Integration of OFDM-based Communication System in CupCarbon Simulator

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Abstract

With the increase in radio communication devices and shared frequency spectrum between these devices, it is critical to neglect the effect of interference on wireless communications. In this paper, we have present the mathematical model of distribution of network interference. For a flexible and accurate representation, interference is modeled by alpha-stable distribution function and we have estimated the values of parameters of alpha-stable distribution depending on total number on nodes in specified area in the network. This allows the better estimation of wireless channel conditions.

We have analyzed the bit error rate (BER) and packet error rate (PER) performance of Orthogonal Frequency Division Multiplexing (OFDM)based communication system by varying the total number of nodes in wireless sensor network (WSN). We have also integrated a PHY layer based on Orthogonal Frequency Division Multiplexing (OFDM) in the CupCarbon simulator with the consideration of impulsive network interference.

1. Introduction

Due to limited radio spectrum, it is not completely possible for large wireless networks to communicate without interference. Probably other neighboring radio devices from inside or outside of the network will transmit data using the same or nearby radio frequency band at the same time. Consequently, at the receiver, many undesired signals from interfering nodes will add up into the desired signal. This phenomena is called interference and it causes the performance degradation in communication networks.

Alpha-Stable distribution that satisfies Generalized Central Limit Theorem and presents heavy tails, allows to take these rare events into account in a more accurate way. Except of Gaussian distribution, alpha-stable distribution has huge amount of scatter and infinite variance [1].

The rapid growth in the field of WSNs entails the need of creating new simulators that have more specific capabilities to tackle interference and multipath propagation effects that are present in wireless environment. Finding a suitable simulation environment that allows researchers to verify new ideas and compare proposed future solutions in a virtual environment is a difficult task. CupCarbon is an open source WSN simulator. It provides better analysis and understanding of WSN protocols. This simulator runs under the Java environment and can be downloaded from the Internet [1]. It supports wireless communication interference models and signal propagation models like Gaussian and alpha-stable models.

The objective of this research is to include physical layer based on orthogonal frequency division multiplexing in a general WSN simulator, CupCarbon.

2. System Model

2.1. Wireless Sensor Network Environment

Let a sensor network of n nodes with spatial density λ, if a node's transmitter T_0 transmits data to the other node with receiver R_x, the received signal will be:

$$Y = h_0 X_0 + \sum_{i=0}^{n} h_i X_i \tag{1}$$

where X_0 is transmitted signal of antenna T_0 and convoluted with wireless channel response h_0. Term $\sum_{i=1}^{n} h_i X_i$ represents the accumulated interfering signals generated by other RF nodes or devices and can be modeled with Additive White Gaussian Noise (AWGN) model and alpha-stable noise models, respectively.

$$\sum_{i=1}^{n} h_i X_i = \underbrace{\sum_{i=1}^{u} h_i X_i}_{ImpulsiveNoise} + \underbrace{\sum_{i=u}^{n} h_i X_i}_{GaussianNoise} \tag{2}$$

Spatial density λ depends on total number of active nodes within the specified area around a transceiver. λ can be calculate as:

$$\lambda = \frac{n}{area} \times \%\, of\ active\ nodes \tag{3}$$

where n is total number of nodes in a network or in specified area.

[1](http://www.cupcarbon.com)

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2.2. OFDM Based Transceiver

OFDM is the variant of Multi-Carrier Modulation. Figure 1 shows the block diagram for the OFDM communication system. The input signal $S(t)$ will be converted into its sampling version $S[n]$, that will share over N sub-carriers. The input data is converted from serial to parallel OFDM symbols. The required amplitude and phase of each sub-carrier is calculated using predefined modulation technique (e.g. BPSK, QPSK or QAM). Then demultiplexing is applied to load OFDM symbols over each sub-carrier. Then, these OFDM symbols are transferred to the IFFT block for IFFT operation to generate the transmit samples. These parallel OFDM symbols are converted back into serial stream through the process called multiplexing. Cyclic prefix of length L is added to the serial data at this point. This signal is transmitted over the wireless channel. The exact but opposite operation is taken place at the receiver to convert the received signal into data as shown in Figure 1 [2].

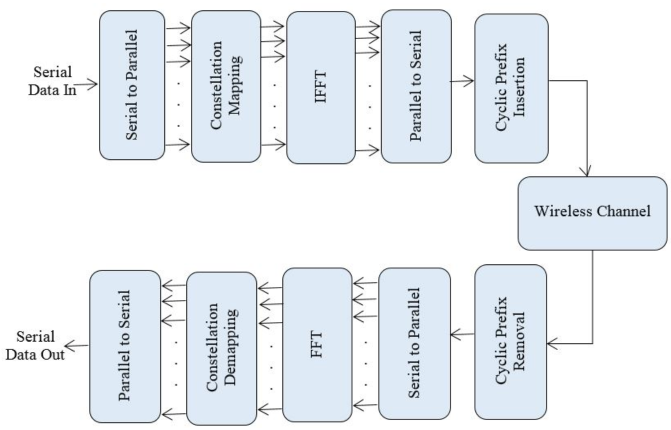

Figure 1. Block diagram of OFDM based Transceiver.

3. Simulation Results

Fig. 2 shows the bit error rate performance of an OFDM based wireless communication system with alpha-stable interference model in WSN applications. Vertical axis shows BER values. Fig. 3 shows the PER performance of an OFDM based wireless communication system with alpha-stable noise in WSN applications. Vertical axis shows PER performance of the system.

Horizontal axis in Fig. 2 and Fig. 3 shows the values for λ which is spatial density of the network within the specified area around a node. It can be seen from Fig. 2 that as the spatial density of network increases the BER performances decreases. In these simulations we have considered that 10% of total nodes are active in the specified area, at the same time.

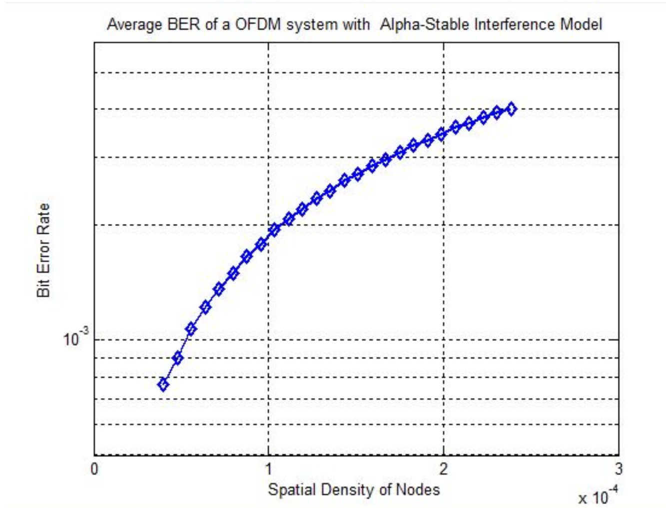

Figure 2. BER performance of PHY layer based on OFDM with alpha-stable interference model.

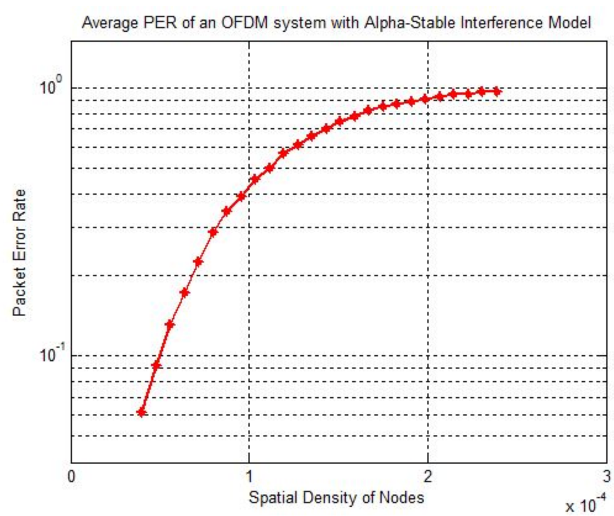

Figure 3. PER performance of PHY layer based on OFDM with alpha-stable interference model.

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