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Improvement of the Content Transmission in Broadcasting Systems: Potential Proposal to Rayleigh and Rician Multichannel MIMO Systems

Reinaldo Padilha, Yuzo Iano, Ana Carolina B. Monteiro and Hermes José Loschi

***Abstract* — In the last years, the transmission of signals has been a widely approached theme, aiming the creation of methodologies that make channels increasingly efficient. Based on that, the present study implements a model based on discrete events applied to a broadcasting system entitled hybrid method, using the Simulink simulation environment of the MATLAB software. This study has the objective of improve the transmission of content, through a pre-coding process of bits applying discrete events in the signal before of the modulation process. This proposal brings a different approach, in which the signal transmission on the channel is realized in the discrete domain with the implementation of discrete entities in the process of bit generation. The results show better computational performance related to time and memory utilization related to the compression of the information, showing improvement 9.61 to 26,5%, respectively.**

***Index Terms* — discrete events, memory, simulation, bits.**

I. INTRODUCTION

Computer simulations are excellent tool that supports the best knowledge of the behavior of a broadcasting system without building it, your results are accurate in general, compared to the analytic model. In the simulation environment, can be studied complex systems that would otherwise be difficult to investigate [1] [2] [9] [14] [15] [16]. As also can be used in engineering broadcasting to develop um proposal investigating the effect these changes without producing a physical prototype, providing the flexibility to implement different types of system architecture analyzing different layers, such as physical, transport, transmission and higher layers, improving and validating the system for different applications [1 - 9] [14 - 18].

The modeling Discrete Event is mainly used to represent the system being analyzed as a sequence of operations being performed on entities (transactions of state) of certain types such as data packets, bits, etc. The entities are discrete items of interest in a discrete event simulation. The meaning of an entity depends on what is being modeled and the type of system, and can have attributes that affect the way they are handled or may change as the entity flows through the process [1] [3] [5] [9 - 12].

Discrete events are the results of actions that occur in the system, an event that changes its state, being these actions intentional, spontaneously controlled or with the verification of a condition [3] [37 - 42].

This technique has been used to model concepts with a high-level of abstraction, as patients in a hospital in the healthcare system, clients in a queue in bank system, emails on a server and/or transmission of data packets in telecommunication's systems, etc. [2] [9 - 16].

Through of academic records, can be verified modeling of high-level of abstraction concepts such as people in business process systems, computers in computer networking systems, nodes in networks of data or telephone communication, vehicles in transport systems, service providers such as banks, transaction systems for databases, communication protocols in telecommunication's systems, people in call centers, vehicles in

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intelligent transport systems, process control in control engineering, military equipment in defense systems, as many others [19 - 36]. In this way, are clear that the technique of modeling of discrete events is generally used to model concepts with a high-level of abstraction [42].

In this study, the authors developed a hybrid model for broadcasting and for radio broadcasting using an AWGN (Additive White Gaussian Noise) channel with advanced modulation format DQPSK (Differential Quadrature Phase Shift Keying) in simulation environment [42]. This study has the objective of to increase the transmission capacity of information content through of the channel.

Which a bit treatment with discrete events methodology was modeled in the step of bit generation, being the differential of this paper the use of discrete events applied in the physical layer of a transmission channel, being this a low-level of abstraction [42], reaching the second objective this paper.

The present paper is organized as follows: Section 2 discusses traditional simulation models, showing the modeling of transmission channel AWGN. Section 3 presents and describes the proposed framework of this paper, based on the hybrid model with discrete event methodology. Section 4 presents the results and, finally, in Section 5, the conclusions are presented as also the potential of the research.

II. TRADITIONAL MODEL

The communication channel is the medium that provides the physical connection between transmitters and receivers in a communication system, be it as a wire, or to a logical connection over a multiplexed medium such as a radio channel in telecommunications and computer networking. Carrying data typically uses two types of media: cable (twisted-pair wire, cable, and fiber-optic cable) and broadcast (microwave, satellite, radio, and infrared). For the analysis and development of proposals for improvement of communication systems, it is important to construct mathematical models that describe the main characteristics of these means and of the changes it makes to the signals transmitted [6] [7] [8] [17] [18].

An AWGN channel is a model practical of a communication system widely used due to its simplicity and mathematical treatment. It applies to a large set of physical channels, which introduces in the transmitted signals a noise modeled statistically as a white Gaussian additive process.

In the context of wireless communications, the main source of thermal noise is the addition of random signals arising from the vibration of atoms in the receiver electronics.

So, use the AWGN in these communication channels having a statistically random radio noise characterized by a wide frequency range with regard to a signal in the communications channel.

Systems operating largely in the AWGN conditions can be exemplified as space communications with highly directional antennas and some point-to-point microwave links.

The modulation formats QPSK (Quadrature Phase Shift Keying) and DPSK are widely used in satellite broadcasting, in various cellular wireless standards such as GSM, CDMA, LTE, 802.11 WLAN, 802.16 fixed and mobile WiMAX, Satellite as also CABLE TV applications. Being that the first is used in the streaming of SD satellite channels and some HD channels, however, the second has higher bit rates of HD video and a high satellite bandwidth, as also DQPSK can be significantly simpler to implement than QPSK [6] [7] [8] [17] [18].

Both DQPSK and QPSK are modulation formats for Digital Video and Radio Broadcasting, the DQPSK modulation is a particular form of QPSK modulation, in which instead of being sent a symbol corresponding to a pure phase parameter, this symbol represents a phase change [1] [4] [8] [17] [18].

In QPSK, the information is transmitted by the absolute phase of each symbol. Already on DQPSK, each set of bits represented by a symbol cause a determined phase variation in the carrier signal, in it, the bits for the data symbols are determined based on the phase change of the previous symbol [4] [8].

In this way, there are four possible states 0, π, $+\pi/4$, $-\pi/4$. Thus, each symbol represents two bits of information. The division of the binary pattern is equal to QPSK, except that a bit string is shifted in phase about of $\pi/4$ or $\pi/2$ depending on the system [4] [8].

This means there is a total of 8 ideal state positions (compared to the 4 states for QPSK). The ideal state positions for symbols alternate between the four states of 45 degrees normally used by QPSK and four states on the axis. Due to this alternation, the ideal trajectory between symbols never crosses zero [1] [4] [8].

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This session is presented a broadcasting system modeled with an AWGN channel with DQPSK modulation. For this, the authors used the Simulink simulation environment of the MATLAB® software in its version 8.3 of 64 bits (2014a).

In the model, Figure 01, the signals corresponding to the bits 0 and 1 are generated, and then modulated in DQPSK, following 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 14dB. Then the signal is demodulated in order to perform the bit error rate (BER) of the channel. The values obtained referring to the BER are sent to the MATLAB workspace, for further processing and generating of the signal BER graph [42].

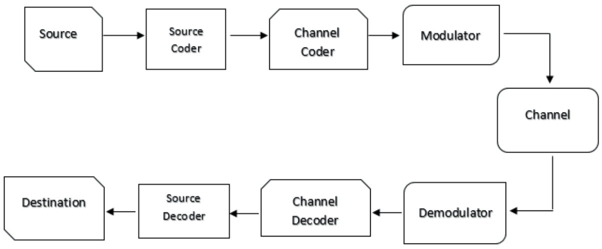

Figure 01 – Traditional Model

III. PROPOSAL

A. Proposal

The modeling of the pre-coding process according to proposal implemented with discrete events is similar with that shown in the previous section. Differentiating that in this model, was added the discrete events process of pre-coding, consisting of the treatment performed on the signal corresponding bit 0. The bit 0 was converted into discrete entities, and forwarded for an FIFO queue with infinite capacity, without limit of capacity and retention in the block. The storing entities in the First-In-First-Out sequence, orders the bits following really your order of arrival, and thus, driving to a server. This server has the configuration of service time equal to the simulation time [42].

The differential of this paper is in the use of discrete events applied in such low-level of abstraction, being the bit generation. After the signal passes through the server, is converted back to its original format respecting the original format and data type specified and maintaining the sampling period respectively. Thus, the signal is modulated in DQPSK and inserted into the AWGN channel, and then demodulated for the purposes of calculating the BER of the signal. The relative values of this BER are also sent to the MATLAB workspace, for further processing and generating of the signal BER graph [42].

The model presented in Figure 02, incorporates the traditional modeling with a proposal presented, as well as highlights the part modeled according to the approach of discrete events, in blue, as previously described [42].

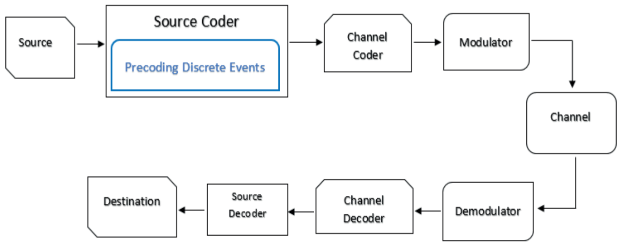

Figure 02 – Hybrid Model

In Figure 03, was used 10000 seconds of simulation time, being placed the flows of transmission of the DQPSK signal in relation to the hybrid model (below) and traditional model (top) for better viewing and comparison, noting that both methodologies generated the same result.

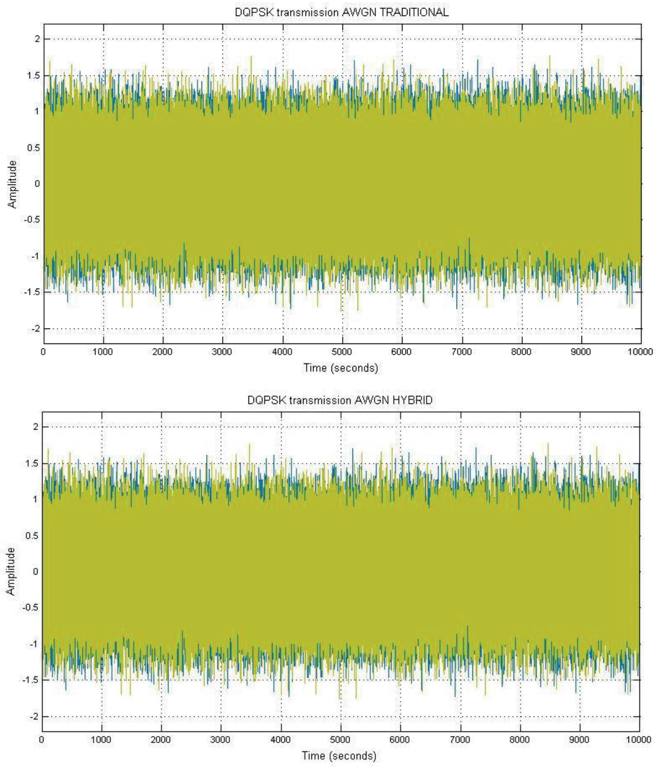

Figure 03 –Transmission Flow DQPSK

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The Constellation Diagram was used to view the constellation of the modulated digital signal also being useful for comparing the performance of one system with another [42].

In Figure 04 is shown the results for visualization of the constellations in 5, 10 and 15 dB, according to the hybrid model (below) and traditional model (top).

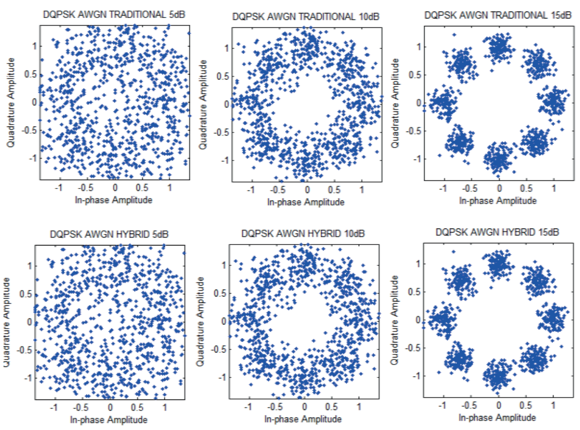

Figure 04 – Simulated DQPSK Constellations

B. Proposal with Rayleigh and Rician

The authors also applied to the proposal presented in a radio broadcasting system, where the mobile wireless channel is susceptible to several impediments including multipath, fading, shadowing, noise among other interferences. In such a way that these deficiencies can cause an enormous degradation in the performance of the system [6] [7] [8].

Rayleigh fading is a useful model of real-world phenomena in wireless communications. Characterized as a statistical model for the propagation effect in an environment with radio signal, is considered a reasonable and ideal model for heavily built urban environments with the propagation of signals in a means where there is no dominant propagation along a line of sight between the transmitter and the receiver [7] [8].

Rician fading is also a useful model of real-world phenomena in wireless communications. Characterized as a stochastic model for the propagation anomaly of the radio signal, caused by the partial cancellation of a radio signal by itself. When the signal reaches the receiver displaying multipath interference, at least one of the paths is changing (lengthening or shortening), and occurs when one of the paths, typically a line-of-sight signal, is much stronger than the others [6] [7] [8].

Generally, wireless networks differ mainly in their physical layer, wherein the transmission of data electromagnetic waves are used that propagate through space. Thus, for this type of transmission an efficient carrier frequency data modulation is required [6] [7] [8].

Within this context was modeled following the pattern of Figure 01, the signals corresponding to bits 0 and 1 are generated and then modulated in DQPSK. Posteriorly it is passed through a multipath Rayleigh fading channel and other with multipath Rayleigh fading, both containing Jakes model with Doppler shift defined at 0.01 Hz, as also inserted a block incorporated which has a math function 1/u [42].

Such a function is required to track the time-variability channel where the receiver implementation ordinarily incorporates an automatic gain control (AGC). After is followed to 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 14dB. Then the signal is demodulated in order 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 [42].

So, applied the same approach in relation to the pre-coding of the bits, noting the same result regarding the transmission flow and the constellations of the systems, validating the proposal [42], as shown in the Figures 05 to 08.

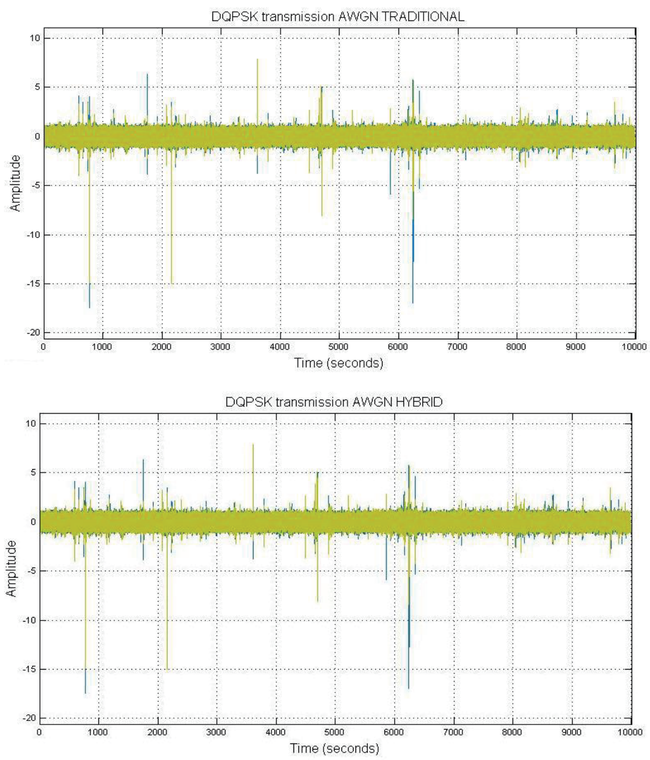

Figure 05 –Transmission Flow Rayleigh DQPSK

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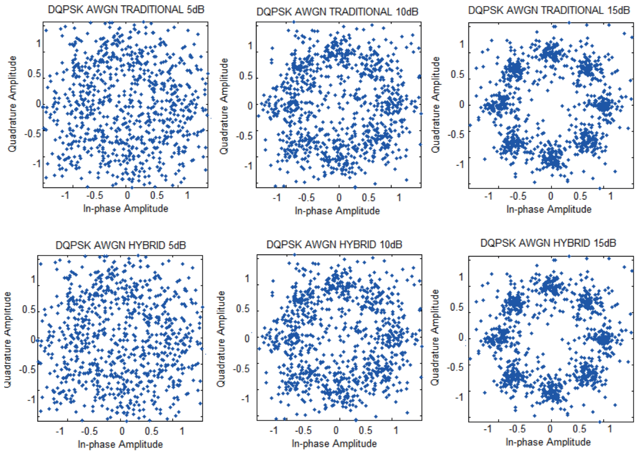

Figure 06 – Simulated DQPSK Constellations Rayleigh

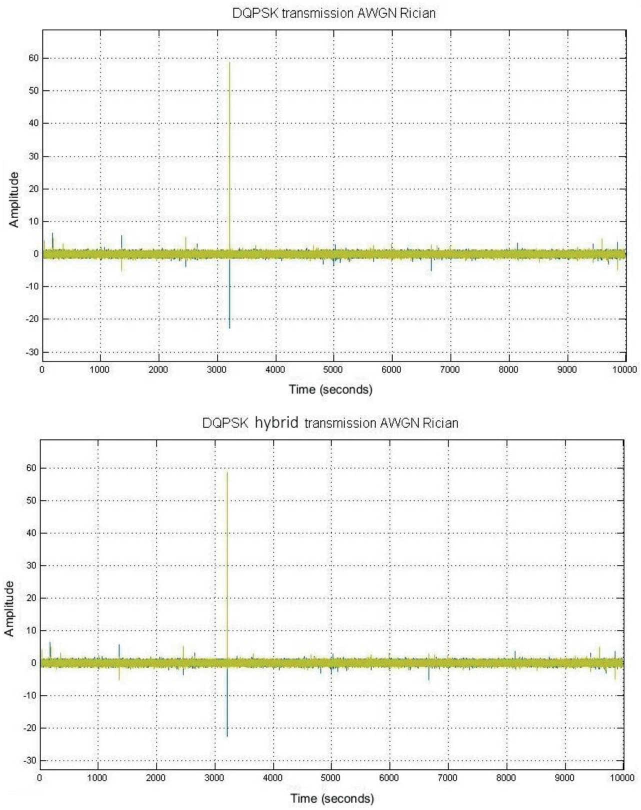

Figure 07 –Transmission Flow Rician DQPSK

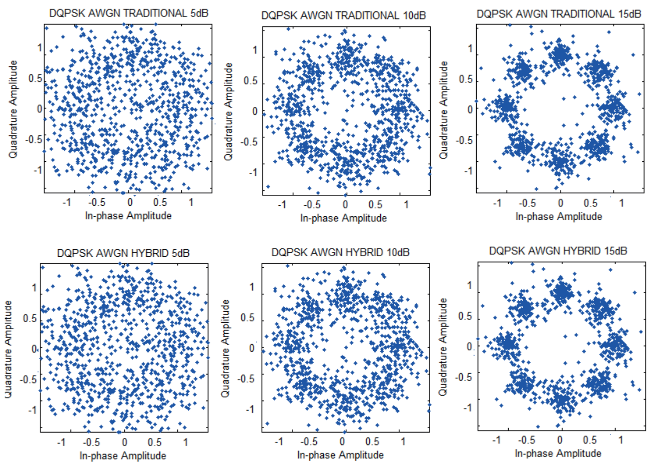

Figure 08 – Simulated DQPSK Constellations Rician

IV. RESULTS

In this section, the results will be presented in relation to the evaluations of the time and memory consumption of the models according to the techniques studied and presented in the previous session. Also, will be presented a comparison among them, simulated on physical machines with different hardware configuration, consisting of an Intel Core i5 processor and 8GB RAM, and another with an Intel Core i3 processor and 4GB RAM [42].

The authors used the commands “tic”, “toc”, and “sim”, via command line at the MATLAB’s prompt, this measuring how much time the model takes to do the simulation (in seconds), that is, the simulation runtime [42].

The “sldiagnostics” function displays information about the modeling system in Simulink. This function is responsible to calculate the time spent on the simulated model, being this, the responsible to the accounting of the time spent in each phase of the simulation of the model (in seconds), that is, the simulation runtime [42].

This function also calculates the sum of all the memory consumption processes used in the model in simulation, by the ProcessMemUsage parameter. This parameter counts the amount of memory utilized in each phase of the model, during the entire simulation, displaying the total amount in MB [42].

In the same way, the authors analyzed the first simulation of both models in each command, and more the “cputime” command, which returns the total CPU time (in seconds). This command refers to the computation time, used by the application in use in MATLAB from the moment it was started. It's important because it is the first simulation that the variables are allocated and the memory reserved for the execution of the model [42], according presented in the Figures 09 to 11.

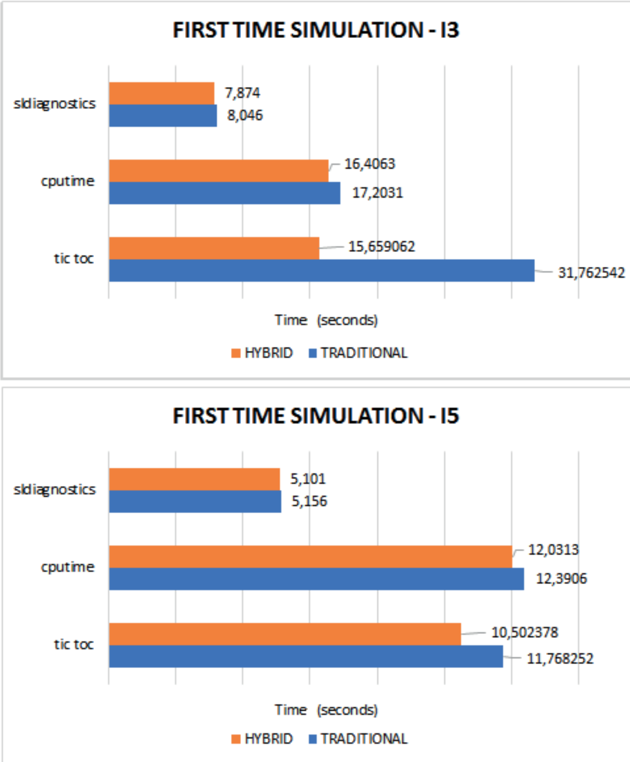

Figure 09 – First-Time Simulation

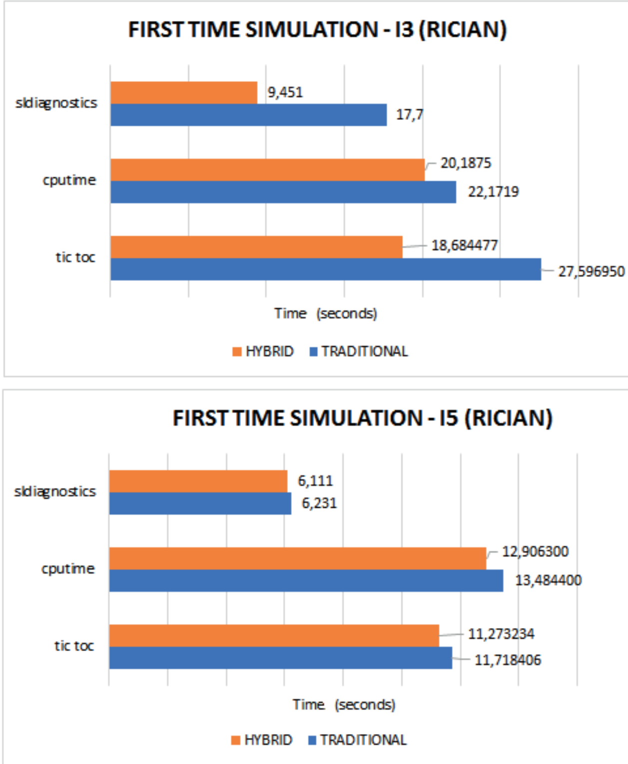

Figure 11 – Rician First-Time Simulation

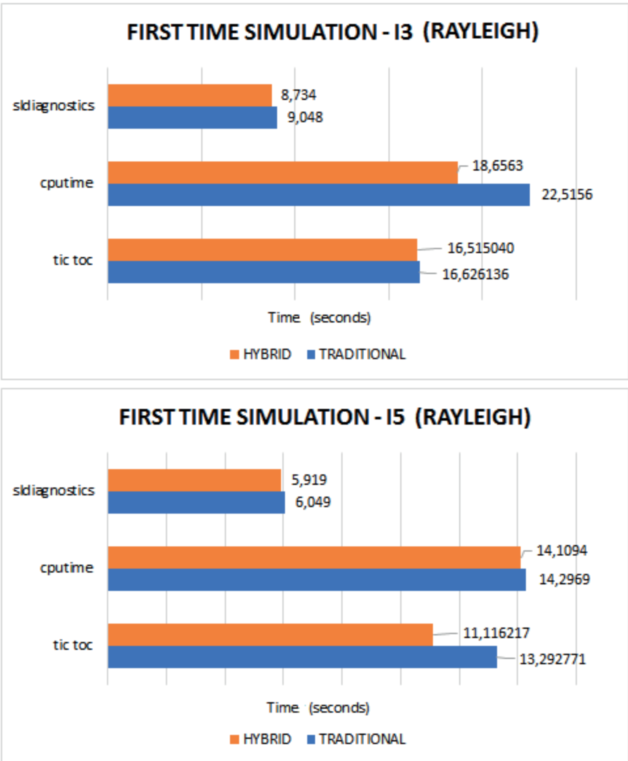

Figure 10 – Rayleigh First-Time Simulation

Similarly, also was observed the first simulation of the models regarding their memory consumption [42], having a better performance as shown in TABLE I and related with the Figures 12 to 14.

TABLE I. COMPUTATIONAL IMPROVEMENT

Memory Consumption / Rate Compression		
Machines	***i3***	***i5***
Broadcasting DQPSK	24,20%	9.61%
Broadcasting DQPSK Rayleigh	26,59%	9.51%
Broadcasting DQPSK Rician	22,85%	11,65%

Can be understood that if in a transmission channel containing the proposal and in another the traditional methodology, they passed the same information content (quantity of bits), without any loss (signal and constellation) and with the same quality (BER). The result related to the memory consumption of the proposal is relative to the compression of the information [42], as shown in TABLE I and related with the Figures 12 to 14.

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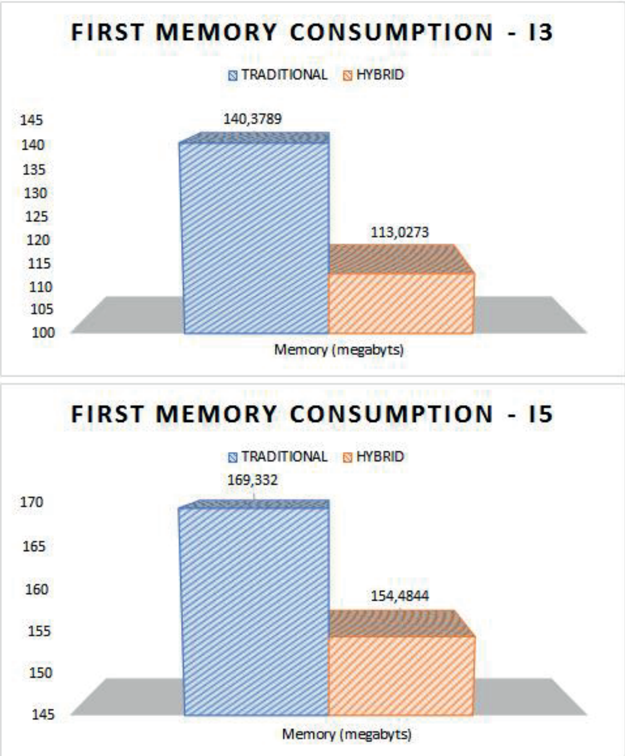

Figure 12 – First Memory Consumption Simulation

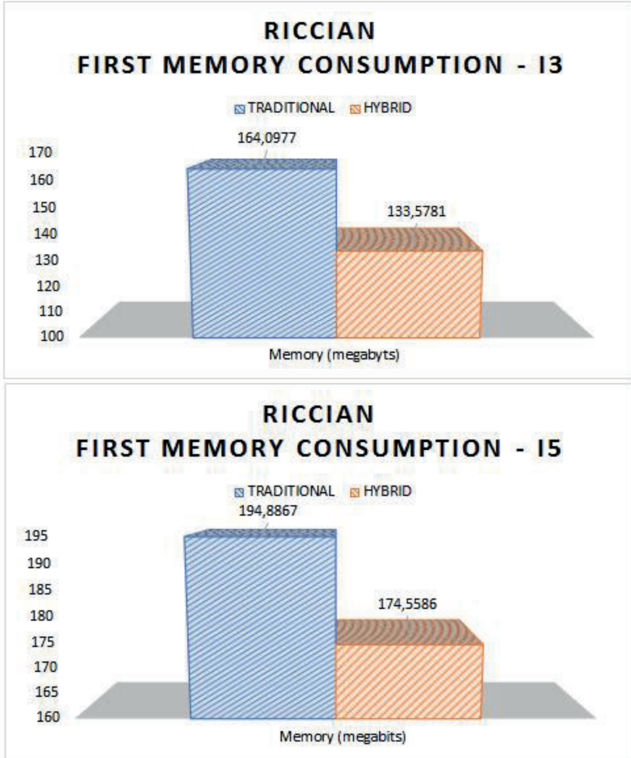

Figure 14 – Rician First Memory Consumption Simulation

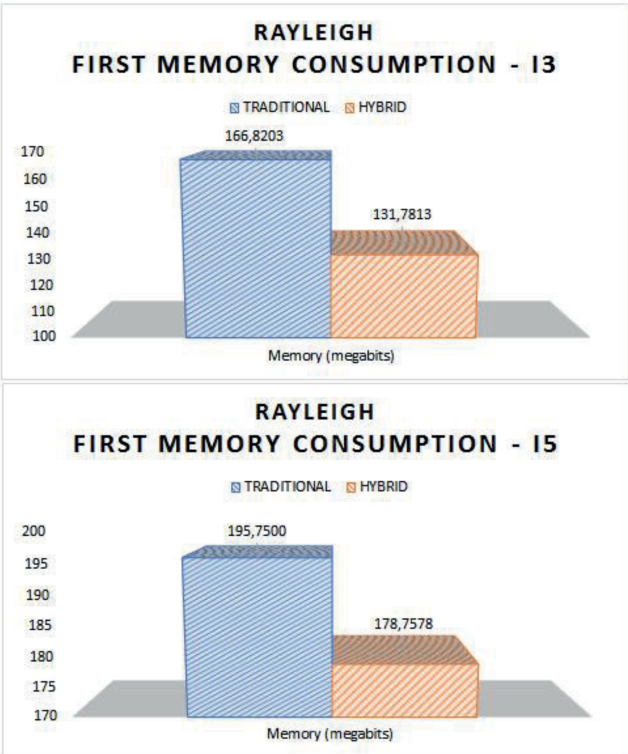

Figure 13 – Rayleigh First Memory Consumption Simulation

Also, is noted that the proposal reduced practically all the memory consumption resulting from Rayleigh and Rician multipath fading in models simulated with such distributions and in both machines. Equalizing its resource consumption to a channel without the Rayleigh and Rician techniques, preserving all the benefits and characteristics of propagation across multipaths [42], as shown in the Figures 15 and 16.

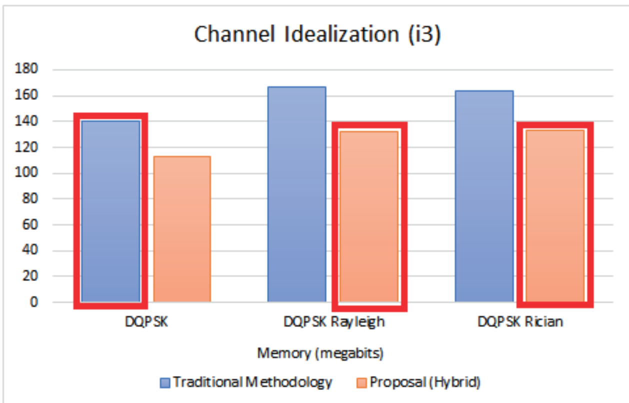

Figure 15 – Channel Idealization i3

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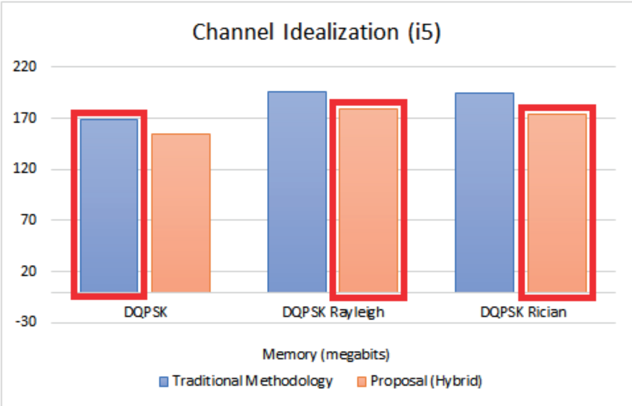

Figure 16 – Channel Idealization i5

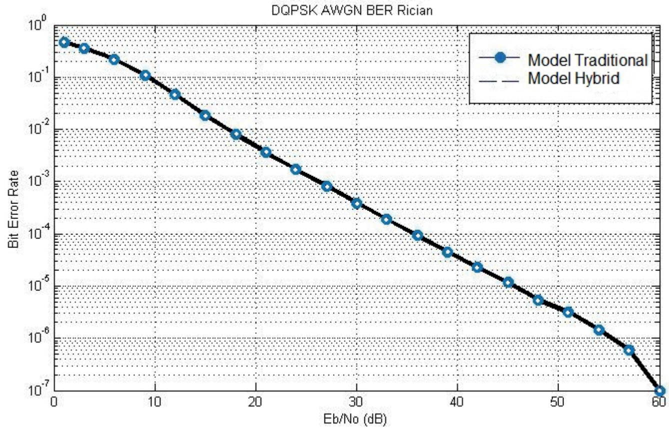

Figure 19 – Performance Rician BER

To analyze the relationship between the simulation methodology and the impact on the physical layer of the channel, scripts were made in the MATLAB workspace for processing of the graph relative to BER. This allows analyzing the performance of bit error rate (BER) in communication's systems [42].

In the Figures 17 to 19, is displayed the performance of the models according to simulation methodologies under study, along with a transmission with noise ranging from 0 to 60 dB.

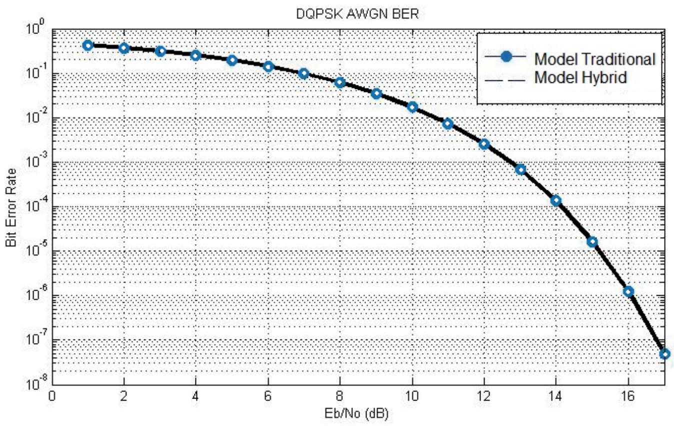

Figure 17 – Performance BER

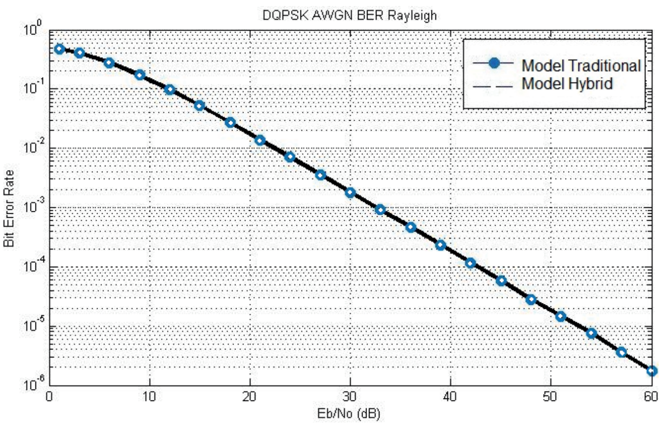

Figure 18 – Performance Rayleigh BER

V. CONCLUSIONS

The use of discrete events applied in a low-level of abstraction such as the bit, in generation phase in a broadcasting system, was the differential of this research since it generally does not apply discrete events in this way.

Evaluating the results, show that the simulation models of broadcasting systems taken a different approach from what is normally done. This proposal applied a concept of a methodology, naturally applied at higher levels, in a lower abstraction level, in bits in the transmission of a channel, through discrete entities

In all scenarios and prospects analyzed the model of the broadcasting system, where was applied the proposal with discrete events show consistent results in the simulated virtual environment. The results obtained on different hardware configurations, evaluated memory consumption and simulation time, and show better performance compared with the model that had only with the traditional methodology.

One extension of the results of this research, being her the compression of the information, strongly affects similar methods performed in higher layers, like MPEG-4 for example, as well as others, can improve them even more since this proposal acts on the bits.

The results related to channel idealization showed the potential of the proposal on Rayleigh and Rician multi-channel MIMO systems, where it is considered within the context of NOMA (Non-Orthogonal Multiple Access), future cellular radio access, 5G.

The purpose of this research together with the proposal presented in this paper is to contribute to the study area and in growing development, the broadcasting.

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