

An Effective Investigation On Deep Learning Based CSI-Driven Adaptive Handover Among OFDM, FBMC And Noma For QoS Enhancement In Next-Generation Wireless Networks

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Abstract

Machine Learning and Deep Learning are transforming modern wireless communications. With the increasing number of users in cellular networks and need for increased bandwidth requirement owing to multimedia applications, the choice and utilization of effective multiplexing techniques for 6G onwards has become mandatory. Orthogonal Frequency Division Multiplexing (OFDM), Filter Bank Multicarrier (FBMC) and Non-Orthogonal Multiple Access (NOMA) have been leading contenders for multiplexing for future generation wireless communications. High data rates, low bit error rate (BER), low latency and packet loss are fundamental requirements of wireless communications which may be challenging to achieve under fading channel conditions with mobile users. One of the technologies may perform better than the other under practical channel conditions and user attributes which points to the fact that co-existence and vertical handover among the technologies would increase the Quality of Service (QoS) if a choice among multiple techniques is provided. Moreover, estimating the wireless channel state information (CSI) would also facilitate the decision of picking a particular technology in real time scenarios.

Keywords: Wireless Communications, Machine Learning, Software Defined Networks, Channel State Information (CSI)

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I. Introduction

With the advent of data driven machine learning models, wireless networks are also harnessing pattern recognition and estimation for improving Quality of Service (QoS) metrics in pervasive networks such as internet of things (IoT), edge computing and fog computing. One such practical application happens to be switching from one multiple access technique to the other, often termed as handover. It is necessary to meet the constraints of hardware as well as software in terms of available bandwidth and latency to design optimal networks. Often a rigid network design doesn't suffice for the network constraints in real time. Hence, handover is an essential part of the network design wherein the network can switch between different configurations so as to maintain satisfactory quality of service.

Table.1 Major Handover Types

OFDM	NOMA	Comparative Analysis
Orthogonal sub-carrier separation	Power Level Separation	NOMA exhibits higher spectral efficiency
Mandatory: Orthogonality among carriers	Mandatory: Significant power difference among carriers	Fading conditions may deteriorate power level Separation.
Relatively lower throughput	Relatively higher throughput	NOMA beats OFDM in throughput metric.

Relative lesser Spectral efficiency „ η “	Relatively higher Spectral efficiency „ η “	NOMA beats OFDM in terms of spectral efficiency
Reception requires Orthogonal separation: relatively simpler	Reception requires power separation: relatively complex	OFDM clearly has a less Complex receiver design than NOMA
By dint of orthogonality, the effect of path loss is less prominent.	By dint of power separation, the effect of path loss is much more prominent.	OFDM clearly triumphs over NOMA if impact of QoS based on path loss is considered

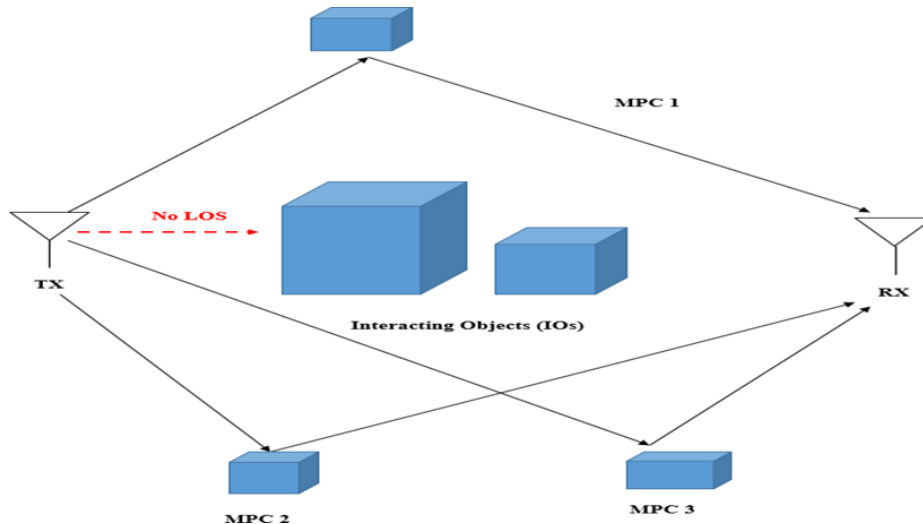


Fig. 1.-The Rayleigh Fading Model

The Rayleigh Fading Channel: A Rayleigh fading channel is a wireless channel in which there is no line of sight (LOS) but only multi path components (MPCs). Rayleigh fading is a channel model when there are many objects in the environment that scatter the radio signal before it arrives at the receiver. Such objects are called interacting objects or IOs. The Rayleigh fading channel is typically suited to urban areas with heavy population, buildings etc. This type of fading results in a fluctuating level of power received at the receiver.

II. Objectives Of Study

The objectives of the proposed work are:

- Analyzing the variations in signal strength under fading wireless conditions.
- Analyzing the conditions for co-existence among multiple access techniques.
- Selecting features which can govern vertical handovers.

Designing an optimized automatic data driven handover mechanism among multiple access techniques.

Computing parameters such as iterations to convergence, mean squared error, regression, bit error rate and outage probability.

Obtaining low values of iterations to convergence, BER and outage

III. Proposed Methodology

Need for Handover

Wireless Future generation wireless communications will face the following challenges:

High User Mobility and Interconnected Devices (Ex. IoT/Edge Computing)

Need to support high data rates (~GBps).

Seamless connectivity and minimal outages.

Limited Bandwidth.

Continuously increasing number of users and data traffic.

Moreover, user mobility would result in both temporal and frequency selective nature of wireless channels coming into play, where the channel response would be given by:

$$\text{Channel response} = H(f, t) \tag{3.1}$$

Here,

H represents the channel response

f is the operating frequency

t is the time metric

Channel Estimation

The practical wireless channels are generally functions of frequency and time both. The channel state information can be obtained by summing up the samples of the channel response at regular time steps of „T“ each assuming quasi-stationary of the channel and can be modelled as [75]:

Here,
 $CSI_t = \sum^n_{i=1} H(f, t - Ti)$ (3.2)
 T is time step for sensing
 $i \in N$; set of natural numbers
 CSI_t temporal channel state response

H corresponds to the frequency domain response of the practical wireless channel. Practical wireless channels seldom follow the conditions for distortion less transmission given by [76]:

$H(\omega) = K \forall \omega$ (3.3)

$P(\omega) = -k(\omega) \forall \omega$ (3.4)

Here,
 $H(\omega)$ represents the magnitude response of the channel.
 $P(\omega)$ represents the phase response of the channel.
 ω represents the angular frequency given by:

$\omega = 2\pi f$ (3.5)

K is a constant
 $-k(\omega)$ represents a linear function of ω

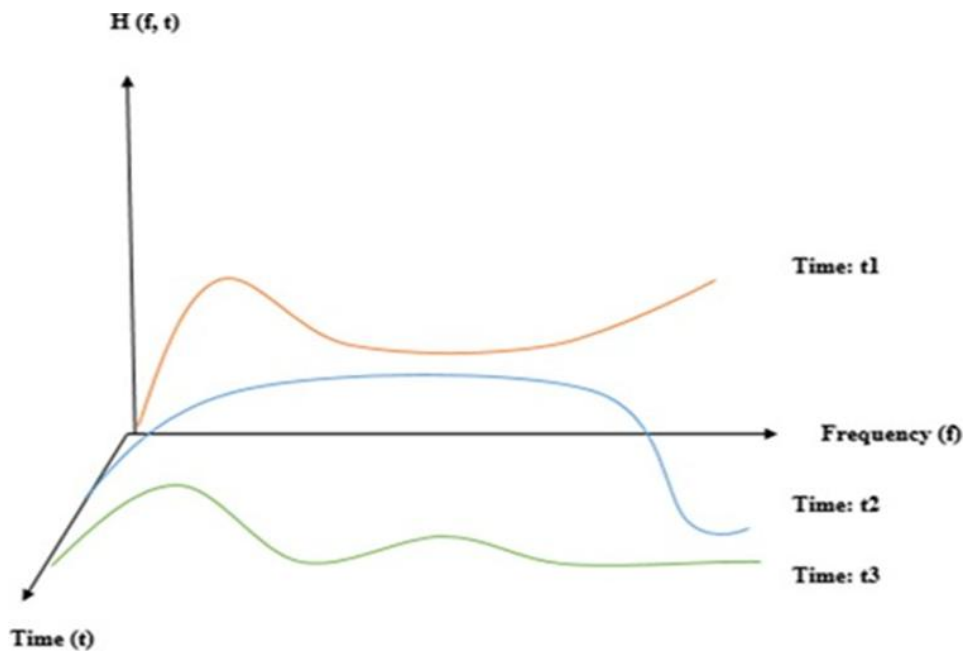


Fig.2 Practical Channel Characteristics

Thus, the need for estimating the channel response is critically important for two major reasons:

- Obtaining the CSI
- Obtaining the spectrum hole in the system.

Obtaining the spectrum holes i.e. the free part of the spectrum is necessary to allocate spectrum to new users and can be done through cognizance of the channel through the channel sensing mechanism of cognitive networks.

Channel Sensing and Equalization:

It is necessary to sense the channel conditions continuously or recursively as the channel’s response and hence the channel state information (CSI) keeps changing [77]. A typical frequency selective channel sensing illustration is depicted in figure 4.2.

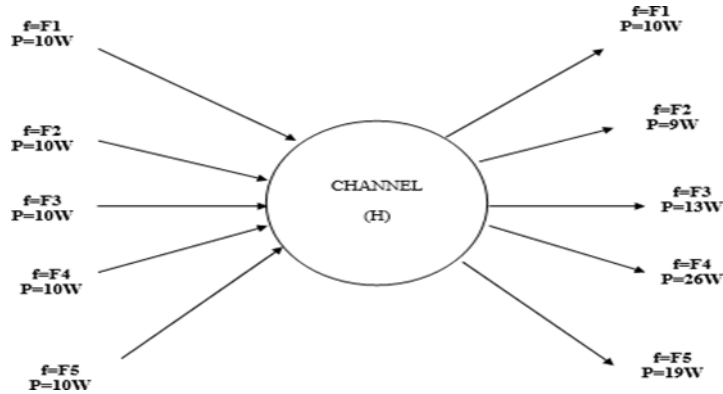


Fig.3 Frequency Selective Nature of channel

Figure 3 depicts a typical channel response H for a frequency selective practical wireless channel typically utilized in IoT systems. The channel response is often evaluated based on the sensed energy for each frequency. For instance, the channel Response of any frequency f is computed as,

$$H_f = \frac{O_f}{I_f}$$

Where,

H_f is the channel response for frequency f .

O_f is the output power of the channel for frequency f .

I_f is the input power of the channel for frequency f .

To estimate the complete channel response (CSI) or $H(f, t)$, the channel is to be sensed periodically, every T_S seconds for all the frequencies in the bandwidth under interest.

Here,

T_S is called the sampling time for the cognitive network.

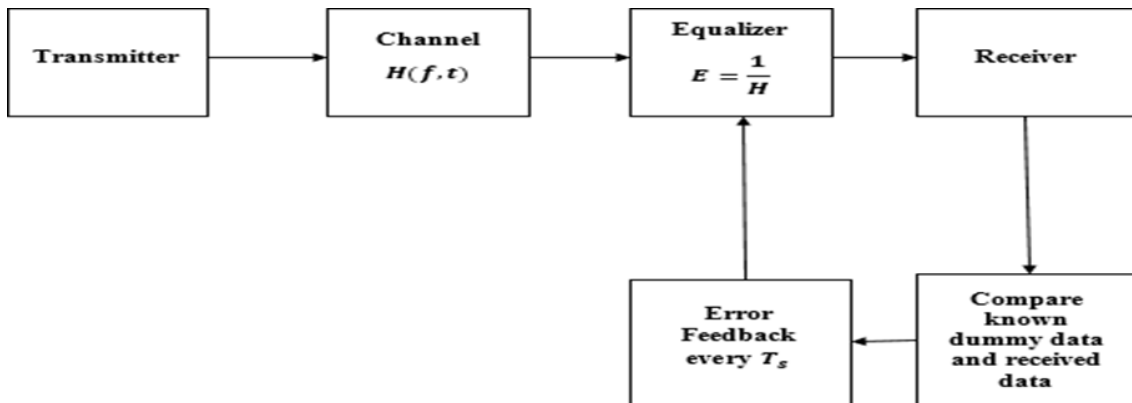


Fig.4 The Equalization Mechanism

The equalization has to be performed every T_S seconds as the channel sensing has to be repeated periodically to estimate the updated channel response. The advantage of such an approach would be an updated version of the channel state information (CSI) but having a major constraint of enhanced complexity of the system. Thus, the proposed algorithm aims at continuously estimating the channel state response to evaluate the jamming activity and avoiding the bandwidth section which is prone to moderate and high jamming activity.

IV. Experimental Results & Graphs:

Expected Results

The proposed system has been designed so as to emulate a real-world wireless data transfer mechanism that is identical to IoT data transmission. The simulation results are presented subsequently.

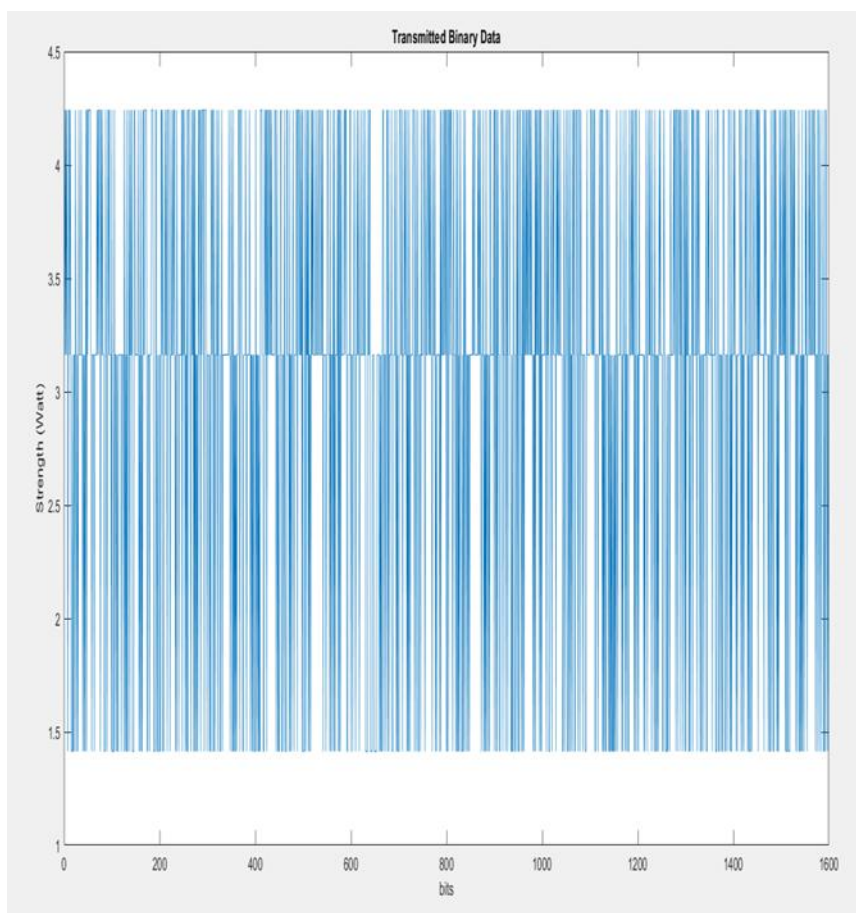


Fig.5 Transmitted binary data

Figure 5 depicts the transmitted binary data that emulates an actual IoT binary data transmission pattern. For the sake of visualization, only 1600 binary samples of the entire bit stream is shown.

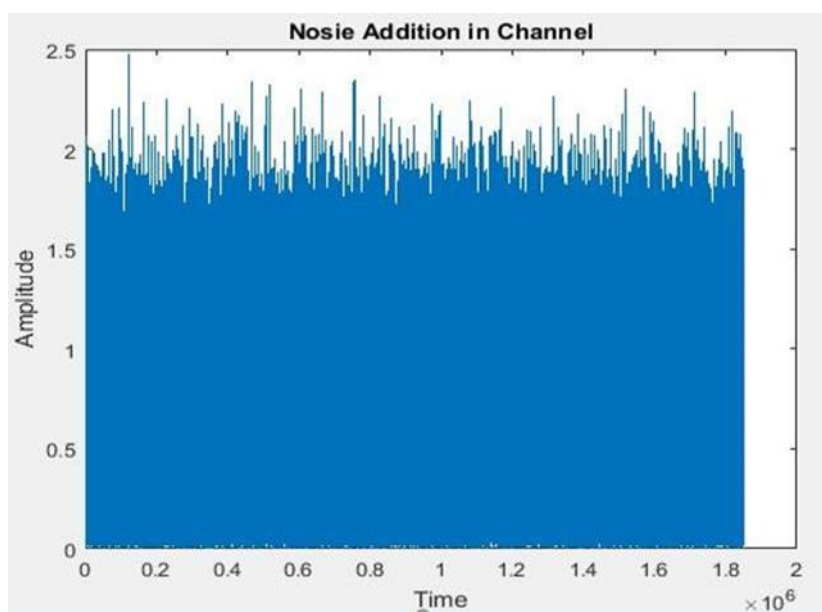


Fig.6 Noise Addition

Figure 6 depicts the addition of the random fluctuations and noise to the data signal. The addition of noise and disturbance is inevitable and simulates an actual transmission model.

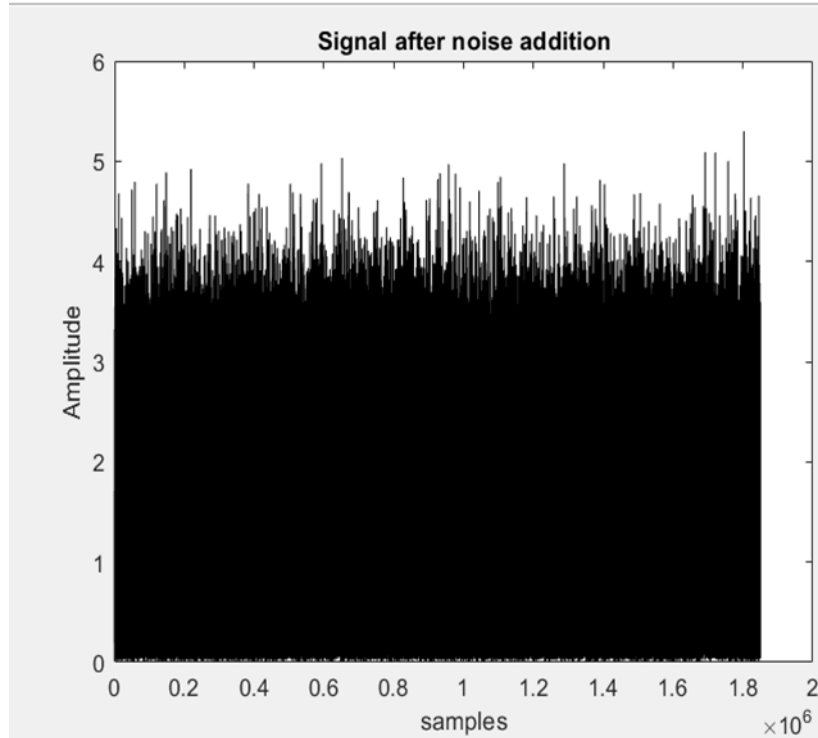


Fig.7 Data Stream after Noise Addition

Figure 7 depicts the IoT data stream after the addition of noise. The noise addition has been assumed to follow a Gaussian or white noise pattern thereby exhibiting a constant noise psd over the entire bandwidth of transmission (random fluctuation in time domain)

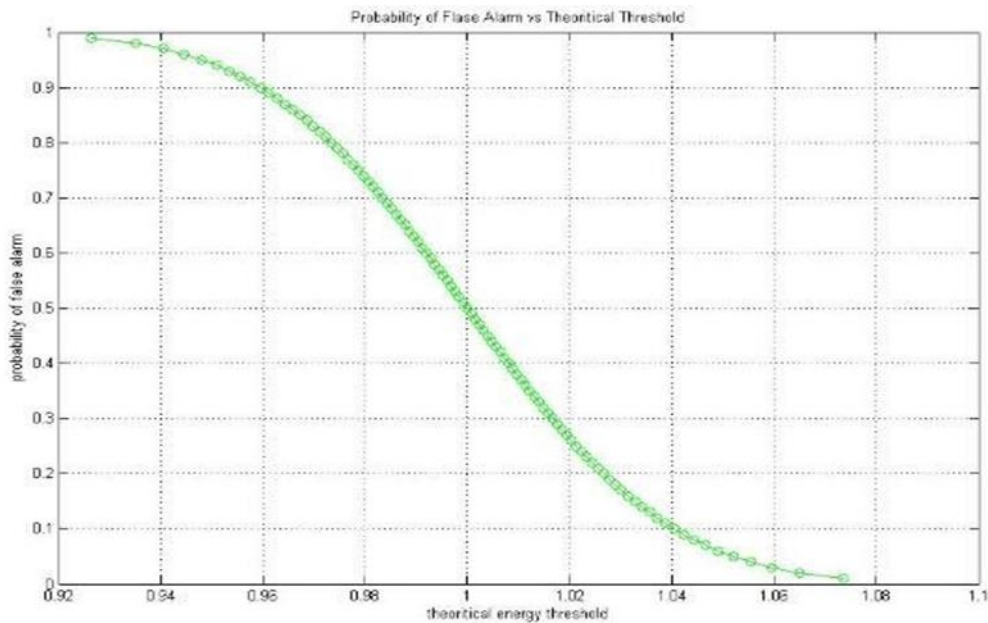


Fig. 8 Ideal probability of false alarm

Figure 8 depicts the probability of false alarm with respect to the variations in the energy threshold. It can be clearly observed that as the energy threshold increases, the probability of false alarm keeps plummeting. This supports the theoretical standpoint as noise is typically weak in nature compared to the signal strength. Thus, noise, deceiving the receiver completely would be extremely uncommon with the increase in the energy threshold for the detection of signals.

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