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# A QoS Enabled Handover Mechanism for Future Generation Wireless Networks

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**ABSTRACT:** Wireless communication is undergoing a paradigm shift with emergence of high performance machine learning (ML) computing and internet of things (IoT). The demand for bandwidth has significantly risen due to multimedia applications and high speed data transfer. However, with increasing number of cellular users, the challenge is to effectively manage the limited spectrum allotment for wireless communication while maintaining satisfactory quality of service. Hence, different multiplexing techniques have been used to effectively use the available bandwidth. Recently, the concept of automatic fallback in receivers are gaining popularity due to high mobility in vehicular networks and IoT. Automatic fallback and handover mechanisms often utilize the channel state information (CSI) of the radio and can switch between technologies to provide the best available quality of service for particular spatial and temporal channel conditions. This paper presents a handover mechanism for wireless networks based on Quality of Service (QoS) of the system based on the System QoS. It has been shown that the proposed approach attains low values of error rate thus rendering high handover reliability.

**Keywords:**Wireless Networks, Handover, Channel State Information (CSI), Cognitive Networks, Software Defined Networks (SDNs).

## I. INTRODUCTION:

Wireless communications beyond 5G has emerged as new paradigm with enormous new possibilities such as metaverse, digital clones, large scale automation and internet of things to name a few [1]. However, all these new age concepts critically depend on the bandwidth availability and spectrum management in wireless networks. As bandwidth is limited, hence, effectively using the bandwidth is critically important to cater to the following needs [2]:

1) Increasing number of users.
2) Increased bandwidth requirement owing to multimedia data transfer.
3) Need for high data rates.
4) Limited available bandwidth.

Non-Orthogonal Multiple Access (NOMA) has gained a lot of attention as the future of multiple access techniques.Ubiquitously used variants of multiplexing happen to be FDM, OFDM and TDM [3]. However, NOMA owing to its effective spectral efficiency is sought after as the next generation multiple access technique. As in frequency division multiplexing and time division multiplexing, the signals of different users are separated in the frequency and time domains respectively, the signals in NOMA based multiple access, separation occurs in terms of the power value [4]One of the concerning issues however lies in the detection of the NOMA signal at the receiving end with the separation of the different user signals in the case of multipath propagation and small scale fading effects[5]. Conventional wireless networks are being re-configured as software defined networks (SDNs).

The pervasive nature of future wide area networks, IoT, Fog networks and cellular communications along with the necessity of higher data rate would need a constant monitoring and compliance to high quality of service (QoS) metrics. While different multiple access techniques are available at out disposal to accommodate the increasing number of users, yet sticking to one technique may not render desirable QoS metrics. Hence, there is an inevitable need for handover mechanisms which can used to automatically switch from one technique to the other in case one of the technique's parameters starts degrading [6]. Thus, automatic handover mechanisms would be better suited through fallback in SDNs whose architecture is depicted in figure 1.

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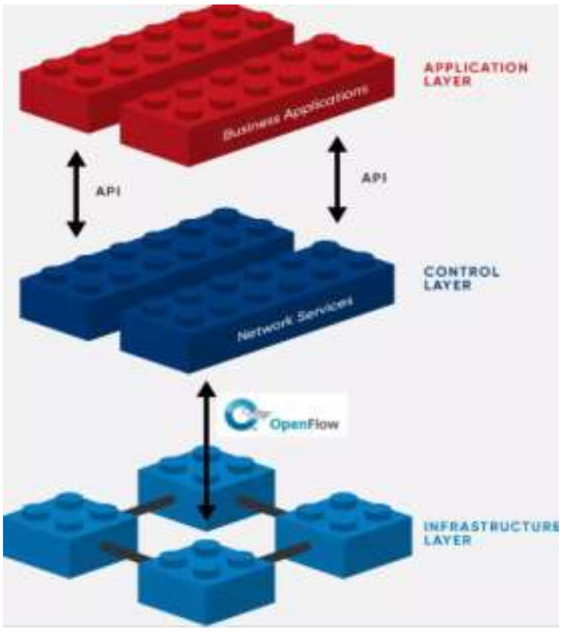


**Fig.1 The SDN framework**

The subsequent section presents the multipath propagation model and need for handover.

## II. MULTIPATH PROPAGATION AND CHANNEL GAIN

The problem with wireless communication is the random nature of wireless channel and the mobility of users. While the random nature of wireless channel creates distortions in the received signal, the mobility of users results in fading effects and signal degradation. Typically these two effect act in conjugation and result in degradation in the Quality of Service (QoS) of the system, which can be evaluated in terms of the latency, interference and bit error rate of the system [7]. Practical channels do not follow the conditions for distortion less transmission given by:

$$\mathbf{mod(H(f) = k} \qquad \textbf{(1)}$$

Here,
H(f) is the channel frequency response
K is constant

After considering the multipath effects, it is convenient to understand the concept of successive signal detection and equalization. Practical wireless channels generally depict multi path propagation from different interacting objects (IOs) and hence show a discrete non-singular channel response[8].

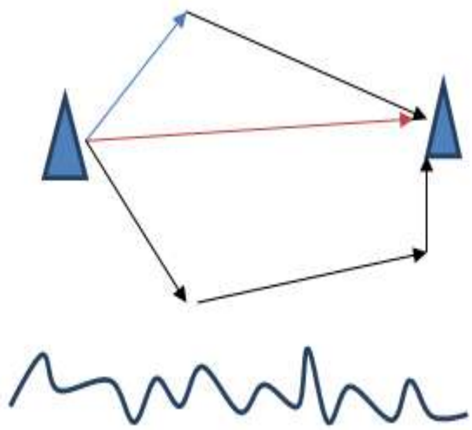

**Fig.2 Inter Symbol Interference (ISI) caused due to multipath propagation**

The impulse response of such a channel can be modeled as:

$$\mathbf{h(t) = \sum_{i=1}^{k} \delta_i(t)} \qquad \textbf{(2)}$$

Here,
H(t) is the impulse response of the channel
δ represents the impulse function
The frequency domain counterpart of the channel impulse response is the channel frequency response H(f) given by[9]:

$$\mathbf{H(f) = \int_{-\infty}^{\infty} h(t) e^{-j\omega t}\, dt} \qquad \textbf{(3)}$$

Here,
The operator represents the Fourier Transform
H(f) is the channel in frequency domain
h(t) is the impulse response of the channel
ω represents angular frequency
t is the time variable

## III. PROPOSED HANDOVER MECHANISM BASED ON AUTOMATIC FALLBACK

Typically, even with the use of equalizers and inter-leavers, noise effects can not be mitigated completely. They act as reduction mechanisms. Signal fading effects result in outages and poor quality of service. Hence alternatives to restore quality of service are sought [10]. One of the most effective techniques is the use of handover [11].Vertical handovers refer to the automatic fall-over from one technology to another in order to maintain communication. In cellular communication, candidates with similar QoS performance can be considered for handover[12]. As far as 5G and onward technologies are concerned, OFDM and NOMA are suitable candidates due to their high spectral efficiency. In case NOMA is the preferred candidate, an automatic fall back candidate can be considered to be OFDM. However, the choice of candidates to implement handover should satisfy the conditions of co-existence [13]

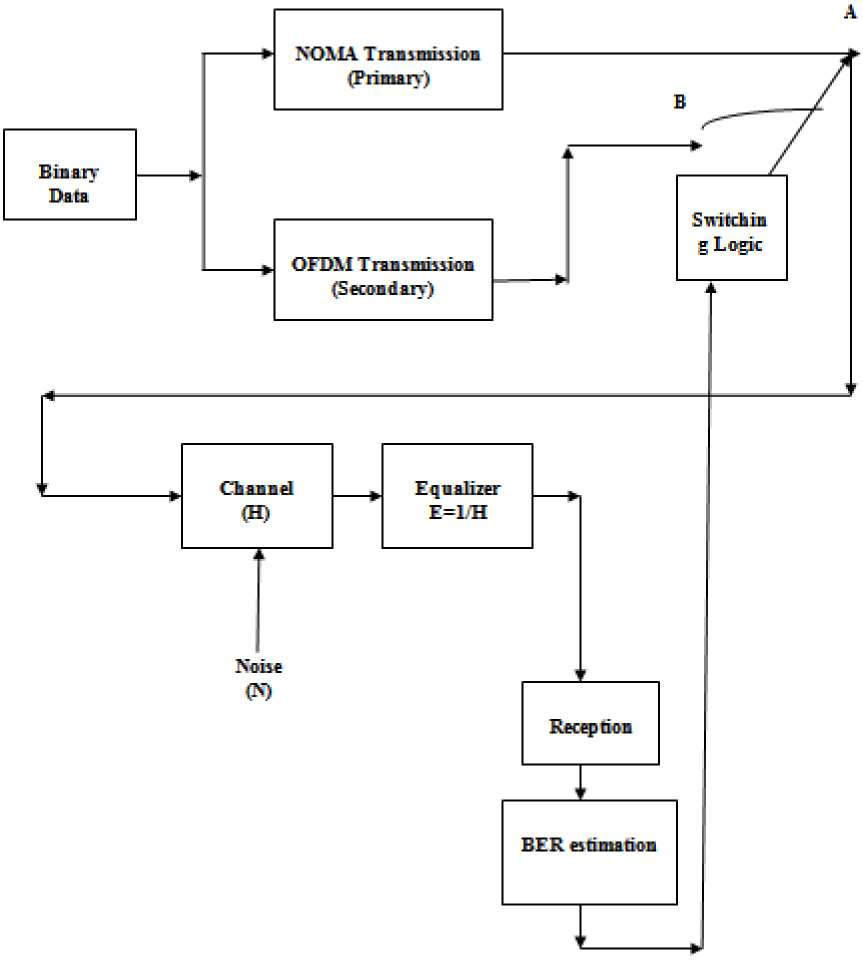


**Fig.3 Proposed Transceiver Design**

To estimate the channel,
Compute the error in time domain as:
$e(t) = y(t) - d(t)$ at the receiving end.
Obtain h(t) as:

$$\mathbf{h(t) = y(t = e(t)} \qquad \textbf{(4)}$$

The flowchart of the proposed system shows the flow of control in the handover process.

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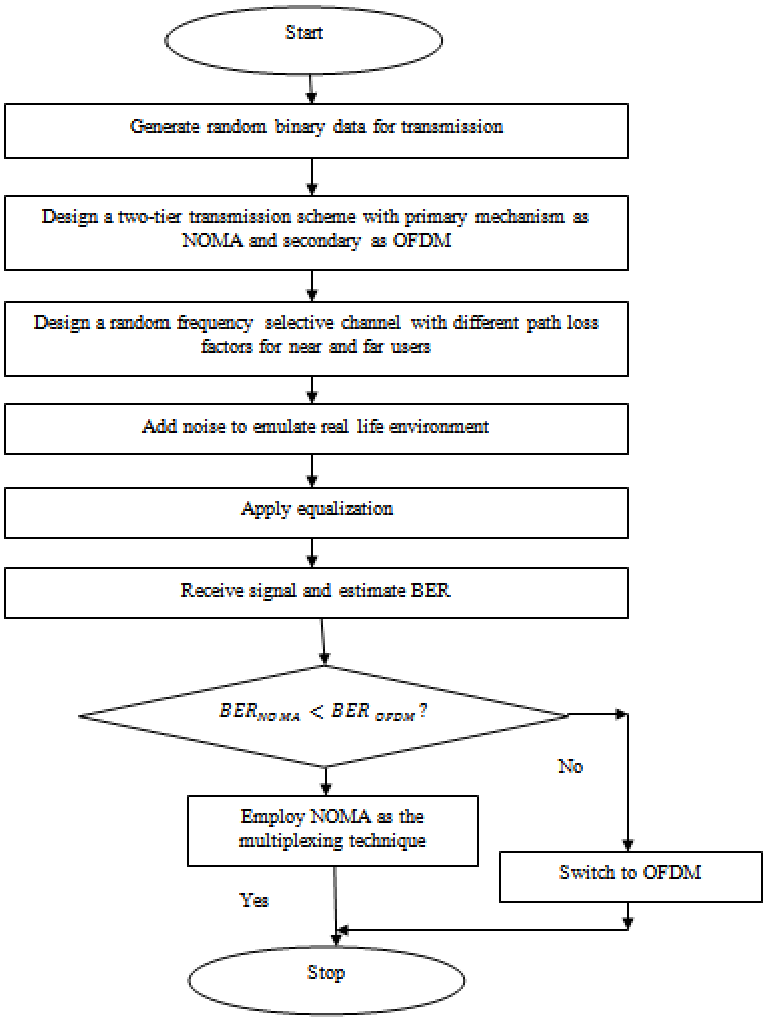


**Fig. 4 Flowchart of proposed system**

To, estimate the BER of the system for NOMA and OFDM,
if ($BER_{NOMA} < BER_{OFDM}$ )
{
Choose NOMA as the transmission technique
else
{
Fall back to OFDM
}
It has been discussed that a major challenge of NOMA based multiple access technique is the fact that small scale fading effects and multipath propagation make the amplitude of the power variable at the receiving end. This results in difficulty of separating the signals of different users with equal reliability [14].
This process can be applied iteratively for samples over a period 'T'. Thus the samples of the equalizer (to be designed as a filter) can be given by:

$$\mathbf{h(t) = \sum_{i=1}^{N} h_i(t)} \quad \textbf{(5)}$$

Finally, convert h(t) in the frequency domain by evaluation of:

$$\mathbf{H(f) = \int_{-\infty}^{+\infty} h(t)e^{-j2\pi ft}dt} \quad \textbf{(6)}$$

For reception of the signal, evaluate the following:

$$\mathbf{S_i = sign\{real[S_{composite}(t)]\}} \quad \textbf{(7)}$$

$$\mathbf{S_q = sign\{real[S_{composite}(t)]\}} \quad \textbf{(8)}$$

Here,
I represents the in-phase component

The error rate is the most common reliability metric and is defined as:

$$\mathbf{BER} = \frac{\text{Number of Error Bits}}{\text{Total Number of Bits}} \quad \mathbf{(9)}$$

Moreover, the BER depends on the SNR of the system mathematically which is given by:

$$\mathbf{P_{err} = f\,\{Q\left[\sqrt{\frac{S}{N}}\right]\}(10)}$$

Here,
Q represents the Q function
S represents signal power
N represents noise power

## IV. EXPERIMENTAL RESULTS

The typical multi user detection mechanism has been developed in the proposed work.

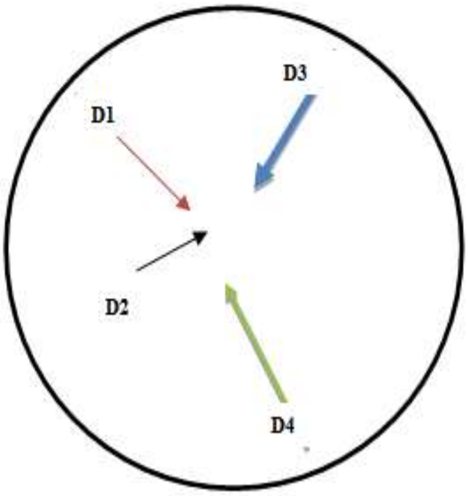


**Fig.5 A typical MUD scenario.**

The multipath propagation mechanism in the system generally comprises of:

1) LOS (ideal)
2) MPC for near users
3) MPC for far users.

The significance of the multipath propagation model is the fact that often the amplitude at the receiver keeps varying due to the fact that small scale fading is prevalent at the receiving end.
In this case,
LOS travels d1
MPC 1 travels d2
MPC 2 travels d3

Also,
**d1<d2<d3**

Different users send their signals at different power levels. In general, the user farthest away from the receiver would face the most severe fading. On the contrary, the user nearest to the base station would face the least fading, Hence, the users can be categorized into 2 major categories which are:

1) **Near User**
2) **Far User**

TheCognitive networks have gained a lot of prominence majorly after the advancements in high performance stochastic computing which enables real time analysis of channel models to estimate the channel conditions [15]. Moreover, cognitive radio networks (CRNs) are capable of selecting the band of frequency and also the modulation type and the power metrics that are required and are the best fit for the specific conditions of an area and its regulatory policies. The spectrum sensing mechanisms is a very active research area in relation to the cognitive radio networks. This domain has advanced immensely as the number of cognitive radio applications have increased over the last few years [16].

The system is designed on **MATLAB 2022a** whose results are presented subsequently. The binary data transmission has been used to emulate an IoT system model. The near and far user cases have been employed for the proposed model with NOMA and OFDM being the handover techniques.

:

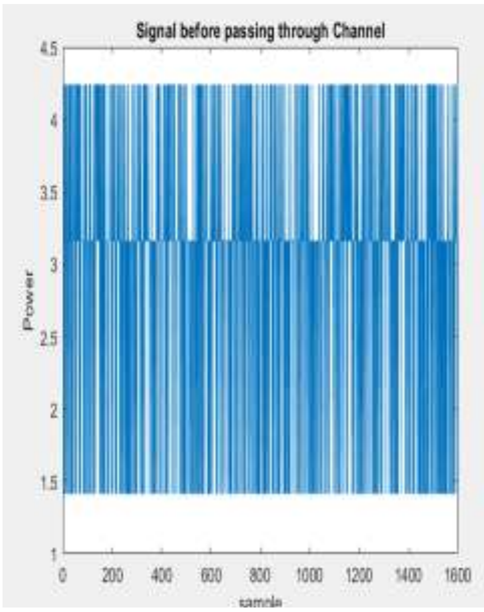


**Fig.6 Transmitted binary signal**

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The (AWGN) model does not adequately represent the channel for these modern applications. Moreover, the Line-Of-Sight (LOS) path between the transmitter and the receiver may or may not exist in such a channel.

Here,

psd represents the power spectral density

f represents frequency

$\frac{N_0}{2}$ represents the two sided AWGN psd

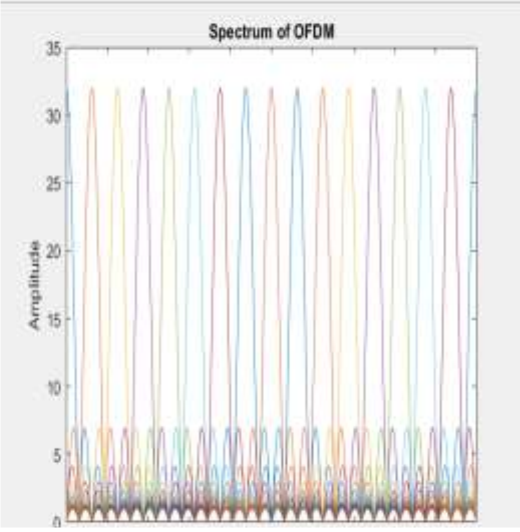


**Fig.7 Spectrum of OFDM**

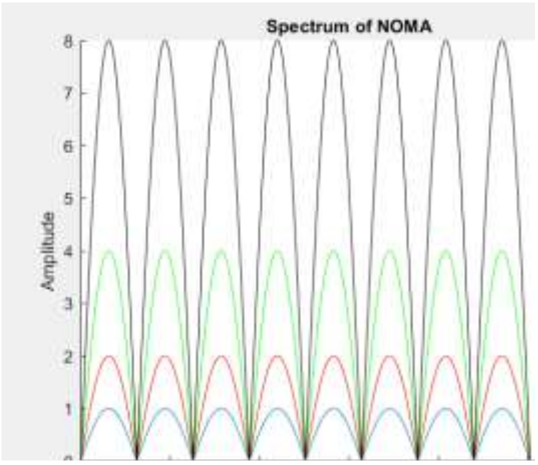


**Fig.8 Spectrum of NOMA**

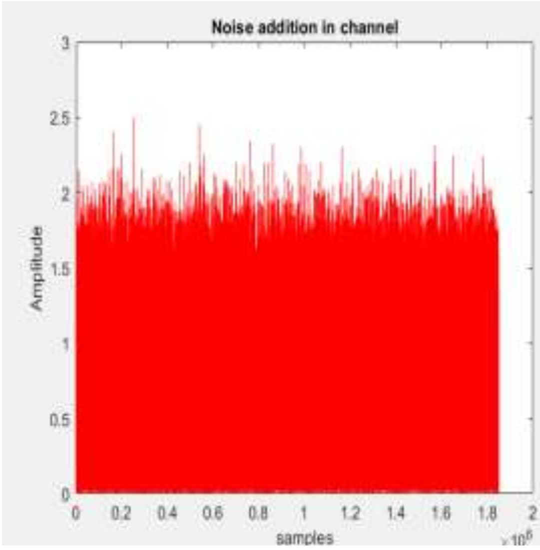


**Fig.9 Addition of Noise in the Channel**

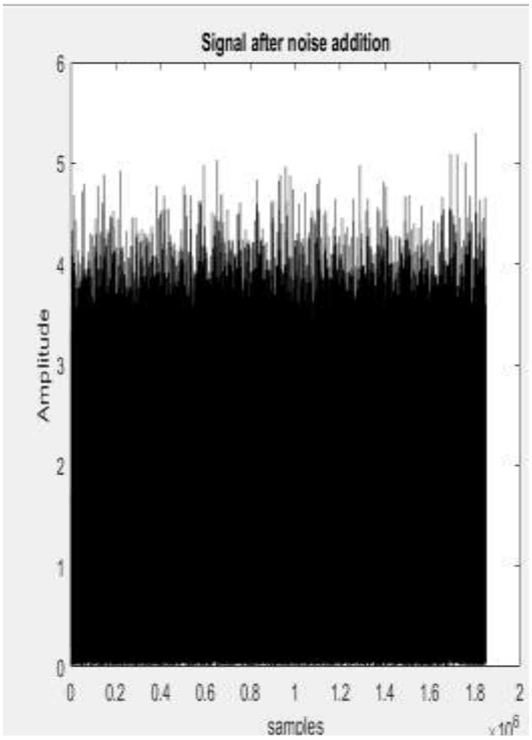


**Fig.10 Signal after passing through channel**

Figure 10 depicts the signal which has been affected by the white noise in the system.

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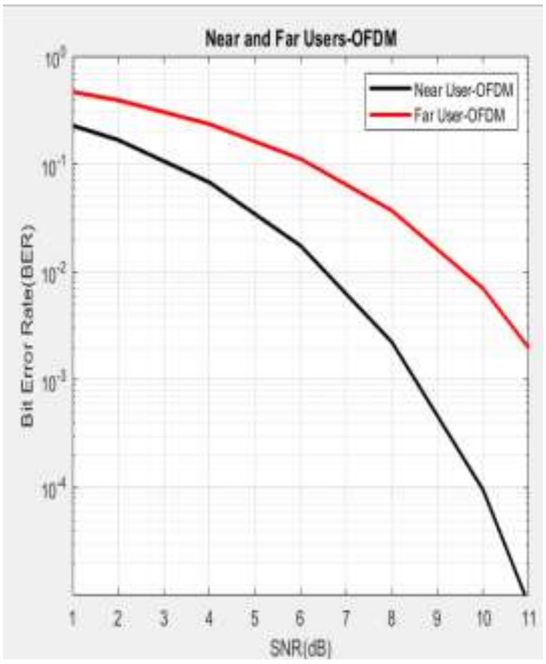


**Fig.11 Near and Far user condition for OFDM**

The figure above depicts the BER performance for near and far users in OFDM. It can be seen that the far users have a higher BER compared to the near users.

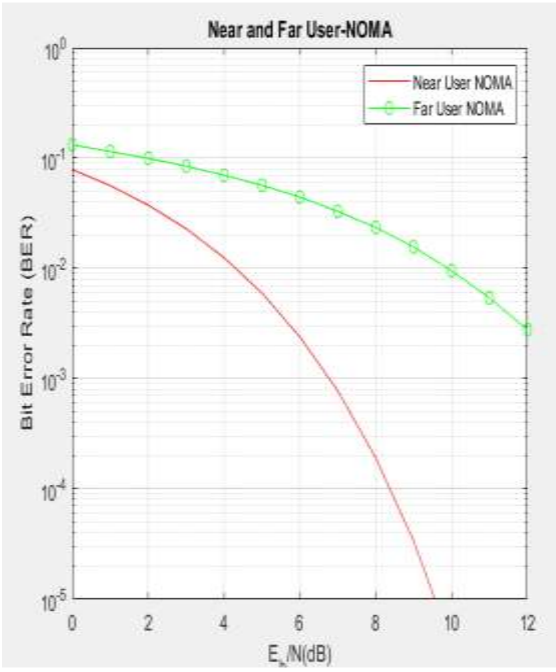


**Fig.12 Average user without proposed algorithm**

The figure above depicts the BER performance for near and far users in NOMA. It can be seen that, as in the case of OFDM, for NOMA too the far users have a higher BER compared to the near users.

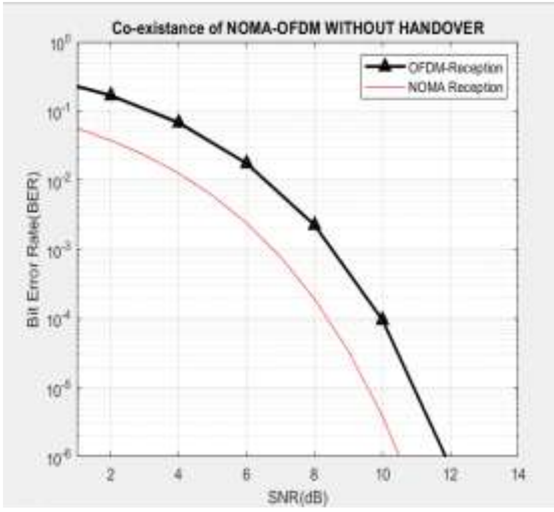


**Fig.13 Co-existence of NOMA-OFDM**

The figure above shows the BER condition for the co-existence of NOMA and OFDM without the handover condition as the primary modulation scheme (NOMA) has a low BER metric value for the entire range of SNR.

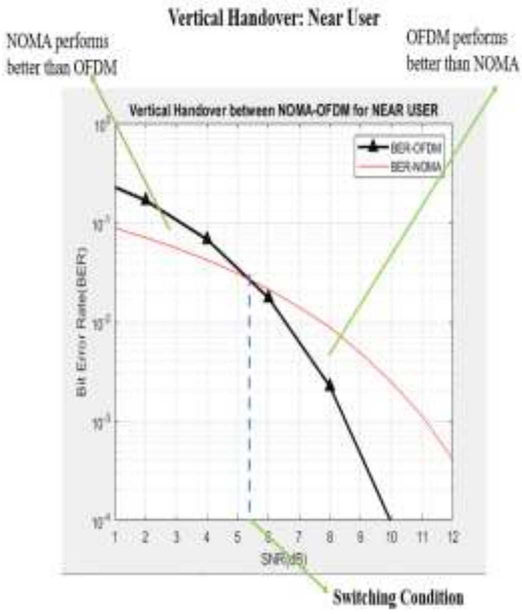


**Fig.14 Vertical handover for near user condition**

The figure above shows the condition for switching among NOMA and OFDM for the near user scenario. It can be seen that prior to the intersection point, NOMA performs better while after the intersection point, OFDM performs better in terms of system BER.

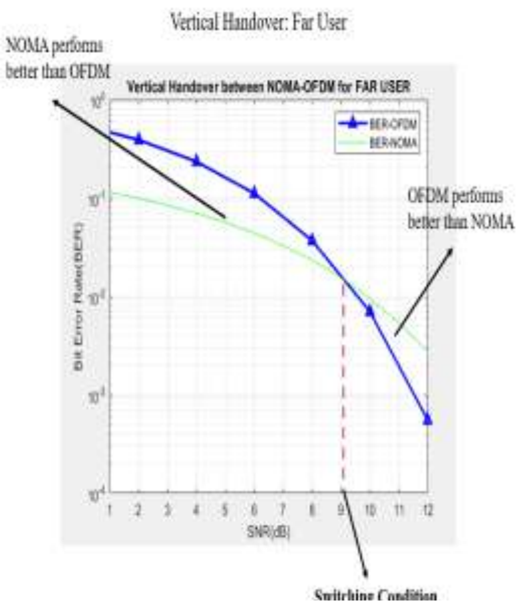


**Fig.15 Vertical handover for far user condition**

The figure above shows the condition for switching among NOMA and OFDM for the far user scenario. A similar pattern is seen with the difference that the BER now falls slower compared to the near user condition implying the fact that SNR is relatively less.

## V. CONCLUSION

It can be concluded from previous discussions that automatic fallback is necessary for practical wireless systems as multi-path propagation, fading effects and noise result in signal degradation and increase in the bit error rate of the system. In this work, a system is designed which employs automatic fallback between two contenders which are chosen as NOMA and OFDM. The BER is chosen as the switching parameter. It has be earlier shown that OFDM and NOMA can serve to be competing or parallel contenders for transmission.It has been shown that in case of non-intersecting BER curves, the condition remains to be that of non-handover since one of the techniques for transmission continuously outperforms the other in terms of the performance metric (BER). In case of handover, concurrent BER curves for OFDM and NOMA intersect to create a point of intersection. The region prior to and subsequent to the intersection point govern the technology to be used.

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