A Proposal to Improve Channels with Rician Fading Through the Methodology CBEDE

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***Abstract* - Many technological advances have aided in the evolution of society and in the improvement of many services. Where many of the existing methodologies present large consumption of computational memory as well as slowness in sending data. With this focus, the present study aims to develop DES (Discrete Event Simulation) based model. This model is called CBEDE (Coding of Bits for Entities by means of Discrete Events) and aims to improve the transmission of content in wireless telecommunication systems. The present study implemented a model CBEDE applied to a system, and advanced modulation format DBPSK in a simulation environment, the Simulink simulation environment of the MATLAB software, improving the transmission of data, through a pre-coding process of bits applying discrete events in the signal before of the modulation process. The signal transmission on the channel occurs in the discrete domain with the implementation of discrete entities in the process of bit generation applied at a low level of abstraction in a wireless telecommunication system. The simulation considered the advanced Differential Binary Phase Shift Keying (DBPSK) as the modulation format for signal transmission in an AWGN channel. The results show improvements of 79.89% in memory utilization, related to information compression, in the context of the research.**

Keywords - Discrete Events, Simulation, Precoding, DBPSK Modulation, CBEDE, Telecommunications, Rician

I. INTRODUCTION

Fading degrades the communication system performance due to a loss of signal power without decreasing the noise power over some or all the signal bandwidth, the received signal fluctuates, varies in intensity at each instant, increases and decreases through nulls and zeros of voltage

The probability of experiencing fading with the concomitant bit errors as the Signal-to-Noise Ratio (SNR) drops on the channel limits the link performance.

The adequate simulation of multipath fading channels is a fundamental issue in the development and evaluation of wireless systems. Since the multiple path occurs when there is more than one path available for the propagation of the radio signal. The phenomenon of reflection, diffraction and scattering give rise to additional paths of propagation between transmitter and receiver.

Multipath fading (MF) affects most forms of radio communications links in one way or another. MF occurs in an environment where there is multipath propagation, and the paths change for some reason, resulting of propagating multiple versions of signals transmitted across different paths before they reach the receiver [6 - 8].

The Rician fading model is ideally suitable of real-world phenomena, being a stochastic model for the propagation anomaly of the radio signal, caused by the partial cancellation of a radio signal by itself, the signal reaches the receiver exhibiting multipath interference and at least one of the paths is changing, lengthening or shortening occurs when one of the paths, typically a line-of-sight signal, is much stronger than the others [6 - 8].

The discrete event mainly relates to the model representing the system as a sequence of operations performed on entities (transactions) of certain types such as data packets, bits, among others. These entities are discrete in a discrete event simulation. This technique is usually used to model concepts having a high level of abstraction, such as clients in a queue, flow of vehicles, transmission of data packets, can be applied from the exchange of emails on a server even the transmission of data packets between devices connected in a network, also uses the queuing concept and can be used to manage people data and so forth [1 - 11].

This paper proposes a wireless system model simulation built upon an AWGN channel with the advanced modulation format called differential binary phase shift keying (DBPSK) to improve the transmission capacity of information content through the channel and to compensate to the additional complexity posed by multipath techniques.

A bit treatment with discrete events methodology inserted in the bit generation step applied in a low abstraction level is the differential and main contribution of this research. As the current world is more and more digital, it is important to develop new techniques that are effective and consume less and less resources.

This paper is organized as follows: Section 3 discusses the traditional method of modeling an AWGN transmission channel. Section 4 presents and describes the proposal of methodology. Section 5 presents the results and, finally, in Section 6, the conclusions are presented as also the potential of the research.

A. Objectives: Given the above, the technique of discrete events can be applied in the treatment of bits in its generation stage, being responsible for their conversion into discrete entities. This process is the result of a methodology used in a lower level of application, which acts on the physical layer, than the already used, usually in the transport layer. Able to reduce the consumption of computational resources, such as memory, which is an important parameter to meet the needs of an increasingly technological world.

II. TRADITIONAL METHODS

A digital communication system performance corresponds typically to the probability of bit detection errors (BER) in the presence of thermal noise, which is the fundamental quality measure of a digital telecommunication link, where erroneous bits arise in digital communications systems as a result of several distinct practical effects such as synchronization failures between the transmitter and the receiver, component defects, noise, among many others.

The so-called additive white Gaussian noise (AWGN) channel model (Figure 01) is widely used due to its mathematical modeling simplicity, and application to a large set of physical [12 - 14]. In the same way, this noise is also widely used in the modeling of digital television channels due to its ease of implementation and analysis, as well as its good adherence to the measured results.

The basic AWGN model emulates the effect of many naturally occurring random processes. This noise is additive because it is added to any signal (the received signal equals the transmitted signal plus noise). In the frequency domain, white noise interferes with all frequencies, which leads to a uniform power spectrum across for all frequencies. [12 - 14].

The mobile wireless channel is susceptible to several interferences including multipath, fading, shadowing, and other types of noise due to general deficiencies that cause a considerable degradation in the performance of the system [14 - 17].

Rician fading is also a useful model of real-world phenomena in wireless communications, the signal reaches the receiver exhibiting multipath interference, and at least one of the paths is changing, lengthening or shortening. This factor occurs when the dominant component of the received signal is stationary, a condition normally found in line-of-sight channels [14 - 17].

The DBPSK modulation removes phase ambiguity and the need for phase acquisition and tracking and resulting in decreases the energy cost. Using a non-coherent approach to circumvent the requires for coherent reference signal at the receiver, the phase of the signal changes between two angles separated by 180° (equal BPSK) with one phase characterized by the binary 1 and the other phase by 0 in its constellation. Since it does not require phase synchronization, it is noted useful for digital communications systems and widely used by wireless LANs [12 - 17].

The research presented in this section shows an AWGN transmission channel with DBPSK modulation. Being used the Simulink simulation environment of the MATLAB® software in its version 8.3 of 64 bits (2014a).

The model from Figure 02 shows the modeling relative to the traditional method (also called no fading) and with the proposed innovation and added the fading (Figure 03), and it also highlights the part modeled using discrete events in blue.

Figures 03 and 04 presents a model where the signals corresponding to bits *0* and *1* are generated and then modulated in DBPSK, passing through a multipath Rician fading channel with Jakes model with Doppler shift defined at *0.01* Hz, as also inserted a block incorporated which has a math function 1/u.

Such a function is required to track the channel time-variability where the receiver implementation ordinarily incorporates an automatic gain control (AGC). Posteriorly, for an AWGN channel according to the parameters specified as sample time of 1 second, power input signal of 1 watt, initial seed in the generator of 37 and in the channel of 67, Eb/No of 0 to 15dB. Then, the signal is demodulated to perform the bit error rate (BER) of the channel. The values obtained referring the BER are sent to the MATLAB® workspace, for further processing and generating of the signal BER graph.

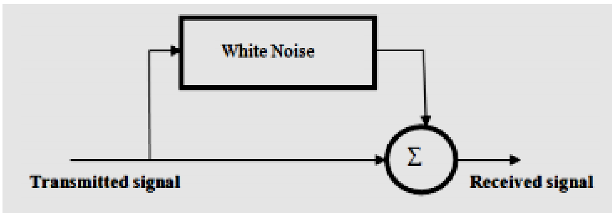

Fig.01. Representation of AWGN channel

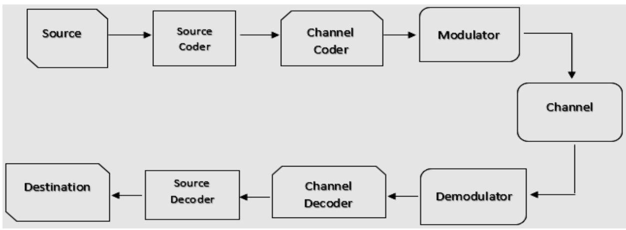

Fig.02. Demonstration of Traditional Model (no fading)

III. METHODOLOGY PROPOSED

The discrete event model follows in the footsteps of the previous section. Differentiating that now was added the discrete events process of pre-coding (low-level abstraction), being the treatment performed on the signal relative to bits 0 e 1.

This time-based signal will be converted to a specific type following the output parameter, an integer, the bit. By means of the Real-World Value (RWV) function, the actual value of the input signal will be maintained. Then a rounding is performed with the floor function. This function will be responsible for rounding the values to the nearest smallest integer. Also, being carried out a Zero-Order Hold (ZOH), which will realize the final effect of the conversion of the signal to the time domain, causing its reconstruction and maintaining each sample value by a specific time interval.

In this way, the signal is modulated in DBPSK and inserted into the AWGN channel, and then demodulated to calculate the BER of the signal.

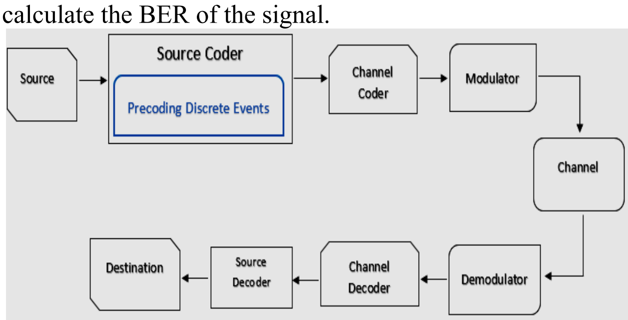

Fig.03. Model with the Proposal of this research

The proposed method was implemented in a wireless system with a mobile wireless channel susceptible to several impediments like multipath fading, noise, lengthening or shortening, among other interferences [6 - 8] as seen in Figure 04. The signals corresponding to the bits *0* and *1* are generated and then modulated in DBPSK. Then, it passes through a multipath Rician fading channel, integrating Jakes model with a Doppler shift defined at *0.01* Hz, as also inserted a block incorporated which has a math function *1/u*.

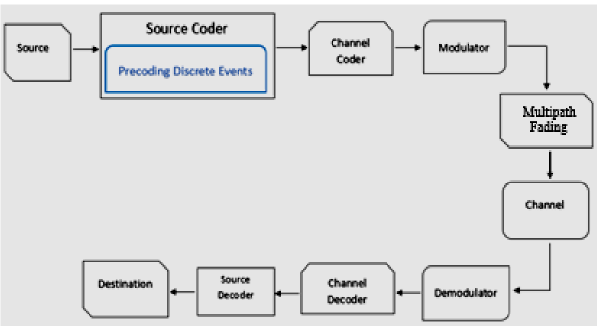

Fig.04. Wireless Model with the Proposal of this study

Such a function is required to track the channel time-variability, where the receiver implementation ordinarily incorporates an automatic gain control (AGC). Next, an AWGN channel follows according to the parameters specified at a sample time of 1 second, with an input signal power of 1-Watt, initial seed in the generator of the 37th and the 67th channels, with Eb/No ranging from *0* to *15* dB. Then, the signal is demodulated to obtain the channel BER.

Figures 05 use *10000* seconds of simulation time. They also show the transmission flow for the DBPSK signal in the proposed (right) and the traditional methods (left) for comparison using multipath fading with Rician distributions. Note that both methodologies generated the same result.

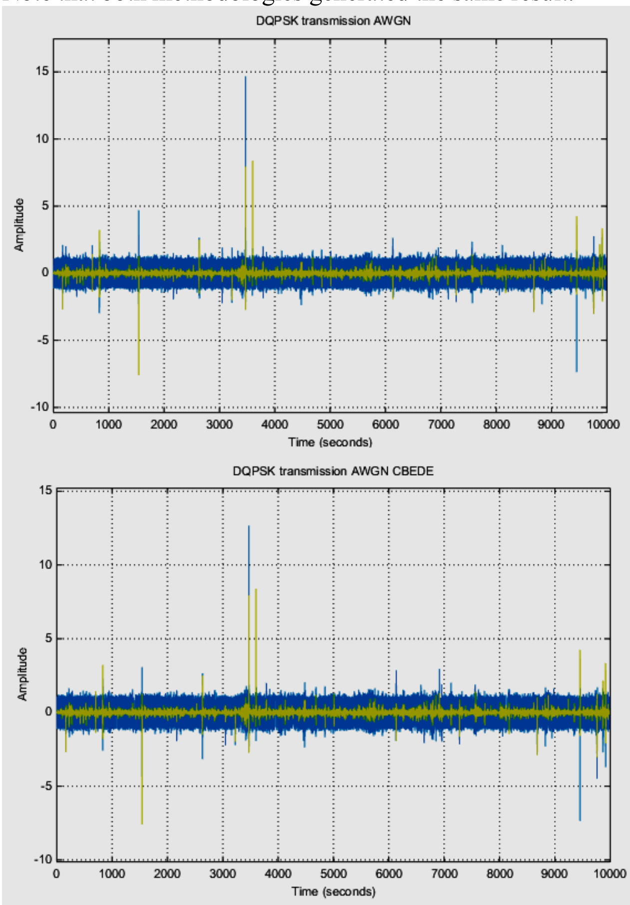

Fig.05. Transmission Flow for DBPSK with Rician Distribution

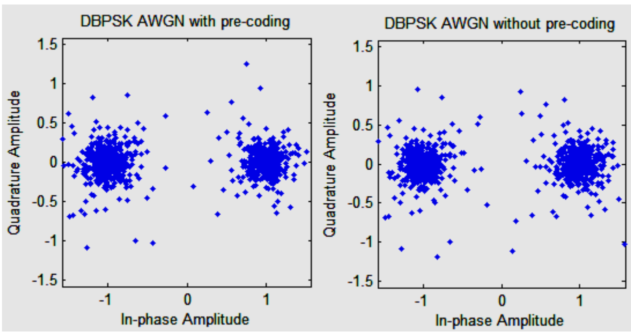

Fig.06. Simulated DBPSK Constellations for the Rician Distribution.

Also used was the scatterplot command, being a scatter diagram or constellation diagram, viewing the constellation of the modulated digital signal, useful for comparing the performance of one system with the other. Figures 06 display the constellations for *15* dB for the proposed (left) and the traditional methods (right) in multipath fading with Rician distributions.

IV. RESULTS AND DISCUSSION

The results correspond to simulations performed with the models presented previously, on a physical machine with hardware configuration, an Intel Core i3 processor and 4GB RAM.

`sldiagnostics` function allows displaying the diagnostic information about the modeling system in Simulink. The **`ProcessMemUsage`** parameter obtains the sum all of the memory consumption for all model processes in the entire simulation. **`ProcessMemUsage`** counts and returns the total amount of memory utilized in each phase of the model in MB. It takes into account that the first simulation of both models, the variables are allocated, and the memory is reserved for the execution of the model according to Figure 07.

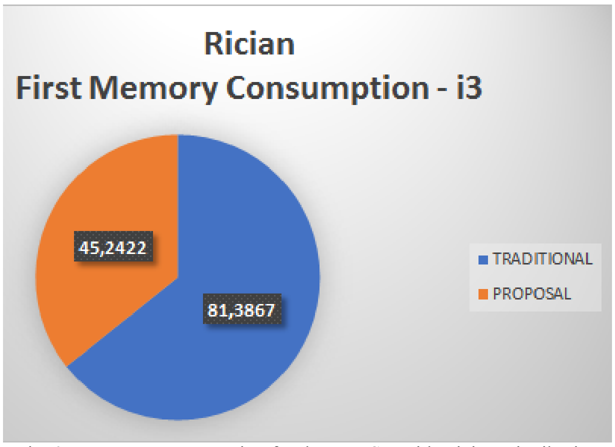

Fig. 07. Memory consumption for the DBPSK with Rician Distribution

So, can be understood that if in a transmission channel containing the proposal and in another the traditional method, they passed the same information content (quantity of bits), without any loss (signal and constellation) and with the same quality (BER).

In this way, a communication channel without any type of fading was simulated, named "no fading", where it is possible to notice that the proposed framework reduced all the memory consumption resulting from Rician Fading in models used in simulations with equalization of its resource consumption to a channel without the techniques while maintaining all the existing benefits and characteristics, as shown in Figure 08.

To analyze the relationship between the simulation methodology (proposed×traditional method), and the impact on the physical layer of the channel, scripts were made in the MATLAB® for processing of the graph BER.

Figure 09 display the performance of the models during transmission with noise ranging from 0 to 22 dB.

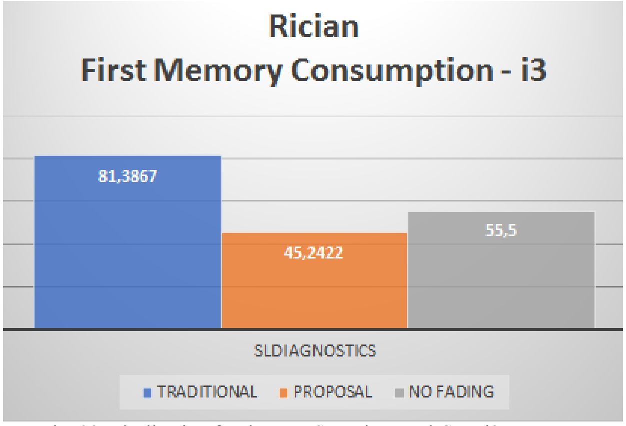

Fig. 08. Idealization for the DBPSK using Intel Core i3 processor

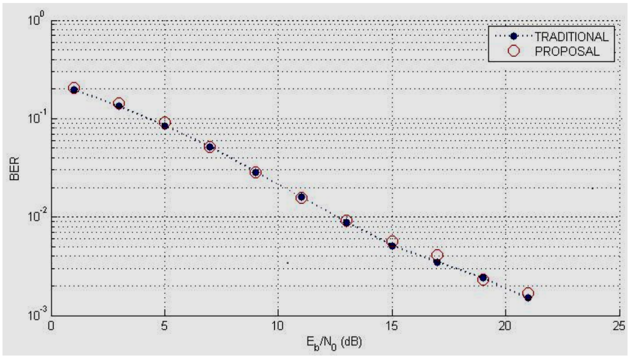

Fig. 09. BER between the models for Rician fading.

V. CONCLUSIONS

The use of discrete events applied and implemented at the lowest level of abstraction possible within a telecommunication system, in bit generation, being developed treatment of the bits before the modulation process, functioning as a differentiated pre-coding process, was central objective of this research.

Another considerable point that the research achieves is the optimal compensation through the proposal presented through the idealization of the transmission channel, with relation to the complexity that techniques of fading by multiple paths, such as Rician exposed here, naturally generate in the channel.

Thus, information compression is a byproduct, since the proposal acts on the bits, having a significant impact on the compression methods performed in higher layers (for example, HEVC, MPEG-4 AVC/H.264, among others) in a broadcasting system.

In researches in recent years, non-orthogonal multiple access (NOMA) schemes have received significant attention for the fifth generation (5G) cellular networks, being believed as the near future, being the first reason to adopt NOMA in 5G owes to its ability to serve multiple users using the same time and frequency resources, where research that can bring new technologies as presented in this paper, which allow a lower consumption of resources without loss in quality, and still can compensate for the additional complexity brought by the techniques of fading to the telecommunications channel, show an enormous potential for the area in evidence.

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