Chapter 4

Performance and Implementation of OFDM NOMA using Iterative Algorithm

4.1 Performance of Non-Orthogonal Multiple Access in Fading Channels-An Introduction

The proposed NOMA algorithm is a non-orthogonal multiple access methodology that allows the transmission of high power modulated signals to distant users. NOMA is the most recent and significant modulation technique. The basic research is built on the recently created NOMA technology, which is employed by fifth Generation signals and Internet of Things. The power allocation algorithm allocates lesser power to close users while allocating the remaining power to distant users, resulting in more power being allocated much farther consumers [88]. The architecture is running at optimum efficiency when this technique is used. The research focuses on AWGN and Rayleigh disturbances caused by channel fading across downlink and uplink channels of communication. This component is being used to look at fade that is due to different things, along with hardware or software failure. To minimize noise and perform rectification for successful transmission or reception, deep studies are required. The MATLAB module that was constructed compares different factors including such as gain, energy efficiency, and noise present in channels. The waveforms are examined, and the recommended downlink and uplink channel designs are determined using the algorithms mentioned earlier. The proposed model [89] contains a full examination of the fading channel. The method is designed in such a way that the signals can be sent and received without error. The modulation technique is intended to give its NOMA architecture a high level of security by blocking third-party accessibility. To decrease faults and simplify communications in the proposed model, the receiver block in this suggested system is built with an enhanced scramble algorithm. The employment of a sophisticated technique in the building of reliable encryption schemes is known as cryptography [1] [7].

Cryptography is required when collaborating over any untrusted network, regardless of categorization. An important goal in this research is to use MATLAB and Xilinx software solutions to develop an efficient approach to execute NOMA classification, and then to evaluate the results by modeling every blocks in the suggested work. Error rectification is a technique for detecting faults caused by weaknesses in software or hardware. The Hamming algorithm is used to perform data bit correction. Devices that operate on the Internet of Things principle will benefit greatly. Using the energy allocation method, the design concept improves the transmission speed, resulting in more power being delivered to distant users. The NOMA concept is fundamentally based on the power allocation method. Previously, all transmission techniques relied on frequency or time domain. However, technological advancements have enabled designers to transmit signals using power, which is a significant improvement in communication design. that is widely used in Internet of Things devices and 5G technologies

4.1.1 Proposed Design for NOMA

The term "non-orthogonal multiple access" refers to data transmission across a power line. An effective approach of allocation scheme should be adopted to increase communication. The proposed model takes into account the differences between the fading channel noise generated by the AWGN and the generated by the Rayleigh fading channel [90]. The MATLAB Simulink Model has taken to create the celestial chart, and modulation is accomplished through the use of eight phase shift keying. It attenuates channel noise and illustrates the following simulation observations. The suggested model uses Successive Interference Cancellation to delete U2 (user two) signal at receiver one, and U1 (user one) signal is similarly eliminated at receiver two.

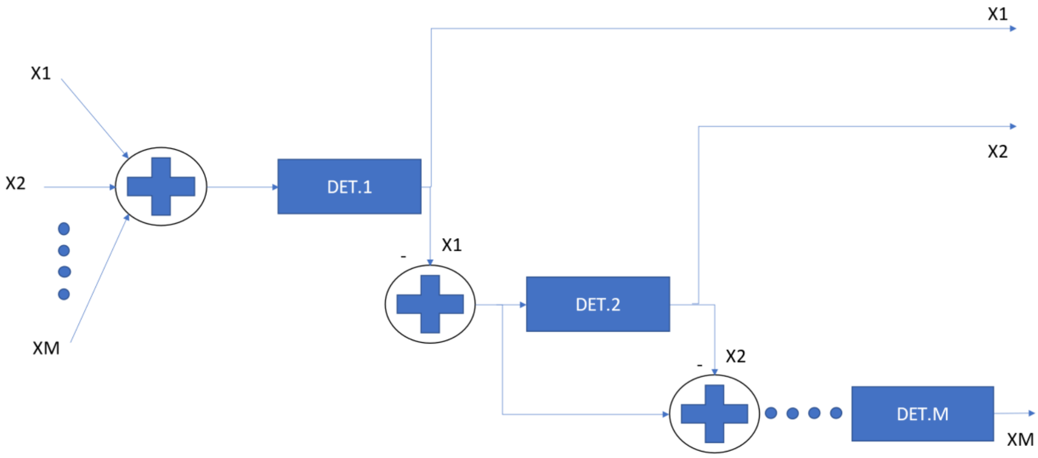

Figure 4.1: SIC Receiver

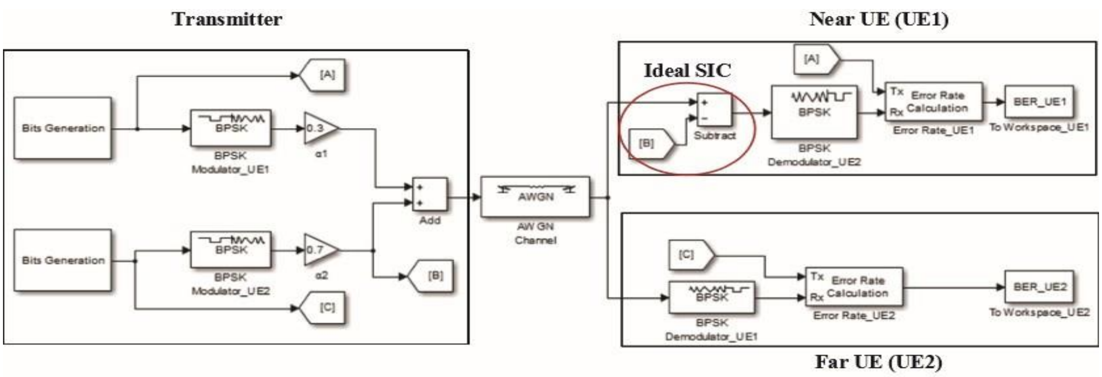

Figure 4.2: AWGN Channel Simulink design Mode

The SIC technique is critical for signal demodulation. Figure 4.1 shows how the signal is decoded using the Successive Interference Cancellation technique [91]. In the first stage, the data is then processed with a high SNR. Decoding is done using a common approach across the model.

4.1.1.1 NOMA for AWGN Fading Channel

The AWGN [92] [12], is a type of white noise that can be added to a channel. It can be seen in the block diagram of a fading channel shown in Figure 4.2.

4.1.1.2 NOMA for Rayleigh Fading Channel

The time-varying characteristics found inside the envelopes of a faded signal are considered for Rayleigh fading channel [92], [12]. Scattering across the receiver and the transmitter, which could be buildings, automobiles, or other things, causes this. Because of all of this, the channel fades. The block diagram for NOMA over a Rayleigh channel is displayed in Figure 4.3.

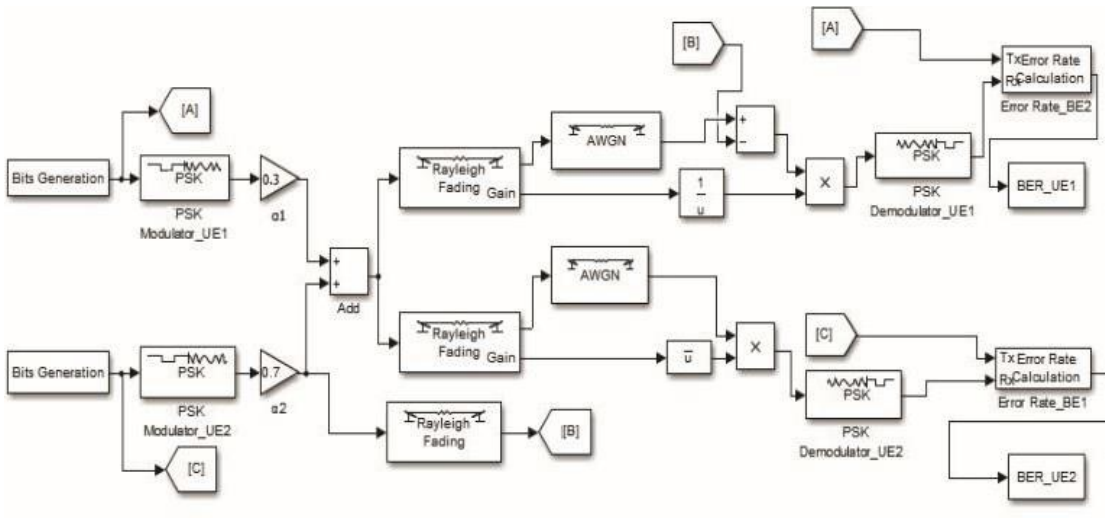

Figure 4.3: Rayleigh Channel Simulink Design Model

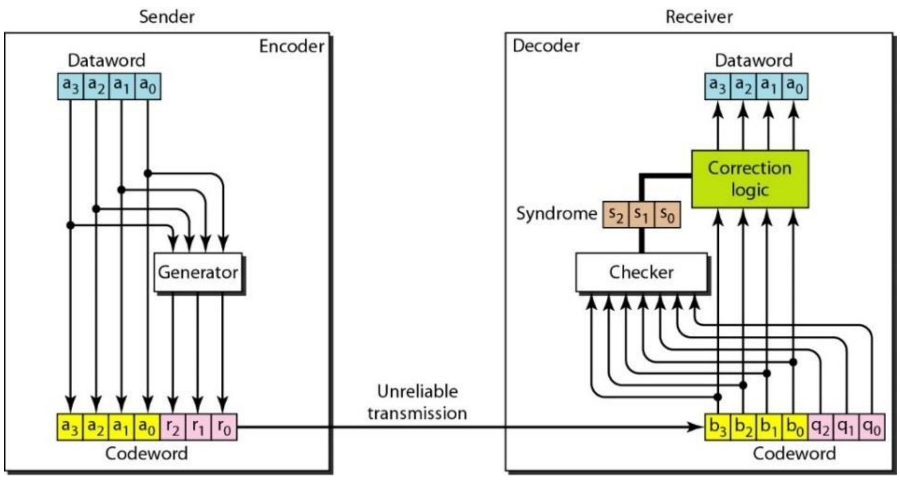

Figure 4.4: Error Correcting Code Design Model [93]

4.1.2 NOMA with Error Correcting Block

The NOMA Architecture Error Correcting Block is depicted in Figure 4.4. The hamming code algorithm is applied to detect single bit errors in the transmission. It can be implemented in the Hamming code algorithm to bypass these errors. The other component of the algorithm is the generation of parity bit, which is used to correct the errors at the decoder [4]. As a result, with the help of this created method, the right output will be conveyed.

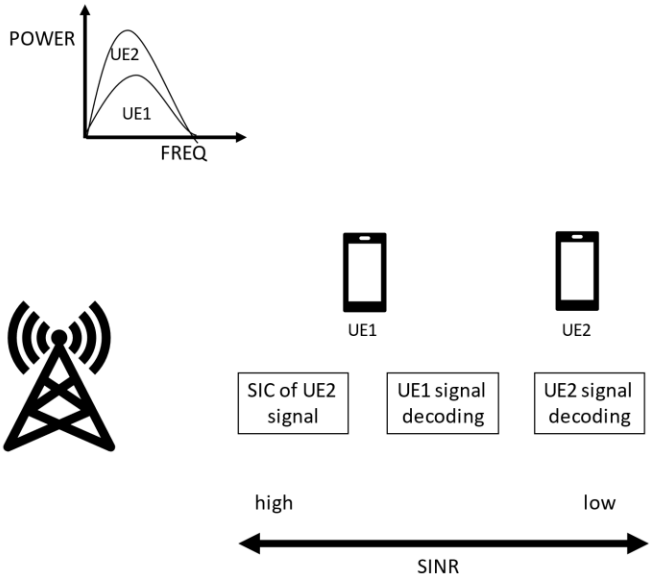

Figure 4.5: Combining Two User in NOMA using Power Allocation [93]

4.1.3 Mathematical Analysis

The MATLAB code has developed to execute the simulation and through mathematical analytical testing in order to elaborate the methodologies included in the NOMA methodology. The power allocation mechanism is described by the downlink device, which is a fundamental model. As previously illustrated, this technique employs a mathematical expression. As can be seen, the near user should be given less power, while the distant consumer consumes high power [4]. The power allocation factors for the two users are also taken into account. The combined power allocation factors for the two users are shown in Figure 4.5 and are given as per the composite signal for the two users from the BS as

$$\gamma = \sqrt{\phi_1 P_{m_1}} + \sqrt{\phi_2 P_{m_2}} \tag{4.1}$$

The total power of the system is shown in the equation as P , while m_1 and m_2 are the message signals. The AWGN equation is also shown in this section as

$$y_m = \sum_{k=1}^{k_m} h_{mk}\overline{X} + N_{mk} \tag{4.2}$$

In the case of the m^{th}user, h_{mk} is the receiver antenna, while x is the composite signal. In the case of the AWGN, the noise is added to the m^{th} user. Due to the random disturbances, channel fading can occur later in the simulations.

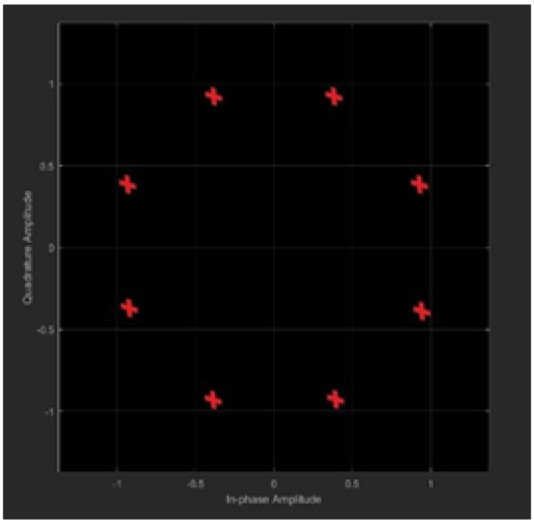

Figure 4.6: 8-PSK Constellation

4.1.4 Simulation Results on Fading Channels

The modulation technique used in this study is 8-ary PSK. The model used in this study is a constellation model that shows the signal trajectory and constellation diagrams. The SIMULINK Model is used to calculate the values of the error vector magnitude and the modulation error rate. These values can be seen in Figure 4.6 and 4.7. The simulation shows how the system modulation works.

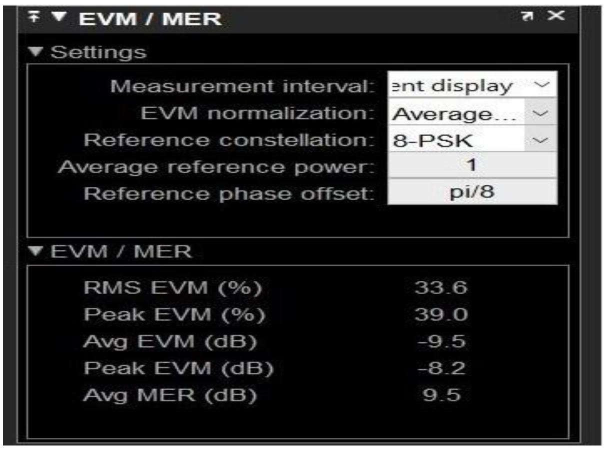

Figure 4.7: Modulation Error Rate and Error Vector Magnitude Quantities for 8-PSK Modulator

These values demonstrate how the system modulation performs. These computations additionally aid in the improvement of the system by providing specific EVM and MER measures, which ensure that the modulation scheme remains stable.

4.1.4.1 Bit Error Rate Analysis using NOMA

For Bit Error Rate Assessment, a MATLAB model of the downlink and uplink AWGN is offered. Two users are considered and analyzed. Such two users are divided into two categories: one is close nearby and is known to as a Near User; another is distant apart and therefore is known as a Far User. The BER analyses are carried out using the NOMA design. The downlink and uplink Rayleigh simulations in MATLAB are presented for BER Analysis. The terms far user as well as near user are also used in the design of the Rayleigh channel. Figures 4.8 and 4.9 shows a graph of BER vs SNR for downlink and uplink for AWGN channel. The purpose of this research is to see whether NOMA approach works when channel noise is factored. Key thing to observe is the channel fading in the Rayleigh channel is larger than in the AWGN fading. An analysis of the BER performance in relation to the SNR is also performed in Figure 4.10 and Figure 4.11.

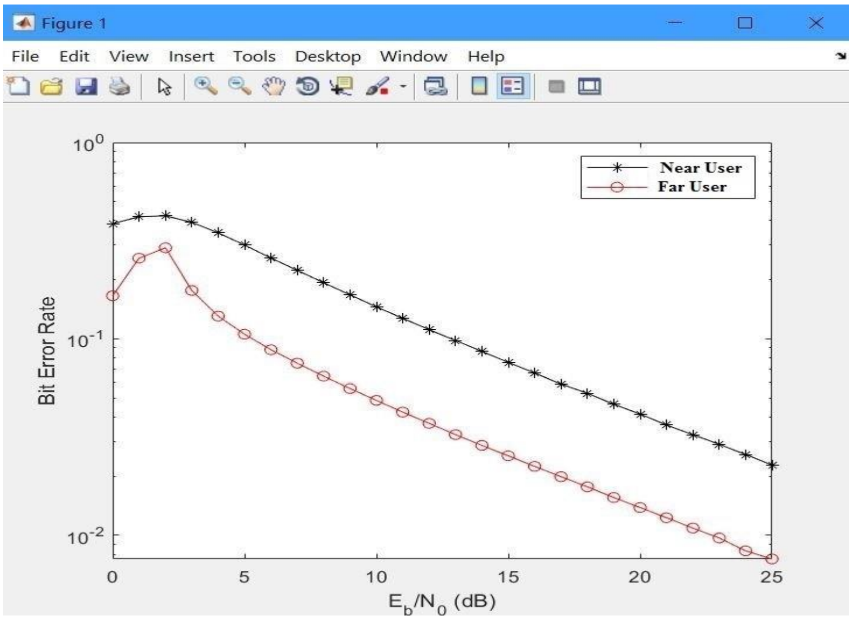

Figure 4.8: BER vs SNR for Downlink of AWGN fading Channel

The BER performance of all users highly depends on the fading parameter. Also the fading concept affects the higher order users more than the lower order users, which is due to the ordering of users based on the channel conditions that resulted in an enhanced performance for higher order users. BER will be mostly determined by the fading. In the implementation strong user refers to the near user.

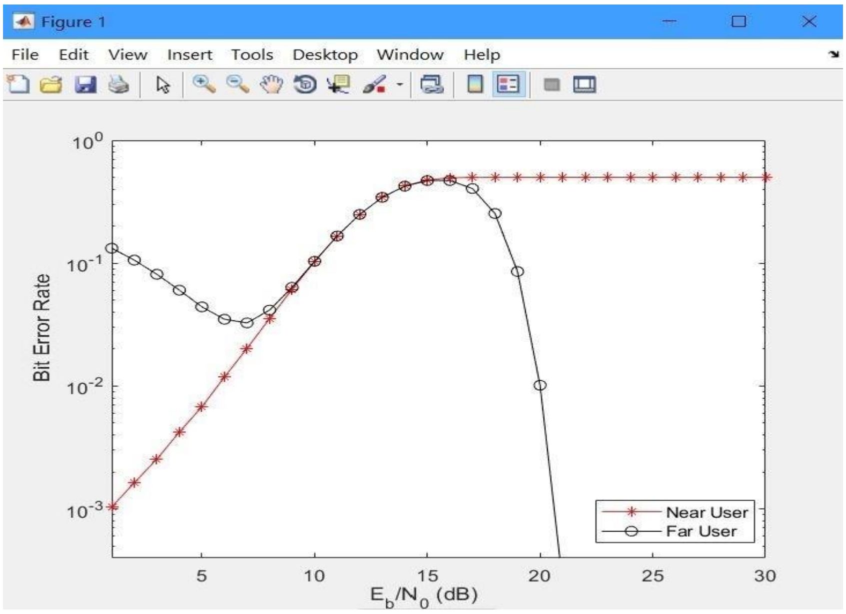

Figure 4.9: BER vs SNR for Uplink of AWGN fading Channel

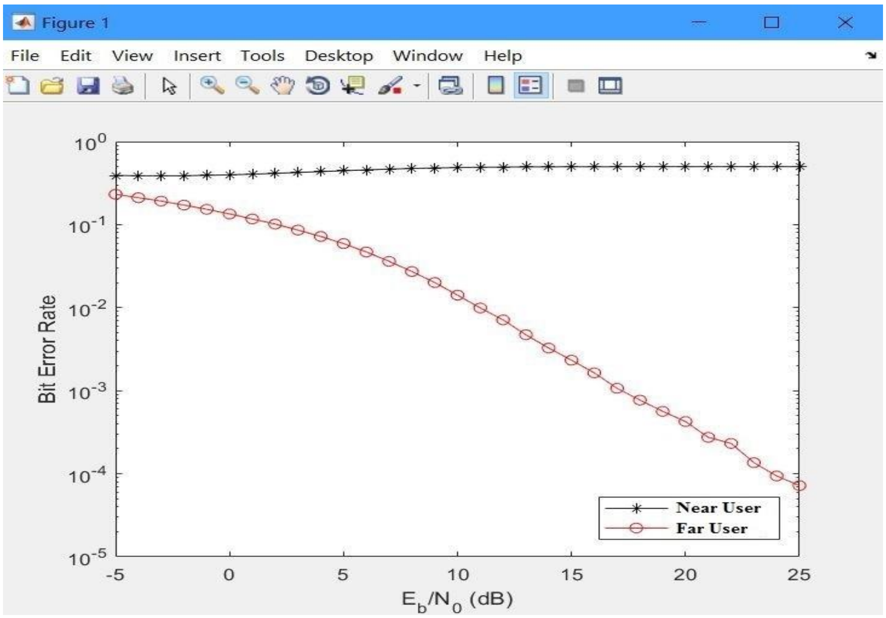

Figure 4.10: Performance of Rayleigh fading channel in the downlink

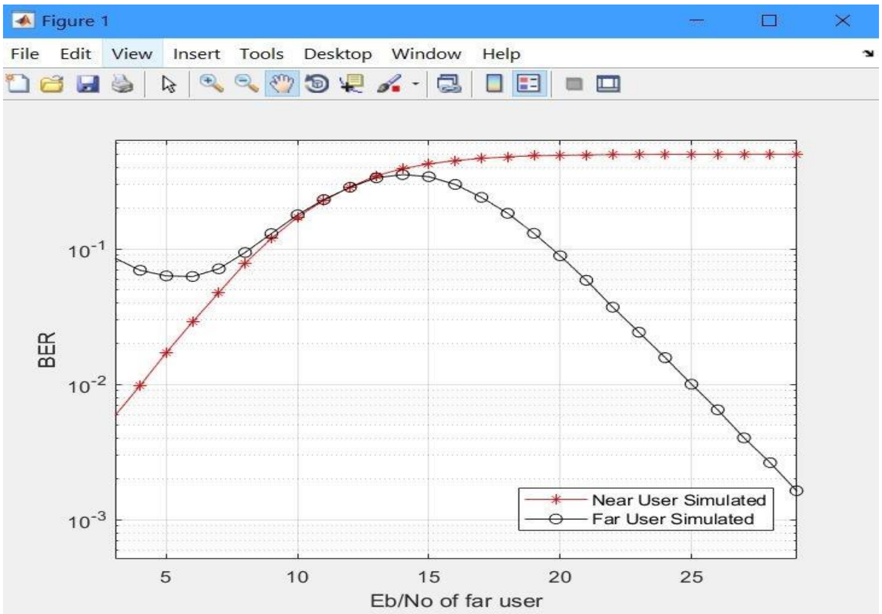

Figure 4.11: Performance of Rayleigh fading channel in the uplink

4.1.4.2 Results of Error Correcting Block using NOMA

The image below shows the simulations of the decoder and encoder blocks. The data is provided by the encoder, and the topmost MSB bit of the data is turned high and broadcast when the data is sent to the decoder. This interaction causes an error, and this is fixed by implementing an error correcting decoder. Despite the error, the data is still received correctly, as shown in Figure 4.12 and Figure 4.13. The implementation of the error correcting decoder uses a 5 bit hamming code to fix the issue.

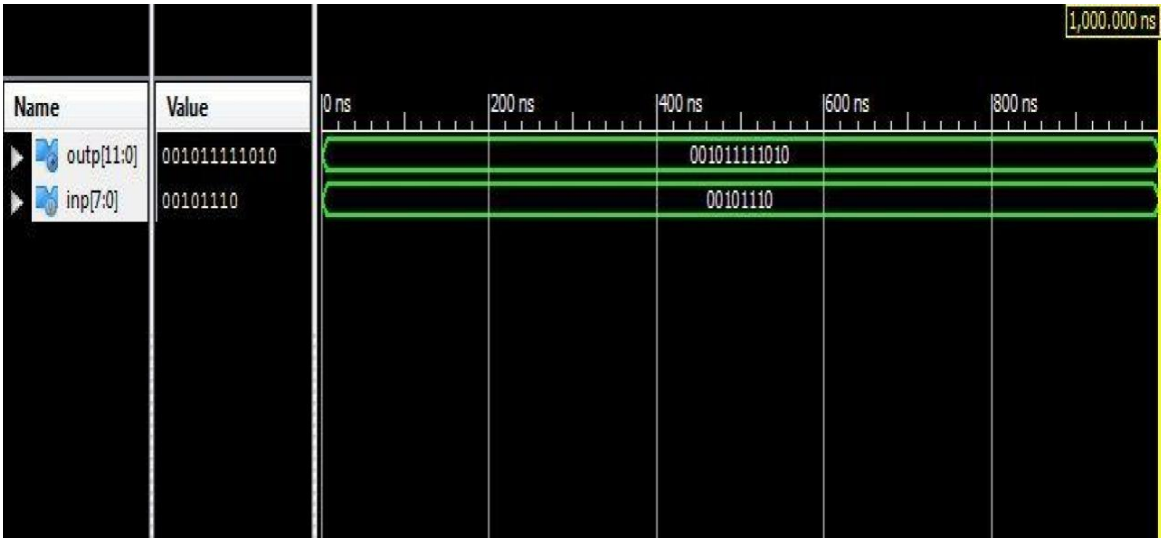

Figure 4.12: Simulation Output for Encoder

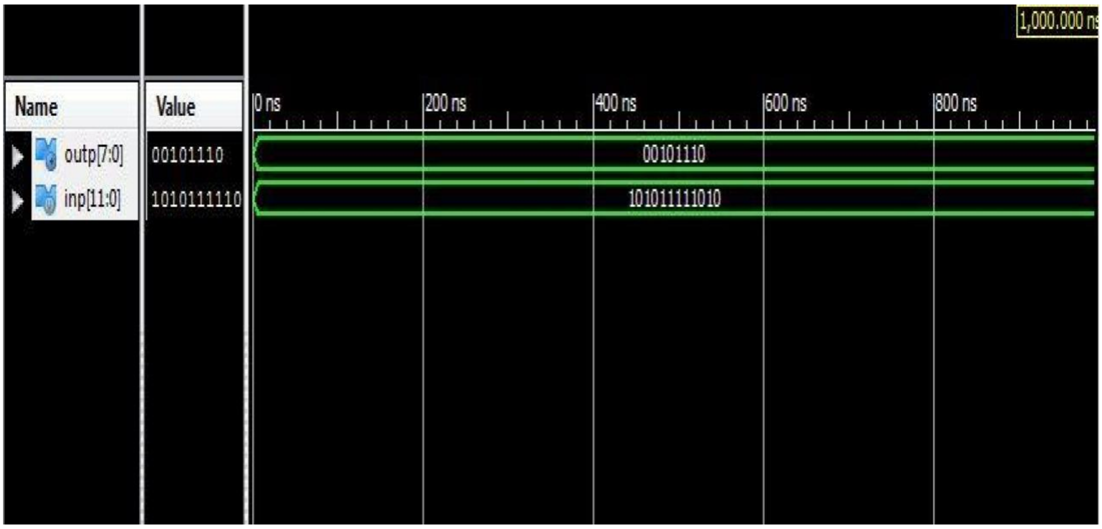

Figure 4.13: Error Correcting Decoder Simulation

Hamming code uses a block parity mechanism. The data is divided into blocks, and parity is added to the block. Hamming code can correct single-bit errors and detect the presence of two-bit errors in a data block. Because of the great distances involved, long transmit times and the requirements for accurate data, it is preferred to use the slower but more precise Hamming code and can be trade off with the overall transmission rate. Using Hamming codes, five bits are generated for error correction, which is shown in Figure 4.12 and 4.13.

4.1.5 Summary on Performance of fading channels in NOMA

The proposed work paves the way for a more in-depth investigation of fading channels in NOMA. The proposed work is a very viable solution with respect to hardware, memory consumption, and simulation time. Many features, like as the constellation and the SNR graph, reveal that the existence of fading channels diminishes the signals. When compared to other algorithms, the NOMA approach uses the power allocation algorithm to enable superior signal transmission. It also ensures that no errors are transmitted. As a result of the simulation results, the proposed methodology achieves reduction in delay, power consumption, area. The NOMA technique's signal transmission is represented using MATLAB and Xilinx programming.

4.2 Implementation of MIMO OFDM NOMA System – An Introduction

Wireless network have become increasingly important in today's society as technology has improved significantly. MIMO wireless network is essential for enhancing connections and spectrum efficiency while also ensuring increased connectivity stability over before overlooked disturbance pathways. The channel access platform is built to provide many users with a variety of communication options. The iterative procedure is used to define a randomized matrix of signals and match the phases towards the recorded amplitude in this research. The transfer of multiple data streams through power domain along existence of both Additive White Gaussian Noise as well as Rayleigh channel is investigated using several access methods such as NOMA, OMA, and AOMA. The data transmitted through the network might change due to interference on its way. The fading channel and additional noise added to the channel are used to calculate the signal power at reception. Using the MATLAB software tool, the effectiveness of all the previous section multiple access strategies is evaluated by means of averaged total amount, i.e. received signal in terms of SNR. In simulations, NOMA outperforms the other two examples, demonstrating that it is a potential approach for 5G wireless technology.

4.2.1 Multiple Access Systems

Multiplexing techniques or access methods are used to service multiple numbers of users in wired or wireless channels. Communication channels, on the other hand, are usually expensive and opulent, whether they are wireless spectrum parts or network cables. As a result, network operators should disperse customers over constrained resources in order to make the greatest use of bandwidth utilization. In addition to afford the economy of scale essential for a victorious communications enterprise, the access methods sometimes allow for the distribution of such specific channels between numerous users.

The various multiple access techniques are shown in Figure 4.14 as Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA),Orthogonal Frequency Division Multiple Access (OFDMA), Spatial Division Multiple Access (SDMA) and Code Division Multiple Access (CDMA). Orthogonal multiple access (OMA) and Non-Orthogonal multiple access (NOMA) are the subjects of this work. Various forms of NOMA include Interleave Division Multiple Access (IDMA LDS), Code Division Multiple Access (CDMA), Power domain Non Orthogonal Multiple Access, and MUSA. Code Division Multiplexing Access, Frequency Division Multiplexing Access, and Time Division Multiplexing Access are three different access technologies used in Orthogonal Multiple Access techniques. None of them can meet the NOMA's better-than-average parameters. In TDMA, the user receives signals in non-overlapping time slots, whereas in FDMA, the user receives signals in overlapping time slots. They necessitate exact time synchronization. Each user's signal is assigned with a precise subcarrier in FDMA.

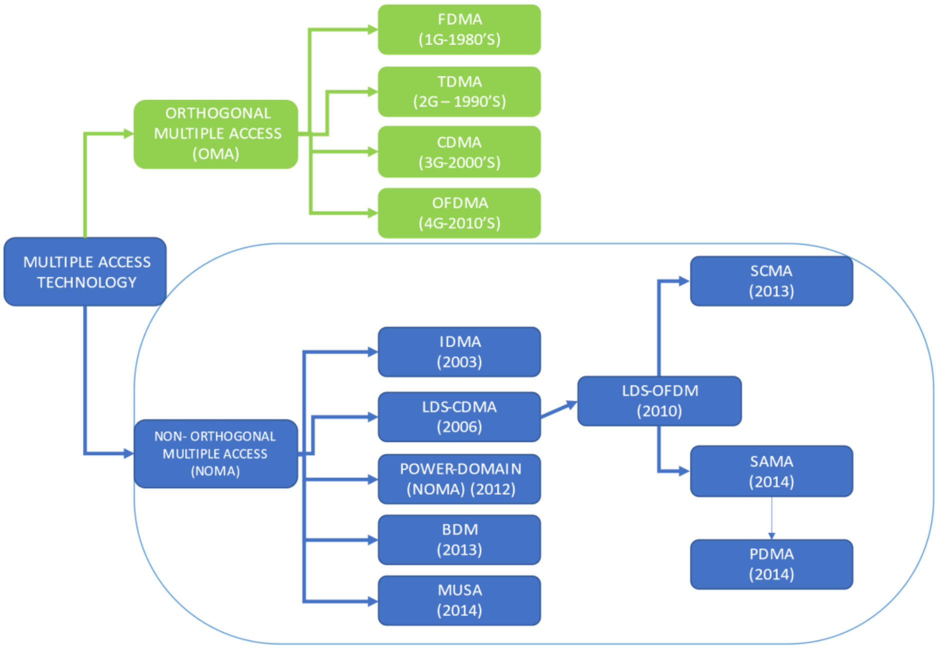

Figure 4.14: Multiple Access Technologies [94]

The CDMA system assigns the users with channels using codes that are generated using spread spectrum technology. NOMA describes the usage of several users in the power domain by examining the channel variations among multiplexed users. In the transmitter part, the overall signal is obtained by the combination or superimposes of different users data on the receiving side, Also the outgoing signals are sent to the same user at the same frequency. Multi-user acquisition techniques like Successive Interference Cancellation (SIC) are employed to obtain the preferred signals, as displayed in Figure 4.15

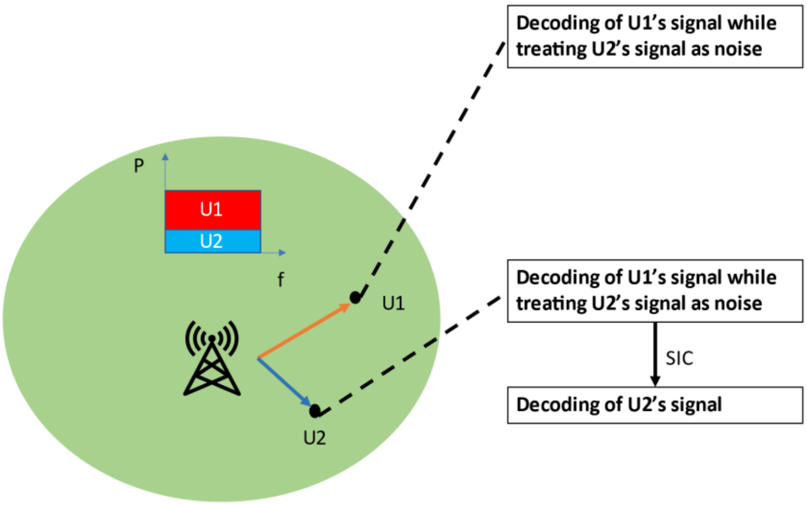

Figure 4.15: NOMA Technology [94]

4.2.2 Iterative Algorithm for NOMA

Given the random array's value, the complex-valued spectrum is defined as $S^o = p^{meas}\, exp(i\phi^o)$ to obtain the zeroth estimate from the series of longitudinal distributions, the following steps are performed on S^o. (ii) Apply the information to the distribution to impose temporal domain limits. In this process, the phase of the spectrum is calculated as $\phi^1 = arg\left(S^{r(1)}\right)$ .The first iteration estimate is then updated $S^1 = p^{meas}\, exp(i\phi^1)$. Iterative process is distinguished by the fact that several results are derived from the early phases, which are not necessarily exact and can be skewed. Because only one profile is required in the end, it is necessary to select and average the solutions provided. Averaging can be divided into several categories:

Averaging in two steps:

The first stage is to utilize the Hilbert profile as a comparison, as shown in Figure 4.16, and the second step is to use a new profile as a reference. The downside is that in order to obtain an advantage in X^2 we have to squander a lot of time. Averaging is a simple technique in which the weight is used to calculate the coefficient parameters that are needed to analyses the level of correlation. The similar procedure is also applicable to uniform averaging. For reconstruction methods, linear sampling is used.

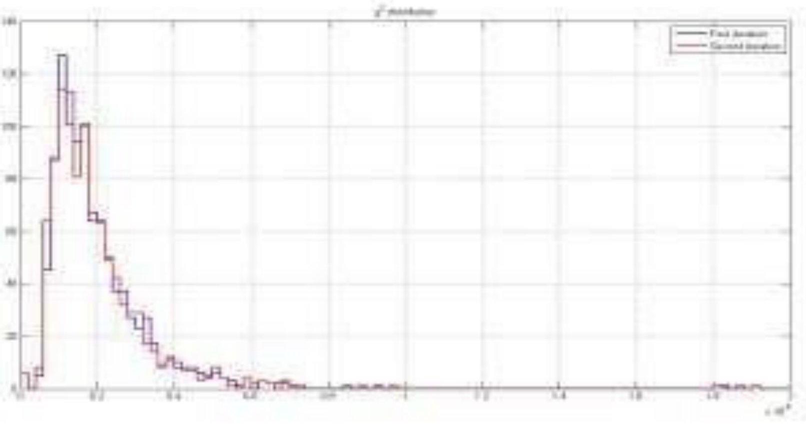

Figure 4.16: Averaging in Iterative Algorithm

Considering that the channel parameters are unknown and changing from time to time, it is difficult to remove the noise component in the frequency domain. The ICI and AWGN in the time domain are zero mean random process. The signal component is located at the lower frequency region and, while the noise component is spread over whole transform region. By applying appropriate filtering, the influence of noise can be suppressed. Moreover partially decoded data is used as side-information to improve the channel estimation and increase SE. We show that users with precise data estimates can help users with poor data estimates to decode.

4.2.3 Iterative Methodology

Multiple-input Multiple-output antenna methodology is used in wireless radio transmission to transmit and receive enormous information over different multiple paths. Various MIMO configurations are possible, such as 2*2, 4*4, and so on. MIMO Systems are divided into three categories: pre-coding, spatial multiplexing, and diversity coding. In MIMO-OFDM systems, channel estimation is an important part of analyzing the system's performance. Pre-coding and scheduling are made easier by measuring CSI.As shown in Figure 4.17, noise is added as an unwanted signal during transmission, interfering with the desired signal. Here, the AWGN and Rayleigh channel conditions are considered. When an AWGN channel is present, the output is calculated as

$$y(m) = x(m) + w(m) \tag{4.3}$$

Where $y(m)$ represents the output, $x(m)$ represents the input, and $w(m)$ represents the noise.

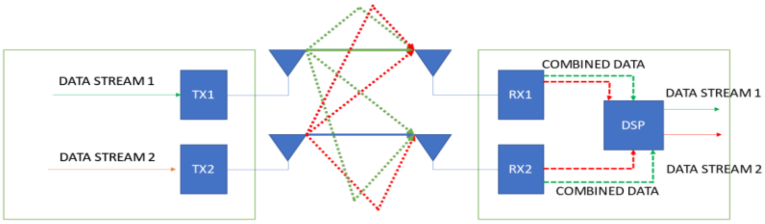

Figure 4.17: MIMO Principle

The output is calculated as follows in the presence of a Rayleigh fading channel,

$$y(m) = h(m)x(m) + w(m) \tag{4.4}$$

Where $h(m)$ denotes the fading process.

NOMA, OMA, and AOMA are the three different types of multiple carrier access systems that are considered here. When user 1 transmits the signal, as shown in Figure 4.18, they note the transmission power. The AWGN is used, with a mean and variance of zero. The decoding process of the users 1 and 2 signals are performed in two stages with the help of the SIC. The second user signal is analyzed first, with the first user signal being treated as noise. The receiver deducts the decoded signal from the receiver end and demodulates user 1 in the following stage. As the signal begins to propagate, it also begins to decay. It is known that as the distance between the antennas grows, signal strength decreases. Since it is a remote or wireless channel, the signal known as a reverberation or an echo signal that leads to a phasing lag in the delivery. With respect to MIMO, channel estimation is performed in the presence and absence of NOMA. The OMA (without NOMA) is implemented using a fixed and adaptive form of TDMA. Like in Figure 4.19, the Power Control feature in NOMA is used to reduce channel interference. In this case, the interference cancellation is performed using SIC (successive interference cancellation). NOMA, OMA, and AMOA are the three methods used to estimate the channel of a MIMO. Initialize the parameters such as SNR, power factors, and time synchronization.

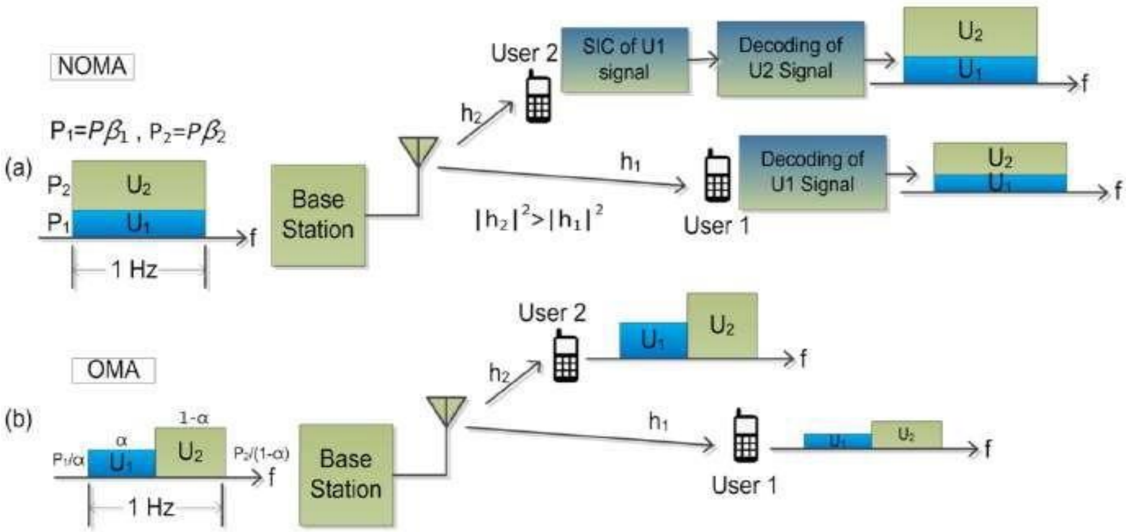

Figure 4.18: Illustration of (a) NOMA (b) OMA for two user scenario [4]

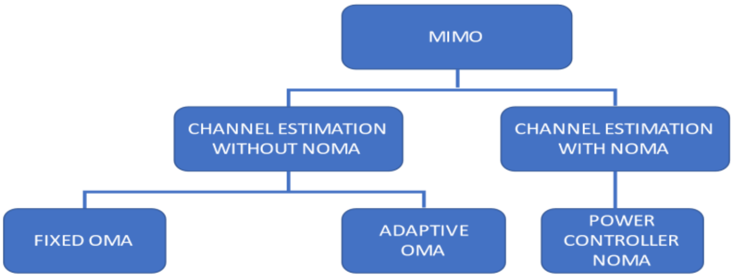

Figure 4.19: Method of Channel parameters prediction with and without NOMA

For the given threshold values, all losses are added together. They are calculated with SNR values in mind, as well as for multiple users. The fading losses are compared to the calculated Gaussian g^{th} values; the signal strength is estimated and presented as the result if the fading loss is substantial. The SNR for each user is calculated recursively, if the g^{th} values are essentially high, as depicted in Figure 4.20.

Two users are considered in an OFDM that are assumed to work with NOMA scheme, where the users transmit signals $S_k(m), k \in K = \{1,2\}$ on subcarrier $m \in \{1, \ldots \ldots, M\}$. To minimize or completely eliminate the effect of multi user on every sub carrier, two users data are considered. The SNR is estimated as

$$SNR = \frac{P}{N_0} \tag{4.5}$$

Where P denotes the transmit power and N_0 denotes the channel noise.

It is measured in decibels and is referred as

$$SNR_v = 10^{\frac{SNR_{db}}{10}} \tag{4.6}$$

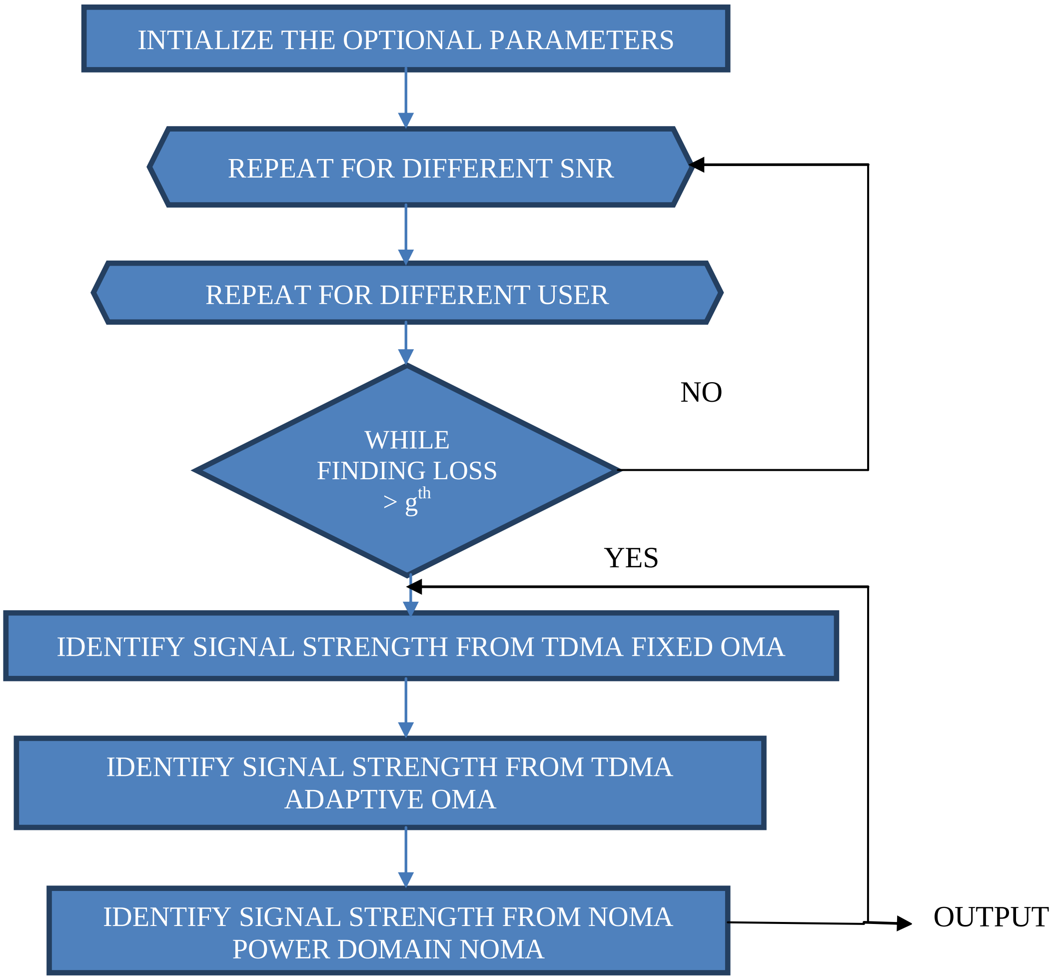

Figure 4.20: Flow chart to calculate different SNR to different users

In the analysis, the SNR time dependent variation is defined in terms of $t_{step} = 0.1\ seconds$ is used in the estimation process. It is calculated using $t_{step}: t_{step}: 1 - t_{step}$.

The Gaussian value is calculated using the route loss factor of -3.76 as

$$g^{th} = \left(\frac{35}{289}\right)^{PL} \tag{4.7}$$

This parameter is arrived by keeping the minimum normalized distance between users and the BS as 35/289, corresponding to an unnormalized distance of 35 m for a LTE cell with radius 289m.Path loss model is Log normal shadowing and the loss factor is considered as -3.76

The phase is determined as a function of time variations and therefore is symbolized by $0: p_{step}: 1$. The mathematical model reflects a uniformly generated signal:

$$a = rand(1,1) \tag{4.8}$$

Random signal is represented by

$$b = rand(1,1) \tag{4.10}$$

Signal transmitted is

$$signal\ T_x = \left(a * b * \sqrt{\frac{3}{2}}\right) * signal \tag{4.11}$$

The following formulas are used to determine Fading Loss and Group Loss:

$$P_{loss} = [norm(a,b)]^{PLfactor} \tag{4.12}$$

$$g_{LS} = P_{loss} + \left(\frac{log_{normal}}{P_{Lavg} * mlog}\right) \tag{4.13}$$

Where $log_{normal} = 10^{rand*0.8}$

Rayleigh gain is necessary to determine the overall loss, and it is derived by

$$R_{gain} = abs\left(\frac{(rand + li * rand)^2}{2}\right) \tag{4.14}$$

Combined or Overall loss is calculated using

$$G_{all} = g_{LS} * R_{gain} \tag{4.15}$$

4.2.3.1 Channel Estimation without the effect of NOMA

For the TDMA-based 4G connectivity, which would be the next development in telecommunications, MIMO-OFDM was developed. The usage of TDMA will address a few of the limitations of CDMA, like minimizing potential and multi - user identification difficulty. In this study, we will perform several numerical simulations to demonstrate the operation of the Adaptive TDMA and the Fixed TDMA. The two users communicate using the OFDM and NOMA combination $S_1(m), x_i \in X_1 = \{1,2\}$ on subcarrier $m \in \{1, \dots \dots M\}$. These two users are used to eliminate or reduce multiuser interference (MUI) on the subcarriers they use, as well as to help reduce computational complexity. Successive cancellation Interference Technique is utilized to propose appropriate distinction among the various users signals that are overlapped.

The distance among the user and the base station is then calculated as Power 'P_L' assigned to the user x_i .similarly the signals from the other users that are assigned on subcarrier m, may be denoted as $X_{x_i}^n(m) = \sqrt{PL_{x_i}(m)S_{x_i}^n(m)}$.

The Fixed TDMA is estimated based on the signal intensity and distortion in the transmission:

$$OMA = log_2(1 + G_{all} * P_{sum})/2 \tag{4.16}$$

The Adaptive TDMA uses a multi-access approach to provide users with multiple access points and designated as g_1, g_2.

The amount of shift in the phase quantity is determined as $p1_v = P_{sum} * PS_v$

The Adaptive Orthogonal multiple access in combination with TDMA is thus mentioned as:

$$rate1 = t_{temp} \tag{4.17}$$

$$rate2 = \left(1 - t_{temp}\right) * log_2\left(\frac{1+p_{zmax}}{(1-t_{max})*G(2)}\right) \tag{4.18}$$

$$AOMA(snr_{ix}) = AOMA(snr_{ix}) + sum(rate1 + rate2) \tag{4.19}$$

4.2.3.2 Channel Estimation with NOMA

The power control approach and the successive interference cancellation method are also shown to be used for the operation of the NOMA and OFDM. The power control method increases the signal strength and helps the signal to travel further distances. As a result, the signal will be able to reach its destination with minimal interference and disruption.

Step 1: To Identify Power control parameters with P_1 and P_2 as contribution of

source 1 and source 2

$$P_1 = P_{sum} + P_s \tag{4.20}$$

$$P_2 = P_{sum} + p1_v \tag{4.21}$$

Step 2: This step defines the equations to estimate the relative amplitudes for both the users

$$rate11 = log_2\left(1 + \frac{(g_1 + p_1)}{g_2 * p_2 + N_O}\right) \tag{4.22}$$

Where N_0 is average noise.

$$rate12 = log_2\left(1 + \frac{\frac{g_2}{p_2}}{N_0}\right) \tag{4.23}$$

Multiplying equation 4.22 and 4.23 we have,

$$Relativerate1 = rate11 * rate12 \tag{4.24}$$

As a result, then derive $rate21$ and $rate22$ for the other user in the same way as shown above, by taking

$$rate21 = log_2\left(1 + \frac{\frac{g_1}{p_1}}{N_0}\right) \tag{4.25}$$

$$rate22 = log_2\left(1 + \frac{(g_2 + p_2)}{g_1 * p_1 + N_O}\right) \tag{4.26}$$

Multiplying equation (4.25) and (4.26) we have,

$$Relativerate2 = rate21 * rate22 \tag{4.27}$$

Step 3: The output signal from the NOMA is then calculated using the relative power R_{1max} and R_{2max} .If the R_{1max} and R_{2max} values are respectively greater than or equal to 1, then the estimation of the signal is done with reference to either Relative Rate 1 or 2.

4.2.4 Simulation Results on NOMA using Iterative Algorithm

The proposed iterative approach is applied to assess the performance of multiple MIMO OFDM systems when the NOMA is present and not present. The average sum rate of the three distinct methods, OMA, AMOA, and NOMA is then calculated and shown in Table 4.1 and Figure 4.21 shows the results of the simulations and it depicts that the average sum-rate of the three methods is affected by the variation of the signal's SNR.

Table 4.1: Average Sum Rate versus SNR with and without NOMA

SNR (dB)	Average Sum Rate		
	Without NOMA		With NOMA
	OMA	AOMA	NOMA
0	0.248	0.275	0.286
5	0.469	0.521	0.551
10	0.839	0.928	1.003
15	1.397	1.53	1.692
20	2.183	2.354	2.664

The results of the simulations clearly tell about the performance of the multiple MIMO OFDM systems is significantly enhanced when the NOMA is present. In Table 4.2 and Figure 4.22, shows the simulation plot of logarithmic versus SNR.

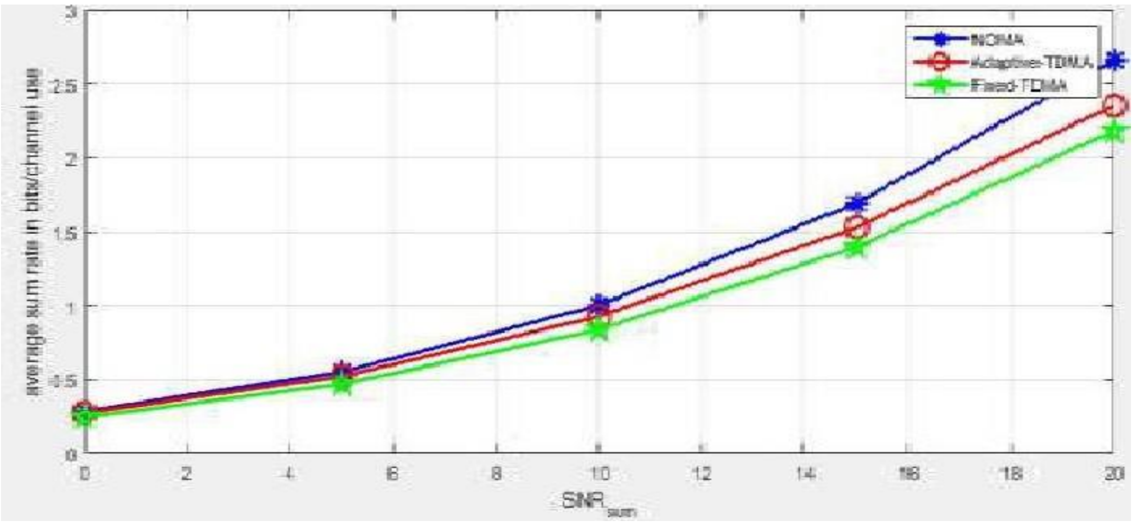

Figure 4.21: Average sum rate versus SNR

Table 4.2: Logarithmic values of Average Sum Rate versus SNR with and without NOMA

SNR (dB)	Average Sum Rate		
	Without NOMA		With NOMA
	Log OMA	Log AOMA	Log NOMA
0	-9.262	-9.261	-9.199
5	-7.135	-7.064	-7.027
10	-5.128	-5.029	-4.957
15	-3.317	-3.196	-3.073
20	-1.703	-1.574	-1.387

4.2.5 Summary of Iterative Algorithm on NOMA

In this work, an iterative strategy is used to tackle the channel prediction process for an OFDM system that is implemented with the concept of NOMA. Two users are shown here transmitting carrier data using a single antenna. When it comes to MIMO, there are a variety of transmissions to consider. We calculated the sum rates that can be achieved with OMA, AOMA, and NOMA using channel parameters that are calculated at the base station. Estimated values for estimated channels either with or without NOMA are provided, and determine that with NOMA, helps in communicating numerous signals simultaneously, also known as MIMO-NOMA. The findings of the studies suggest that using an iterative approach can lead to a significant enhancement in the overall performance of the multiple MIMO OFDM systems. Since the use of the OMA and NOMA in various areas has led to the development of new internet technologies, the proposed method is also beneficial for the transmission of signals.

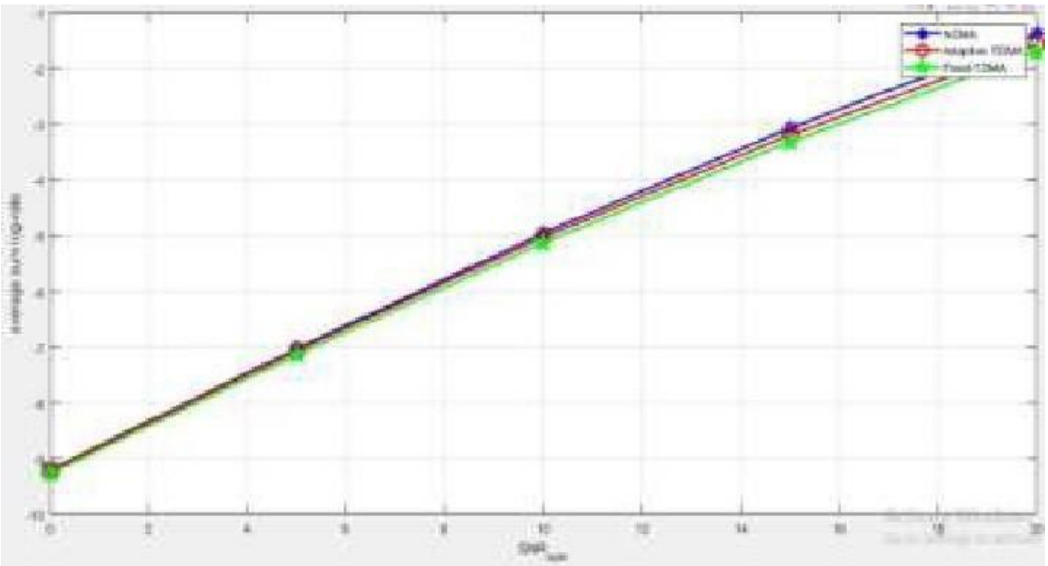

Figure 4.22 Plot of Logarithmic Variation of Average Sum rate vs SNR

4.2.6 Iterative Algorithm with MMSE

This work combines the highest beneficiary methods to get an optimized maximum likelihood detector to initiate the formation of beam formation that is based on the efficient hardware design, which is fast Fourier transform that has been detailed below:

1. The use of a centralized sub-detector at the end of the receiver improves the entire performance of the system by decreasing the complexity and modulation requirements of

the signal detector.

2. The bit error rate, consumption of power and signal to noise ratio are calculated using different kinds of channel approximation and comb-type detector finder codes.

3. The channel approximation which is Block type algorithm is implemented which is created on the pilot method. This is done using LS/MMSE.

4. The reference symbol is taken as a help to synchronize the received signal with the baseband, this complete process is oriented on frequency and the time. The received signal is very similar to the one related to symbol Cox and Schmidl.

5. The Sparse pre-coder performs very well when compared with the signal received by the receiver. It is analyzed using multi-stage optimization techniques.

6. There are few blind channel approaches like MIMO, NOMA and massive MIMO; these are considered to be Approximation standards, through which the compression and priority sensing are compared.

7. The techniques such as decision statistical combining and parallel interference cancellations are used to reduce and eliminate the ISI in the channel, and also this provides a detection of data samples [95] [96]. This is also based on the channel support iterative receiver. This employs soft estimation of the data symbols.

The proposed work will illustrate how the signal is detected in the multiuser network, and it also shows how to optimize the multi beam forming complexity levels and it shows how overall variations in the channel during the multipath propagation.

The major advantages of MIMO technique is proposed here. Few of them are to enhance the reliability, improvement of channel capacity, reduce the fading environment, and finally, measuring the spectral efficiency. The major drawback of MIMO system is, it can't be implemented with extra antennas in the portable devices that are adapted to this network. If a single antenna is being added to the wireless device, then the hardware complexity increases, this in turn will reduce the battery life of the network, it is observed that in several cases there is a scenario where the system experiences minimal diversity, the minimal diversity is because of the overall quantity of antennas. If there is a channel encountering the Doppler Effect, or if there is any in influence whether larger channel that causes delays spread, this will surely lead to the condition that reduces the efficiency.

4.2.6.1 FFT based multi beamforming

To improvise the current capacity of channel, i.e., to increase the bandwidth to a larger extent, the wireless communication of millimeter wave is authorized (>6 GHz).The millimeter waves must be highly directional as to achieve the radio propagation, that utilizes the sharp beam for the radio signal transmissions. The final result of all the system should be reduced power consumption and enhance the system efficiency; this is obtained through the larger array that has a sharp beam for multiple access points. If the signal is in terms of the millimeter wave, the fast Fourier transform is applied to confine it to the high-frequency multi-beam. The bits that are orthogonal XOR influenced by the formation of beam uniformly spaced in a linear array of antennas. The signals are obtained via FFT.

4.2.6.2 The Model of the Radix Factorization

There are few difficulties and cons that are generated because of the use of fast Fourier transform computation. This can be overcome by developing the approximation FFT by using the radix. The resultant will be enhanced energy levels and the performance will also be enhanced as the hardware utilization rate is increased. An extra output parameter should be obtained as an additional parameter that associates with the energy levels of the transceivers model and the latency of overall model. The significant factors that are considered in the estimation of the signal can be transformed into twiddle factors by implementing 2xs Complementary operation and logical swap in different forms of FFT approximations.

4.2.7 Simulation results for Iterative algorithm with MMSE

The ML technique in the proposed work can accommodate in accordance with the design view for the error minimization with the flexible trade off pertaining to the BER. In continuation the proposed ML based detector at the reception node it can easily find out the desired signal with the advantages of multiple beam forming at the sender node with the minimization of the interference among users in the transmission channel. The detector can easily mark the different signals from the proposed receiver in an MIMO channel as shown in Figure 4.23.

The proposed synthesizer for the process of reconstruction in the design, by achieving the minimized overheads with the essential statistical techniques are built for every sub detector for minimal process thereby reducing the number of points for detection of the order of modulation in the communication process. The Maximum likelihood detector is a unique kind of ML detector which is proposed and simulated with the considerable parameters for measuring of complexity and the comparative graph is as depicted in Figure 4.23. Hence it is recommended to select the better ML detector in proportional with the Likelihood to identify the errors which may be responsible for effective data exchange with orthogonal signal beams to assist MIMO systems. During the data transmission, interference at the receiver is also other parameter to consider inevitably hence ML based detector has opted with the Euclidean distance technique for classification of data and errors. The use of an iterative approach can lead to the achievement of significant sum capacity in the estimation of the signal by implementing the multiple signal estimators, such as the ESE of IDMA and the maximal ratio combiner. In the form of an irregular repeat-accumulate, the two are achieving the same sum capacity.

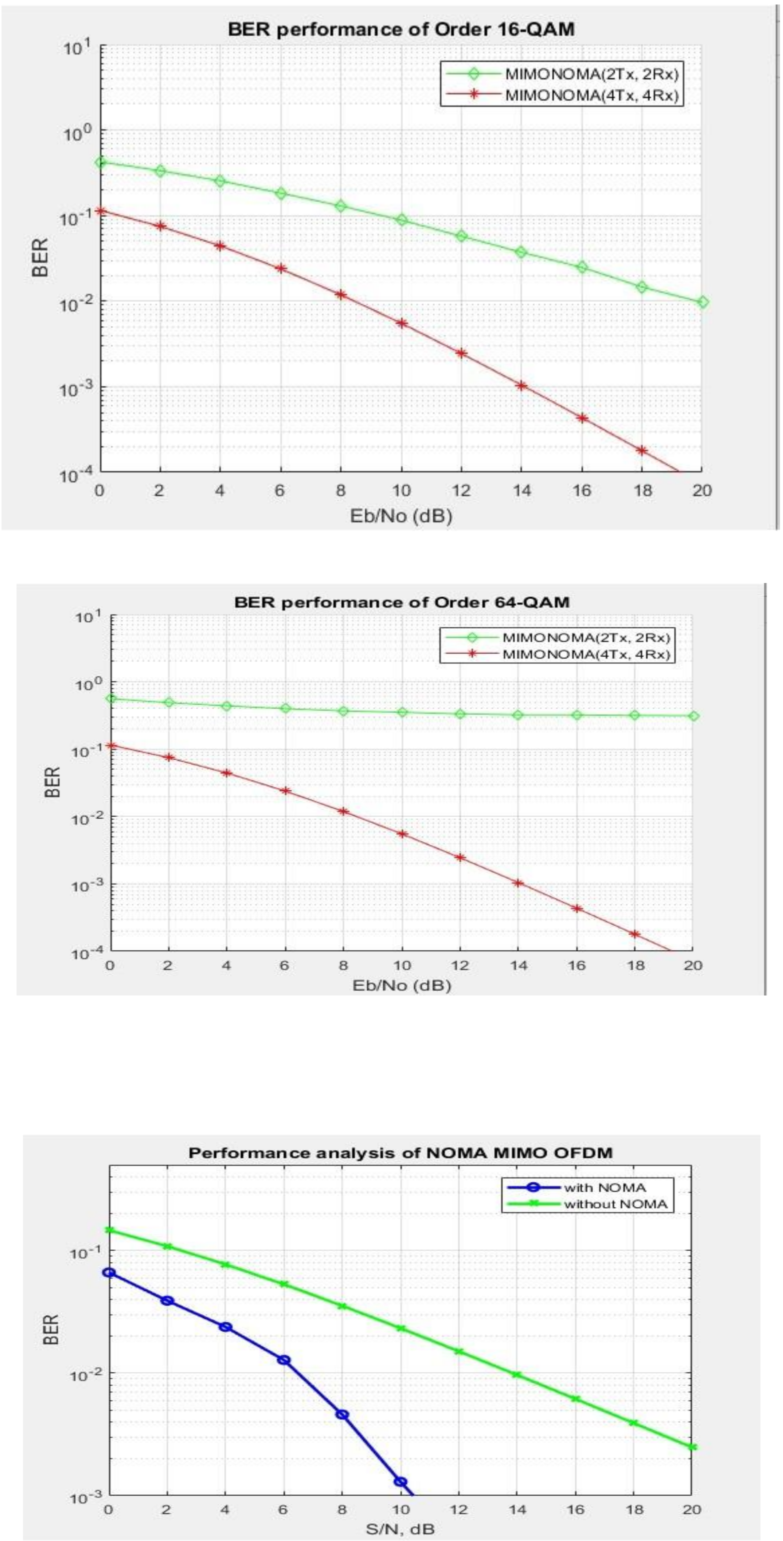

Figure 4.23: BER performance analysis for 2 x 2 and 4 x 4 MIMO-NOMA-OFDM combinations

A multi-user NOMA code is created for the LMMSE detection, which is designed to satisfy the constraints of different users. In order to build effective and efficient transfer functions, the code must be combined with the LMMSE detection. This work presents a feasible rate region for the development of the LMMSE multi-user code. Finally, as illustrated in Figure 4.24, an IRA multiuser code is created for the iterative LMMSE receiver. Simulation findings reveal that the proposed iterative LMMSE detection's BERs are within 1.4dB of the Shannon bounds and do better than existing approaches under various channel loads. Figure 4.25 shows how a typical MIMO NOMA system performs in terms of outage probability. The diagram below shows two clusters composed of two users each with three antennas. The strong and weak users have target data rates of 3 and 1.3 BPCU, respectively. The results of the analysis show that the NOMA system does better than the OMA system at high SNR values.

Figure 4.24: LMMSE reduction with iterations for 64 QAM modulation techniques

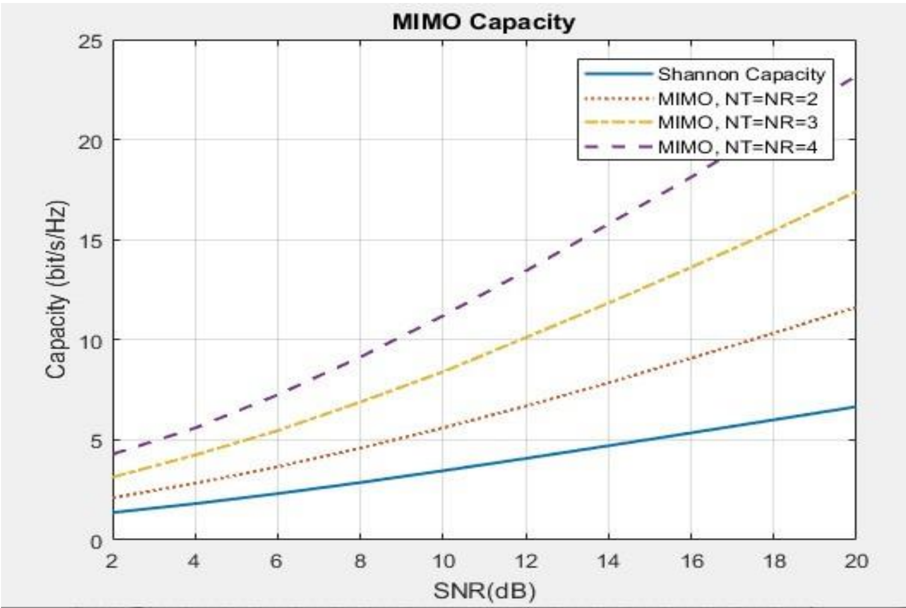

Figure 4.25: SNR level with various antennas representing channel capacity enhancement

The power allocation ratio is 1:4, and the strong and weak users' target data rates are 3 BPCU and 1.3 BPCU correspondingly. The graph shows that the MIMO NOMA system outperforms the MIMO OMA system, especially at high SNR values. The diversity gain of MIMO NOMA and MIMO OMA can be determined by analysing the slopes of the performance waveforms. MIMO NOMA, on the other hand, delivers a superior SE. A novel FFT technique is based on the factorization technique having minimized complexity is achieved in the proposed work. With the comparison carried among the proposed MU-MIMO system with the other existing conventional MIMO systems relative to WSN in terms of capacity of channel which has resulted in notably enhanced data transmission rate. In accordance with the higher data rate results, hence it is recommended to be in line with the Fifth Generation strategy of communication systems.

The major design challenge in terms of the consumption of energy and complexity of hardware with the comparison from existing techniques, for new proposed radix factorized FFT multi beam forming (RF-FFT-MBF) models for satisfaction of the next generation 5G device needs. The obtained results for the scaled highly efficient ML sub detector systems. The present work results with the higher efficient and least error rate for linearly reducing hardware complexity.

The main reason why the existing NOMA-MIMO modulations lose their orthogonality is due to the increasing number of inter-carrier and inter-symbol interference. Despite their good time-frequency localization and reduced OOBE features, the current generation of NOMA-MIMO modulations is still prone to getting affected by these factors. Furthermore, when the system undergoes frequency selective fading and the channel response is no longer at, channel equalization in NOMA-MIMO is a difficult operation. The use of multiple-input multiple-output (MIMO) in NOMA to enhance the efficiency of the system also increases the inter-antenna interference. To reduce the effects of this factor, the literature on the optimization of OFDM with NOMA systems has shown that the system is less sensitive to time-frequency selectivity. In addition, due to the improved robustness of the system's Doppler spread and frequency offset, it is less prone to experiencing significant interference.

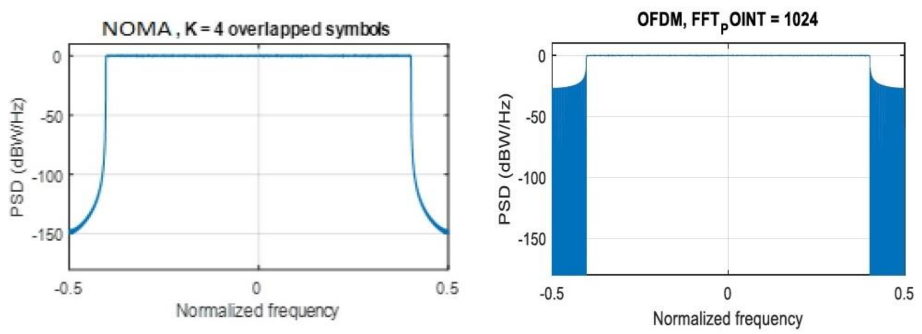

Figure 4.26: NOMA with MIMO vs OFDM performance metric analysis

As illustrated in Figure 4.26, the NOMA system is an excellent solution for reliable communication in temporal and frequency dispersive channels, as well as for multiple access systems. By dividing the spectrum into several tiny sub-channels, the NOMA-MIMO system works on the same multicarrier (MC) premise as the OFDM system. In general, NOMA is a multicarrier system with certain shaping filter approach for orthogonality, as shown in Figure 4.26, which has better NOMA condition than CP OFDM. Signal transmission across a frequency selective channel leads to inter symbol interference (ISI) and inter carrier interference in filter bank multicarrier modulation (FBMC) systems with NOMA (ICI). For weakly frequency selective channels, where each sub channel is at and QoS can be readily enhanced even with traditional equalisers such as the MMSE equalisation, this is inconsequential.

Unfortunately, linear equalizers are not able to deliver the required Quality of Service (QoS) for extremely frequency selective channels due to the lack of capacity. This is why a non-linear algorithm is needed to address this issue. The results of the simulations show that the proposed MMSE detection can outperform the existing approaches. The BER performance of the system can also be affected by the increasing number of modulation orders.

Table 4.3: Comparison of proposed NOMA-MIMO system and OFDM system in terms of SNR and BER under different K values and different levels of QAM modulation

	Proposed			Existing	
Parameter	SNR (dB)	BER	MMSE	SNR	BER
K=4 for 32QAM (PTS-SLM)	87.1	0.0073	0.0006	61dB	9.3x10-3
K=4 for 64QAM(PTS-SLM)	91.3	0.0091	0.0018	71.4dB	15.3x10-3
K=4 for 128QAM(PTS-SLM) of 3bD	63.4	0.0046	0.0031	45dB	10-3

4.2.8 Summary of Iterative Algorithm with MMSE

The contributions of the proposed research work can be listed as follows:

- Setting LMMSE as an adaptive in nature for achieving desirable rate as required.
- For the data of LMMSE estimation, the data can be tabulated for the realization of few things which are listed as follows:
  (i) The total power w.r.t MIMO-NOMA in an asymmetric mode of operation for limited consumers and with the ability of MIMO Non Orthogonal multiplexed access in symmetric mode of operation for registered wireless customers.

(ii) The maximum access edge locations for entire system in an MIMO-NOMA for residual users also.

(iii) Every user in the region of consideration for number of users as two or three in asymmetric mode of MIMO-NOMA.

The best potential closed-form application for two-user NOMA networks with downlink has been identified, highlighting the essence of including latency constraints in traditional optimization problems. Monte-Carlo simulations are also used to demonstrate the system's accuracy. For the downlink NOMA networks, a closed- form technique was designed to quantify the performance rate, Meta distribution, and mean local latency. Closed-form outputs are used to optimize the sent power of the downlink to improve performance without latency constraints or with latency constraints. However, the study of defective SIC, as well as the spatial correlation of intrusion in both downlink and uplink NOMA, has been completed. An achievable evaluation rate of the recursive LMMSE detection is shown for MIMO-NOMA, demonstrating that low-complexity recursive LMMSE detection can have an efficient area if well implemented.

- In two different instances of the repetitive receiver LMMSE in the ESE (Elementary Signal Estimator) including MRC (Maximal Ratio Combiner) in single output and several input criteria. Hence it is noted that single output for ESE of IDMA and single input for MRC by keeping multiple input and multiple output respectively with suitable capacity.
- The receiver is designed to have a suitable algorithm in recursive operation according to its functions.

- For LMMSE recognition process for the nonstandard customized IRA for multiple users are of various kind of approaching intensity of multi user NOMA is dedicatedly constructed.
- For the generation of exterior transfer functions which meets the needs for the different consumers in the network for a specialised IRA multi code is designed and tested by the LMMSE based synthesis.
- A novel LMMSE recognition technique with an novel accumulate technique in repetitive mode which does the good option than other existing techniques and in accordance with existing techniques was noted in the range of less than 0.8dB range.