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PHYSICAL LAYER PERFORMANCE SIMULATOR FOR Wi-Fi HaLow SYSTEMS

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Abstract: ***In the recent years there is a significant expansion of IEEE 802.11 technologies due to a huge demand for a wide spread of wireless communications link across a wide range of radio frequency (RF) spectrum. This paper has a specific interest to words Wireless Fidelity (Wi-Fi) HaLow systems (IEEE 802.11ah) which has an inclination towards internet of things (IoT). Alongside the different mobile technologies available, based upon different IEEE 802.11 technology the wireless local area networks also represent a very wide range of wireless networking technologies. The existing wireless communication technologies in the sub-gigahertz (GHz) bands focused upon factors like low bandwidth, long range communication with many constraint devices. But now due to the huge demand for application requirements it wouldn't fulfil the legacy of internet of things. With the advent of new Wi-Fi standards, the communication has become bidirectional as well as more reliable.***

Keywords—Wireless communication, Wireless fidelity (wi-fi), HaLow system, IEEE 802.11, Internet of Things.

I. INTRODUCTION

There are numerous technologies evolving in the recent years among which the IoT is considered as chief [1]. Alongside the transmission and reception links, it is important to have reliable data link as well as good conditions for reception and decrease the cellular network loads. These could be some of the dependencies on the internet of things-based communication links. The recent trends have seen a continuous and significant expansion of these technologies associated with the Wi-Fi HaLow systems and many more new protocols. We can also see a good extension in the spectrum range of radio frequency [2] and also an increase in the number of use cases with respect to wireless local area network.

At present we have a human centric communication. It can be very much predicted that this leading plot of a human centric communication could be complemented by machine to machine and IOT in the near future. So, these technologies will set to push up the count of communication capable machines or devices. It is one of the estimations that these technologies can introduce more than 60 billion online devices [3] and many of these devices would utilize the concept of a wireless communication to provide cost efficient development and ease of access to the human.

It is a known fact that there is a significant and rapid increase in the count of user equipment and so the demand of the mobile data rates has been extensive. Hence this would bring in the concept to improve the existing functionality of technologies like 3G or 4G cellular networks precisely to small cells. Be it any mobile operators the first choice is always towards the licensed spectrum ensuring the quality of service (QoS) as well as the system control. In today's extensive demand for the fifth generation(5G) technologies, the providers need to find good ways to increase the user data throughput and decrease the latency.

- **Formats and standards**: Generally, the IEEE 802 is referred to the family of IEEE standards which deals with Metropolitan Area Networks and Local Area Networks. A set of specifications for physical layer (PHY) and Medium Access Control (MAC) for IEEE 802.11 is put together to implement the WLAN.
- **QoS support for IEEE 802.11:** According to the project standards of IEEE 802, the target is upon the MAC layer and physical layers. The first specification of IEEE 802.11 was published during 1997 and since then it has undergone several changes and improvements. It is difficult to provide a QoS service using the traditional standards of IEEE 802.11 as they do not provide any explicit mechanisms defined for service differentiation [4]. Numerous variables which are extracted from the general traffic layout are in use, to make sure they have acceptable QoS in these networks. The legacy standards had just the fundamental Distributed Coordination Function (DCF) and optional choice of Point Coordination Function (PCF) improvements like a First In First Out (FIFO) and collision avoidance. Even with the concept of contention free PCF the problem of QoS was unsolved [9]. The services that are provided to the users don't have any kind of optimal performance analysis for various applications like the video and audio applications at the times of heavy loads on the network

- **The IEEE 802.11 ah systems:** It can be called as Wi-Fi HaLow. The IEEE 802.11 ah is one of the wireless networking protocols, published in 2017. It was an amendment of IEEE 802.11 – 2007 wireless network technology. This uses a 900 MHz license exempt bands in-order to provide an extended range Wi-Fi networks operating in the 2.4GHz and 5 GHz bands. It has benefit because of low energy consumption [5] which allows the creation of large groups of stations that co-operate to share the signals, which would support the concept of Internet of Things.

- **The physical layer- 802.11:** The electrical and physical specifications for the devices is defined by the physical layer. In precise it actually defines the relationship among the transmission medium and the device [6]. The physical layer can be split into sub-layers as shown Figure1.

  - Physical Layer Convergence Procedure (PLCP): It acts as adaptation layer. Also, the PLCP is responsible to build packets to different physical layer technologies and for Clear Channel Assessment (CCA).
  - Physical Medium Dependent (PMD) Layer would specify the techniques used for modulation and coding.
  - PHY management layer will take care of management issues such as channel tuning [7].

  Also, the station management sub layer is responsible for the coordination interactions among the PHY and the MAC layers.

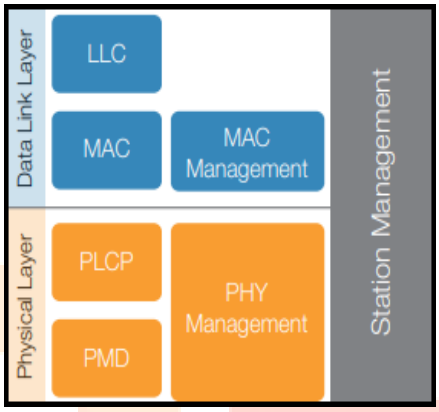


Figure 1: Physical and data link layers of OSI model

II. THE PHYSICAL LAYER SIMULATORS – IEEE 802.11 AH SYSTEMS

The proposed block diagram for the simulators for IEEE 802.11ah is shown in Figure 2. This simulator is designed to work with the physical layer. Each block has its functionality and the detailed explanation is given below. We can try to use three different channels here viz, AWGN, Rayleigh and Rician. These channels work along with different Modulation and Coding Schemes (MCS).

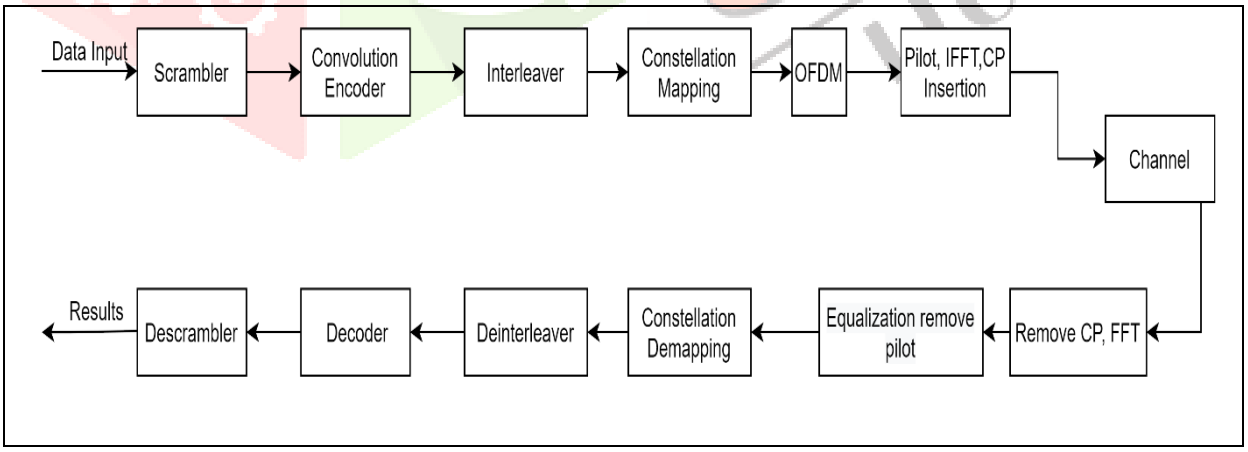


Figure 2: Block diagram of the Wi-Fi HaLow simulator

This work involves in the usage of bit error ratio (BER) and modulation error ratio (MER) as the considerations for the evaluation of the performance. Earlier works had focused on other performance parameters and they had used various other tools. But here the focus is confined upon MATLAB. We can split the entire working among the transmitter and the receiver part and hence the flow goes like this beginning form the transmitter part.

- Data Input: Generation of a random bit streams (bits). And hence is given to the scrambler.

- Scrambler: It is used to break up long sequences of ones and zeros. The data are scrambled by a signal defined with the generator polynomial.

- Convolutional Encoder: Here Forward Error Correction (FEC) scheme for IEEE 802.11ah is used according to the defined modulation and coding schemes (MCSs), using 4 code rates: 1/2, 2/3, 3/4 and 5/6.

- Interleaver: Block Interleaver (in TX signal processing chain) is used for interleaving of the encoded message (on a bit level).

- Constellation Mapping: According to the defined MCSs, modulations BPSK, QPSK, 16-QAM, 64-QAM and 256-QAM can used.

- OFDM, Pilot Insertion, IFFT and Cyclic Prefix (CP): Blocks OFDM, Pilot Insertion, IFFT and CP Insertion ensure the creation of the OFDM symbols containing mapped data and pilots, their frequency-to-time domain conversion and extension with cyclic prefix (CP), respectively. The CP is applied to circumvent inter-symbol interference (ISI) caused by multipath propagation. It is possible to select between normal and short CP lengths. At the end of this process, the IEEE 802.11ah baseband signal is created.

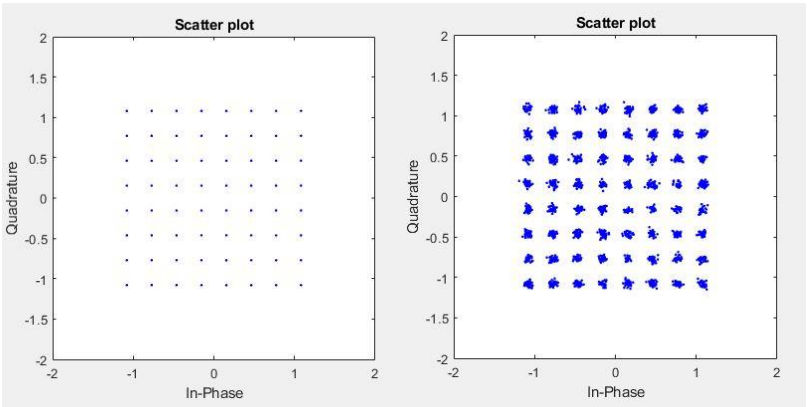
- Channel: As mentioned earlier the block channel allows user of the simulator to select between the following channel models.
- AWGN channel model ('AWGN') – recommended to use for reference simulations
- Rician channel with 20 independent paths.
- Rayleigh channel with 20 independent paths.

At the receiver part the similar configurations are used except for the fact that the signal processing will be reversed. The receiver part also contains the blocks such as the equalization, remove pilots. So, these are basically used to compensate the inter symbol interference (ISI) caused by multipath propagation. The outputs from the simulator shall be evaluated depending on the BER and MER depending upon the signal to noise ratio.

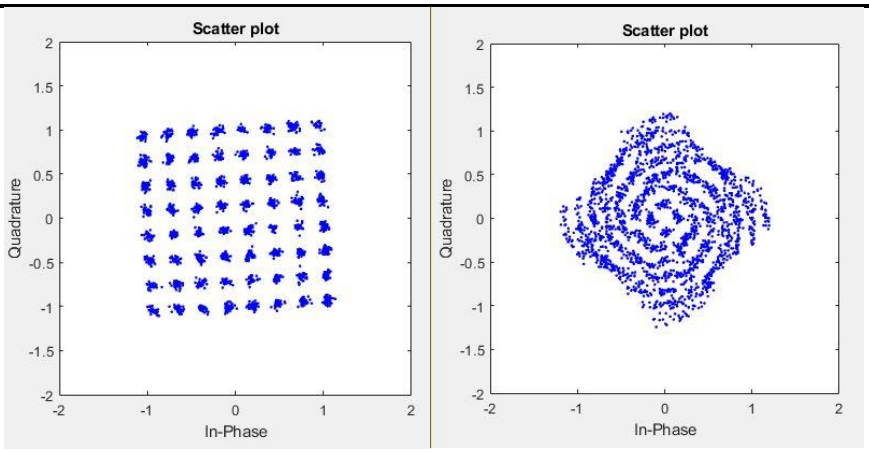
III. SIMULATION RESULTS

According to the above-described construct of the simulators, the performance evaluation results are presented below. The functionality case considered involves the usage of MCS – {0,2,4,6,8} corresponding to the different modulations of BPSK, QPSK and QAM.

The parameter models considered are for AWGN and fading channels (Rayleigh and Rician) are as per the standards of IEEE 802.11. Also, the results considered are a part of the research work, and this analysis is through the constellation diagram, where as the final analysis involves with BER and MER graphs. Now if we can analyze the results for the above 64QAM, (a) describes the scatter plot at the transmitter side where the constellation points are aligned in a particular way with no disturbance. (b) gives us the scatter plot of AWGN channel at the receiver side, where in we see there is a slight spreading of the constellation points. (c) and (d) gives us the scatter plots at the receiver side for Rician and Rayleigh channels respectively. If keenly observed we get to see that these constellation points start revolving from the original position, which is a depiction of noise in the channel. So, for a generalized comparison, it is clear that AWGN channel for these above considered parameters is a better channel compared to the other two.



(a) (b)



(c) (d)

Figure 3: Scatter plots of (a) input at the transmitter,
at the receiver side: (b) AWGN channel (c) Rician channel, (d) Rayleigh channel.

IV. **Conclusion and future work**

In this paper a new approach to have a performance analysis of designed simulators to work for different channels with the concept of BER and MER are under consideration. For a better consideration one can go with the constellation scatter plots for the taken channels under different modulation and coding schemes. This work is undertaken in MATLAB, which is unique from the previous works [7] where in other parameters for the evaluation were used. The research work is still in progress of how these simulators are designed in Simulink. Intermediate results obtained here could help one to analyse the working and concepts related to the Wi-Fi HaLow systems which are of great demand in the future wireless communication technologies.

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