown in fig.1. In such a system, it is considered that three users are sending their encrypted text messages. The binary data extracted from each user's text message are encrypted with a secret key of bit length 8[10]. The encrypted binary data are channel encoded and subsequently digitally modulated [11]. Before IFFT implementation for each user, the number of complex digitally modulated symbols subbanding for the user#3, user#2 and user#1 are128, 256 and 512 respectively in symbol mapping. The proper designed symbol mapped complex digitally modulated data have been undergone multicarrier modulation, and subsequently cyclic prefixed and digital to analog (D/A) converted. The output for all the three users are sum up and feed into spatial multiuser encoding sections. Each output is sent up in two layers where baseband to RF conversion is made before transmission from each of the two transmitting antennas. In receiving section, each user has been equipped with two receiving antennas where primarily RF to baseband conversion is made with detection of the transmitted signal. The detected signal is feed into a spatial multiplexing decoder to extract the respective signal. The extracted signal is A/D converted with the removal of cyclic prefixing and subsequently undergone OFDM demodulation. The demodulated complex symbols are demapped, digitally demodulated, channel decoded, decrypted and eventually users own text messages is retrieved.

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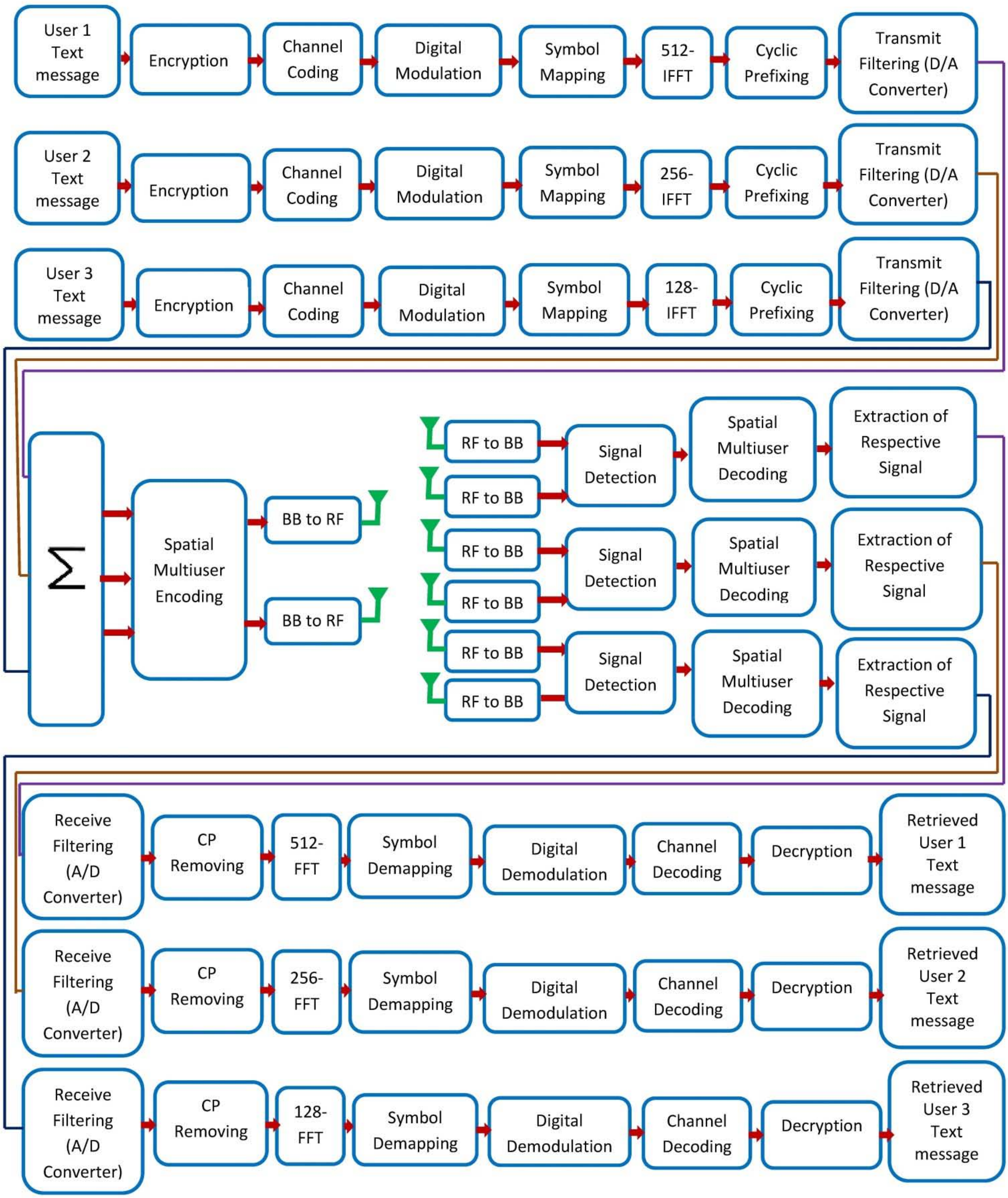

Fig. 1: Block diagram of encrypted text message transmission in 5G compatible frequency-domain subband superposed (FDSS) scheme implemented MIMO OFDM wireless communication system

IV. Results and Discussion

In this section, simulation results using MATLAB R2017a have been presented to illustrate the significant impact of various types of channel coding, signal detection and higher order digital modulation techniques on performance investigation of encrypted text message transmission in 5G compatible frequency-domain subband superposed (FDSS) scheme implemented a MIMO OFDM wireless communication system in terms of bit error rate (BER). It is also considered that the channel state information (CSI) of the cmWave MIMO Rayleigh fading channel is available at the receiver and the fading channel coefficients are constant during simulation. The proposed model is simulated to evaluate the system performance under consideration of parameters presented in Table 1.

Table 1: Summary of the Simulated Model Parameters

Text messages with number of binary bits for user#1, user#2 and user#3	1776, 864 and 432
Bandwidth for subband 1, subband 2 and subband 3 (MHz)	6.66, 6.48 and 6.48
FFT_size for user#1, user#2 and user#3	512, 256 and 128
Subcarrier_spacing for user#1, user#2 and user#3 (KHz)	15, 30 and 60
CP length for user#1 user#2 and user#3	64, 32, 16 samples
Signal detection techniques	Cholesky Decomposition (CD) based ZF detection, Group Detection (GD) approach aided Efficient Zero-Forcing (ZF), Lanczos method based efficient signal detection
Channel coding	LDPC and Repeat and accumulate (RA)
Symbol mapping	16-QAM and 16-PSK
Pulse shaping filter with Rolloff factor	Raised cosine with 0.25
Number of Transmitting or Receiving antennas	2/2
Channel	MIMO fading channel
Signal to noise ratio (SNR)	0 to 10 dB

In analyzing estimated BER values from graphical illustrations presented in Figure 2 through Figure 7 for evaluating the performance of the simulated system, an SNR value of 2 dB is assumed typically. On critical observation, it is also noticeable that in all cases, the simulated system shows better performance in case of user#3 with 16-QAM digital modulation as the efficient transmission bandwidth for user#3 is lower as compared to the scenario for user#1 and user#2. It can be seen from Figure 2 in case of utilizing Repeat and Accumulate Channel Coding, Cholesky decomposition based signal detection techniques, the performance of the simulated system is very much well defined. For user#1, the estimated BER values are 0.0949 and 0.2315 with 16-QAM and 16-PSK digital modulations which ratifies system performance improvement of 3.87 dB.

For user#2, the estimated BER values are 0.0674 and 0.2044 for identical consideration 0f 16-QAM and 16-PSK digital modulations; the system shows the system performance improvement of 4.82 dB. For user#3, the estimated BER values are 0.0398 and 0.1171 with 16-QAM and 16-PSK digital modulations which is indicative of system performance improvement of 4.69 dB. At 5% BER, an SNR gain of 6.2 dB is achieved in 16-QAM as compared to 16-PSK for user#3. From Figure 3, the estimated BER values are 0.0757 and 0.223 with 16-QAM and 16-PSK digital modulations which ratifies system performance improvement of 4.69 dB in case of user#1. For user#2, the estimated BER values are 0.0743 and 0.1905 which confirms that the system shows system performance improvement of 4.09 dB.

In case of user#3, the estimated BER values are 0.0281 and 0.1194 which is indicative of system performance improvement of 6.28 dB. At 5% BER, a SNR gain of 5.6 dB is achieved in 16-QAM as compared to 16-PSK for user#2. In Figure 4 in case of user#1, the estimated BER values are 0.0977 and 0.2242 with 16-QAM and 16-PSK digital modulations which ratifies system performance improvement of 3.61 dB.

In case of user#2, the estimated BER values are 0.0662 and 0.2102 for identical consideration 0f 16-QAM and 16-PSK digital modulations, the system shows the system performance improvement of 5.02 dB For user#3, the estimated BER values are 0.0211 and 0.1054 with 16-QAM and 16-PSK digital modulations which is indicative of system performance improvement of 6.98 dB. At 10% BER, an SNR gain of 6.1 dB has been achieved in 16-QAM as compared to 16-PSK for user#1.

In Figure 5 for user#1, the estimated BER values are 0.2083 and 0.3350 with 16-QAM and 16-PSK digital modulations which ratifies system performance improvement of 2.06 dB. In the case of user#2, the estimated BER values are 0.1806 and 0.3067 for identical consideration 0f 16-QAM and 16-PSK digital modulations, the system shows the system performance improvement of 2.29 dB. In the case of user#3, the estimated BER values are 0.0764 and 0.1991 with 16-QAM and 16-PSK digital modulations which is indicative of system performance improvement of 4.16 dB. At 5% BER, an SNR gain of 4.1 dB has been achieved in 16-QAM as compared to 16-PSK for user#2. In Figure 6 in case of user#1, the estimated BER values are 0.2218 and 0.3238 with16-QAM and 16-PSK digital modulations which ratifies system performance improvement of 1.64 dB. In the case of user#2, the estimated BER values are 0.1447 and 0.2743 for identical consideration of 16-QAM and 16-PSK digital modulations; the system shows the system performance improvement of 2.78 dB. In the case of user#3, the estimated BER values are 0.0602 and 0.2384 with 16-QAM and 16-PSK digital modulations which is indicative of system performance improvement of 5.98 dB. At 5% BER, an SNR gain of 4.2 dB has been achieved in 16-QAM as compared to 16-PSK for user#3. In Figure 7 for user#1, the estimated BER values are 0.2224 and 0.3378 with 16-QAM and 16-PSK digital modulations which makes confirmation of the system performance improvement of 1.81 dB. In the case of user#2, the estimated BER values are 0.1725 and 0.3264 for identical consideration 0f 16-QAM and 16-PSK digital modulations, the system shows the system performance improvement of 2.77 dB. In the case of user#3, the estimated BER values are 0.0764 and 0.2338 with 16-QAM and 16-PSK digital modulations which implies a system performance improvement of 4.86 dB. At 5% BER, an SNR gain of 6.1 dB is achieved in 16-QAM as compared to 16-PSK for user#3.

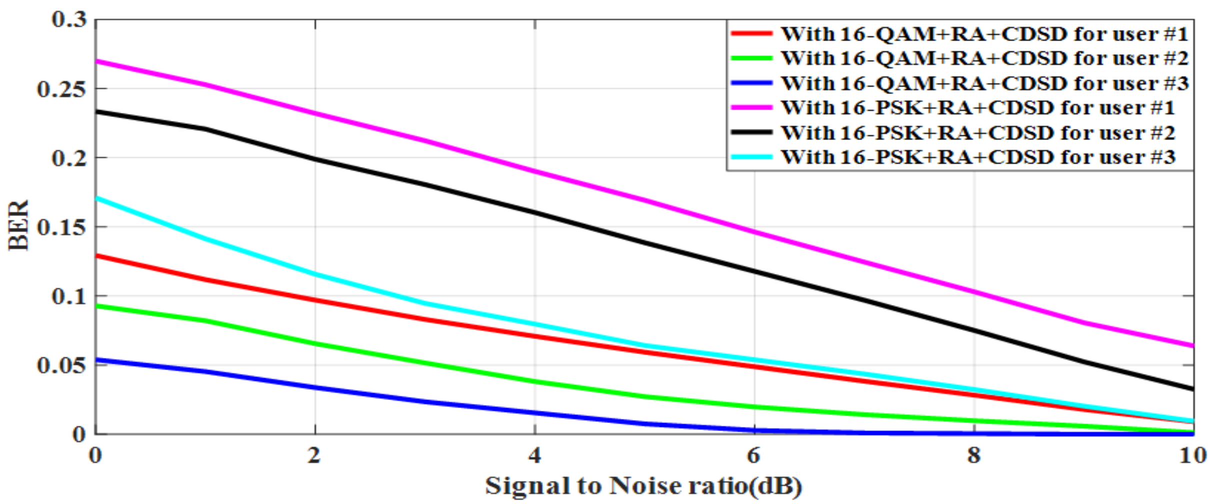

Fig. 2: BER performance of subband superposed scheme implemented multi-user 5G compatible MIMO OFDM system with the utilization of Repeat and Accumulate Channel Coding, Cholesky decomposition based signal detection and higher order digital modulation schemes.

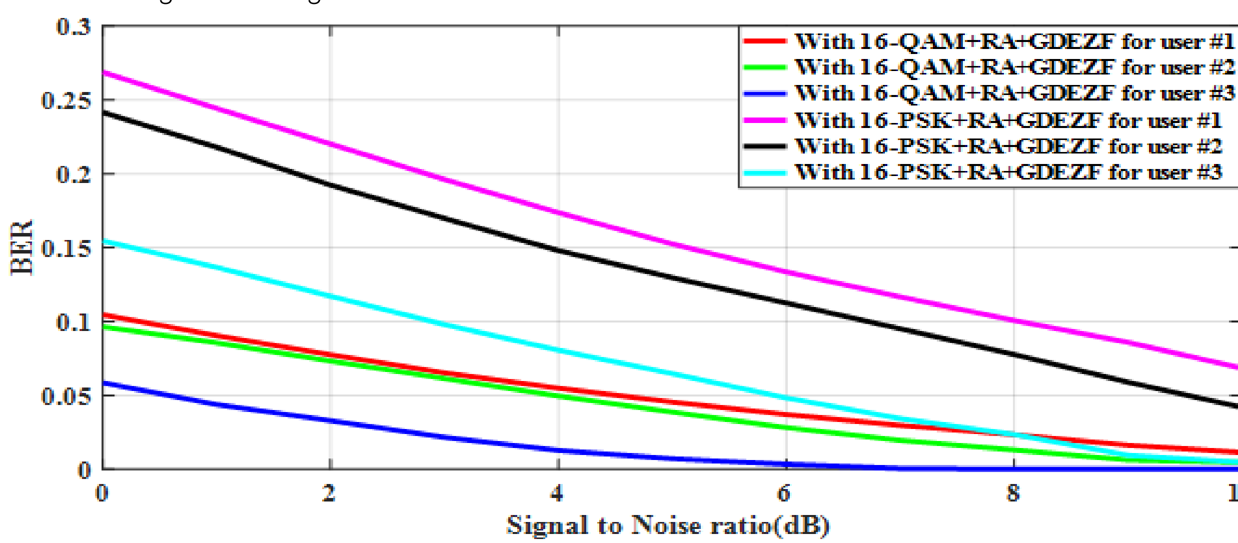

Fig. 3: BER performance of subband superposed scheme implemented multi-user 5G compatible MIMO OFDM system with the utilization of Repeat and Accumulate Channel Coding, Group Detection (GD) approach aided Efficient Zero-Forcing (ZF) signal detection and higher order digital modulation schemes

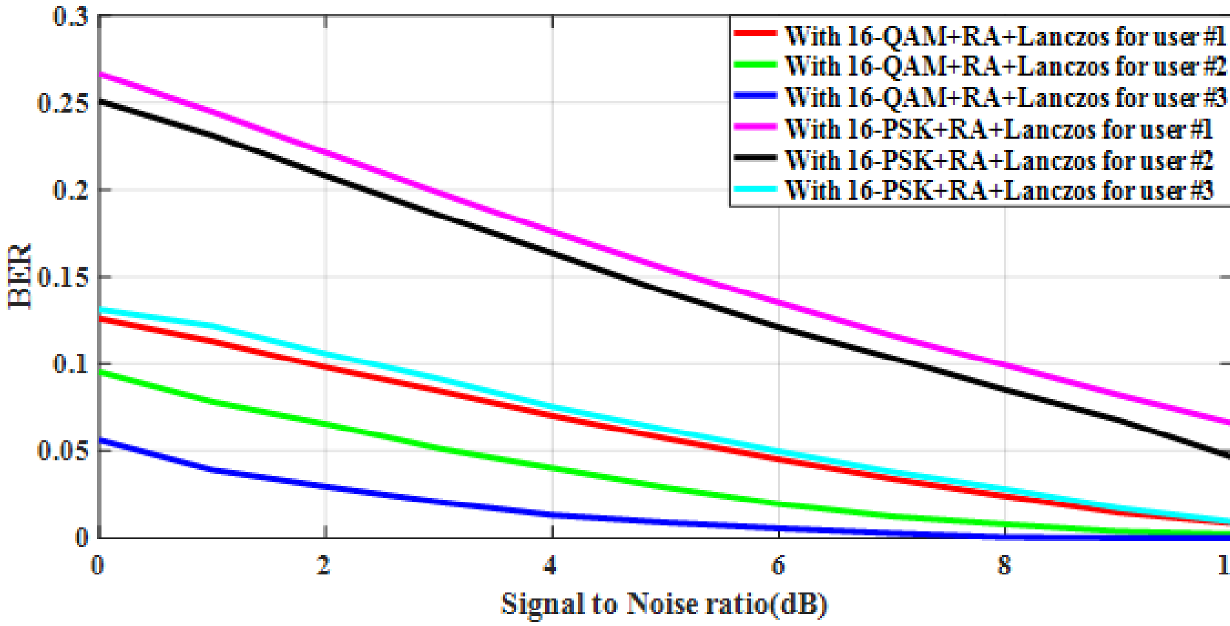

Fig. 4: BER performance of subband superposed scheme implemented multi-user 5G compatible MIMO OFDM system with the utilization of Repeat and Accumulate Channel Coding, Lanczos method based efficient signal detection and higher order digital modulation schemes

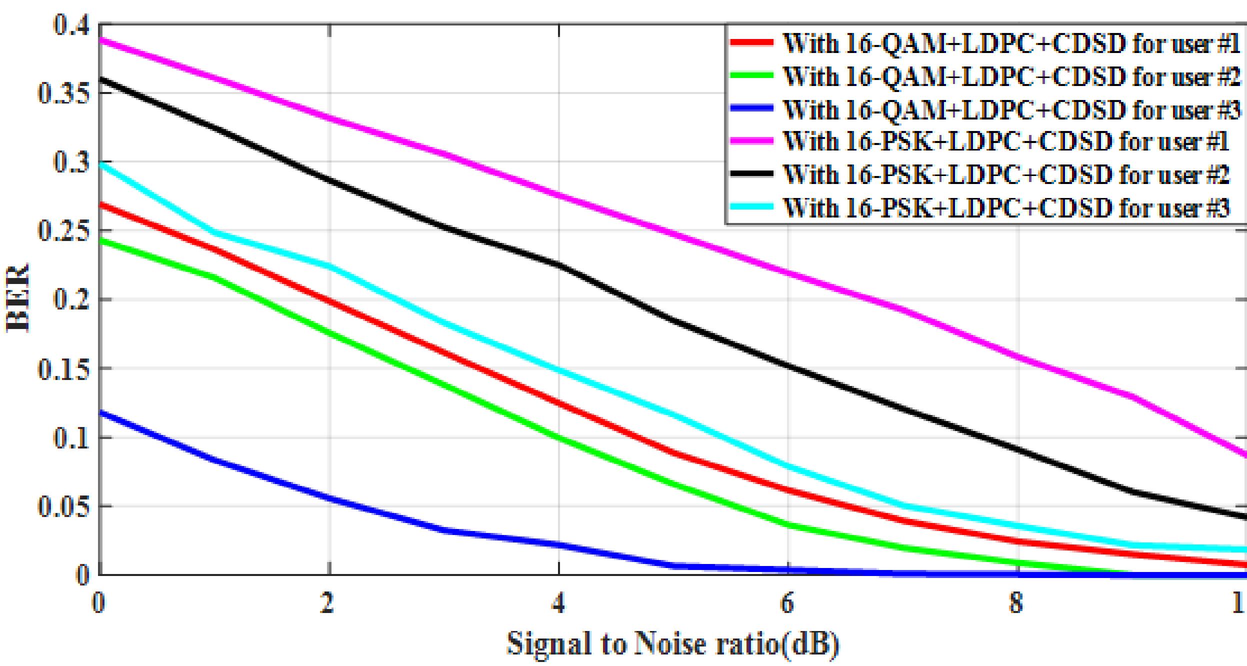

Fig. 5: BER performance of subband superposed scheme implemented multi-user 5G compatible MIMO OFDM system with the utilization of LDPC Channel Coding, Cholesky decomposition based signal detection and higher order digital modulation schemes

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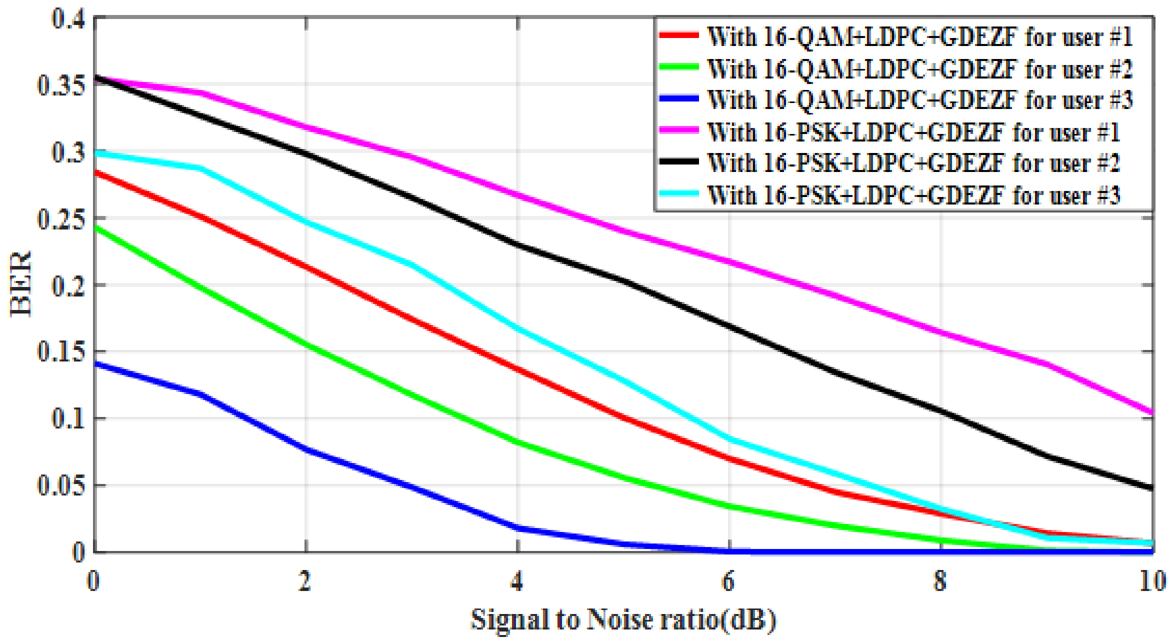

Fig. 6: BER performance of subband superposed scheme implemented multi-user 5G compatible MIMO OFDM system with the utilization of LDPC Channel Coding, Group Detection (GD) approach aided Efficient Zero-Forcing (ZF) signal detection and higher order digital modulation schemes

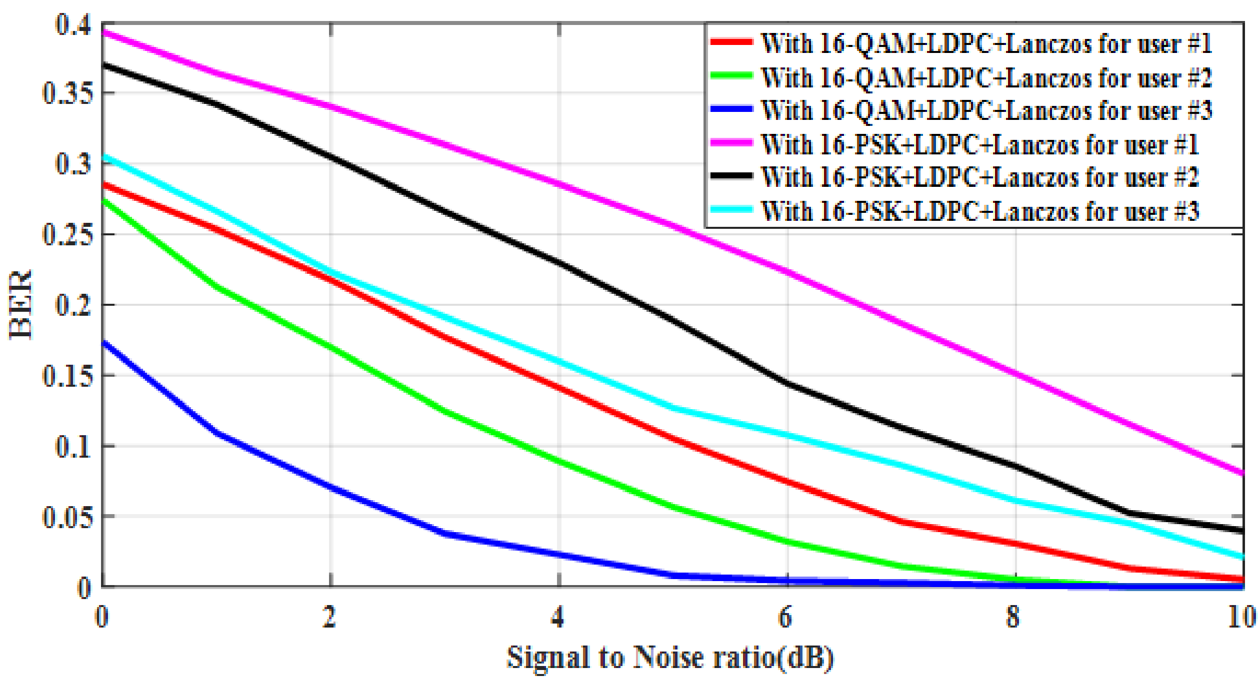

Fig. 7: BER performance of subband superposed scheme implemented multi-user 5G compatible MIMO OFDM system with the utilization of LDPC Channel Coding, Lanczos method based efficient signal detection and higher order digital modulation schemes

It is quite manifest from Figure 8 that the active subcarriers containing data symbols for all of the three users occupy a significant part of the frequency band as compared to null subcarriers. The estimated values of OOB power reduction are found to have values of 18.3431 dB, 18.5560 dB and 19.5358 dB relative to in band-power for user#1, user#2 and user#3 respectively.

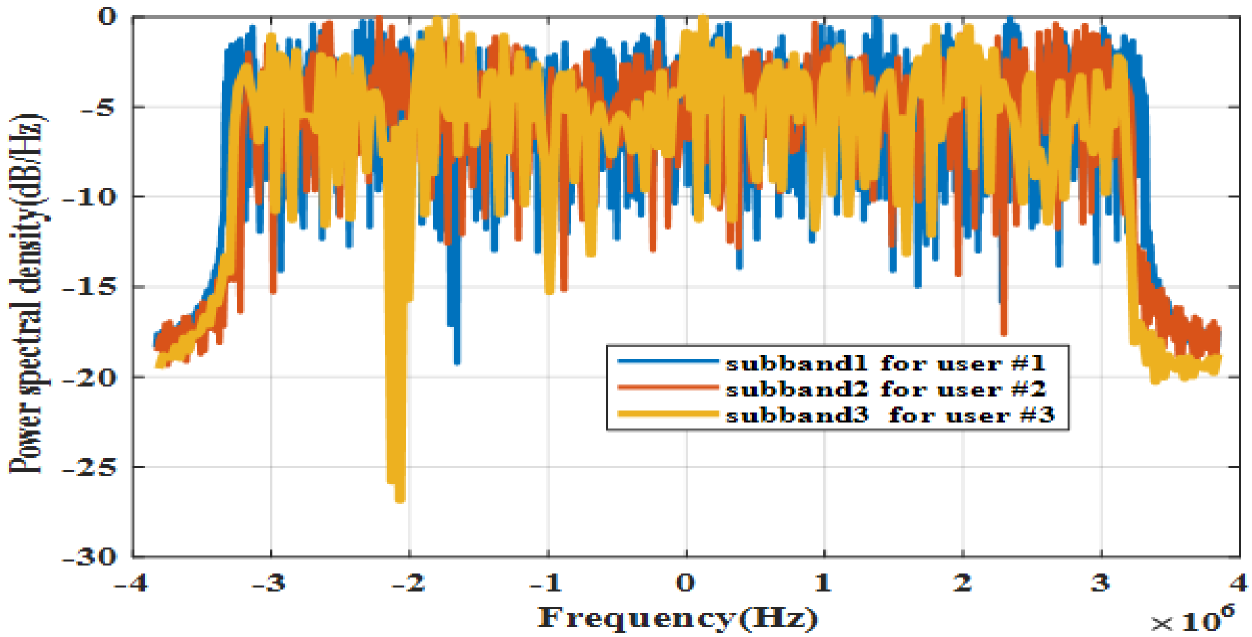

Fig. 8: Estimated Power spectral density of subband superposed scheme implemented multi-user 5G compatible MIMO OFDM system for different sub banded OFDM signal waveforms

In Figure 9, Transmitted and Retrieved encrypted text messages for different users at SNR value of 10 dB in subband superposed scheme implemented multi-user 5G compatible MIMO OFDM system are presented. The red marks indicate the erroneous part of the retrieved text message.

Original transmitted text message for user #1:
Pattern Division Multiple Access (PDMA) is a novel non-orthogonal multiple access technology based on the total optimization of multiple user communication system.
At the receiver, multiple users are detected by SIC on detection method.

Retrieved text message for user #1:
Pattern Division Multiple Access (PDMA) is a novel non/orthogonal multiple access technology `based on the! tot`l optimization of multiple user communication system.
At the receiver, multiple users are detected !by SIG on detectioN(eetlod.

Original transmitted text message for user #2:
Pattern division multiple access(PDMA) was proposed in 2014.
It is a type of non-orthogonal multiple access technology.

Retrieved text message for user #2:
Pattern division multiple access(PDMA) was proposed in 2014.
It is a type of non -orthogonal multiple access technology.

Original transmitted text message for user #3:
D2D technology allows direct communications between devices.

Retrieved text message for user #3:
D2D technology allows direct communications between devices.

Fig. 9: Transmitted and Retrieved encrypted text messages for different users at SNR value of 10 dB in subband superposed scheme implemented multi-user 5G compatible MIMO OFDM system

V. Conclusions

In this paper, we have depicted our simulation work on the suitability of 5G compatible frequency-domain subband superposed (FDSS) scheme implemented a MIMO OFDM wireless communication system in encrypted text message transmission. In our proposed desirable design implemented MIMO simulated system, we have tried to show system performance in terms of its BER and OOB reduction. From the simulative work, it is seen that the system shows better performance in retrieving transmitted text message with the implementation of Repeat and Accumulate Channel Coding with Group Detection (GD) approach aided Efficient Zero-Forcing (ZF) signal detection techniques.

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