Computational Simulation Performance based in Hybrid Modelling with Discrete Events for Telecommunication Systems

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Abstract — **With the objective of improving the transmission of content in telecommunication systems, in simulation environment is proposed a pre-coding process of bits based in the application of discrete events in the signal before of the modulation process. The proposal brings a different approach of usual technical, 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. In general, the simulation tools for a model of telecommunication transmission system are based on continuous and discrete signals. The present work implements a model based on discrete events applied at a low level of abstraction in a telecommunication system named hybrid method, being used the Simulink simulation environment of the MATLAB® software. In the simulation are considered advanced modulation format for signal transmission in an AWGN channel. The results show improvement of 9 to 22% in memory utilization, as also best computational performance.**

Keywords* — *Methodologies, Discrete Events, Simulation.

I. INTRODUCTION

Computer simulations are strong tools that support the best knowledge of how a telecommunication system is operating. In the simulation environment, the designer has the flexibility to implement different types of system architecture to analyze different layers, such as physical, transport, transmission and higher layer, improving and validating the system for different applications [1] [2] [3] [4] [5] [6].

In simulation, the designer can analyze several system parameters to validate its operation, such as i.e., the bit error rate (BER) that is an important parameter to evaluate the quality of the signal transmission evaluations.

The great majority of processes observed in the world consist of continuous changes. Where continuous simulation is suitable for systems in which the variables can change continuously, being non-linear, with differential equations of the first order or integrals. Such systems emphasize a continuous view, that is, looking beyond individual events, but rather the structure as a whole [1] [2]. Such a concept can be well understood, in the simulation of a telecommunications system.

The term Discrete Event is however mainly used in the sense to denote the modeling that suggests representing the system being analyzed as a sequence of operations being performed on entities (transactions) 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] [2].

This technique is usually used to model concepts with a high level of abstraction, such as patients in a hospital, clients in a queue, emails on a server, flow of vehicles, manufacturing enterprise, transmission of data packets in telecommunications systems, among others [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12].

In this work, a hybrid model for telecommunication systems was made and implemented using an AWGN channel and advanced modulation format DBPSK in simulation environment, with the objective of to increase the transmission capacity of information content through of the channel.

Where a bit treatment with discrete events methodology was modeled in the step of bit generation, being the differential of this work the use of discrete events applied in a low level of abstraction. The results show better computational performance related to memory utilization of the simulation model.

The present work is organized as follows: Section 2 discusses traditional simulation models, showing the modeling of transmission channel AWGN. Section 3 presents the proposal 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 search.

II. TELECOMMUNICATION SYSTEM

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, using normally two types of media as cable (twisted-pair wire, cable, and fiber-optic cable) and broadcast (microwave, satellite, radio, and infrared). And so, for the analysis of communication systems, it is important to construct mathematical models that describe the main characteristics of these means and the changes that the signal undergoes when transmitted [13] [14] [15] [16] [17] [18].

A model widely used due to its simplicity and mathematical treatment, and what applies to a large set of physical channels, is the Additive White Gaussian Noise channel model, AWGN, which introduces in the transmitted signals a noise modeled, statistically as a white gaussian additive process [13] [14] [15].

The term differential in modulation format, is related in the codification of the data, being by the presence of a binary one or zero, by similarity or difference of the symbols in relation to the previous signal.

The DBPSK modulation (Differential Binary Phase Shift Keying) eliminates phase ambiguity and the need for phase acquisition and tracking, resulting in advantages in the reduced cost of energy. In this modulation, is employed a non-coherent way to solve the need for a coherent reference signal at the receiver. Thus, the input binary sequence is first differentially encoded and then modulated using a BPSK modulator. And in demodulation, there is no need to know about the initial state of the bit, simplifying synchronization [13] [14] [15] [18].

In BPSK (Binary Phase-Shift Keying), one phase represents the binary 1 and the other phase represents the binary 0, and as the digital input signal changes state, the phase of the output signal changes between two angles separated by 180° [13] [14] [15] [18].

The models presented in this section aim to display a telecommunication system with AWGN channel and DBPSK modulation. For this, was 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 as the bits 0 and 1 are generated, and then modulated in DBPSK, following for a 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.

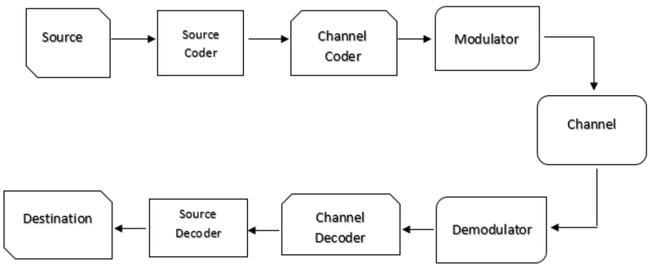

Figure 01 – Traditional Model

III. PROPOSAL

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

Where the differential of this work 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 DBPSK and inserted into the AWGN channel, and then demodulated for the purposes of calculating the BER of the signal. These relative values to this BER are also sent to the MATLAB® workspace, for further processing and generating of the signal BER graph.

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.

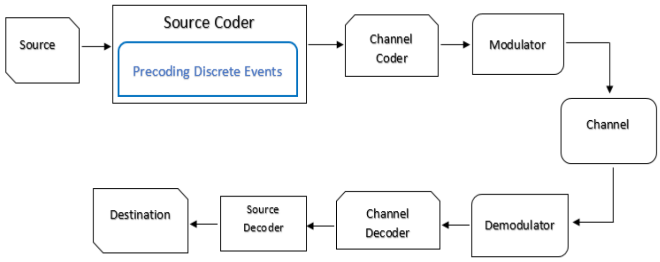

Figure 02 – Hybrid Model

And in Figure 03, using 10000 seconds of simulation time was placed the flows of transmission of the DBPSK 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.

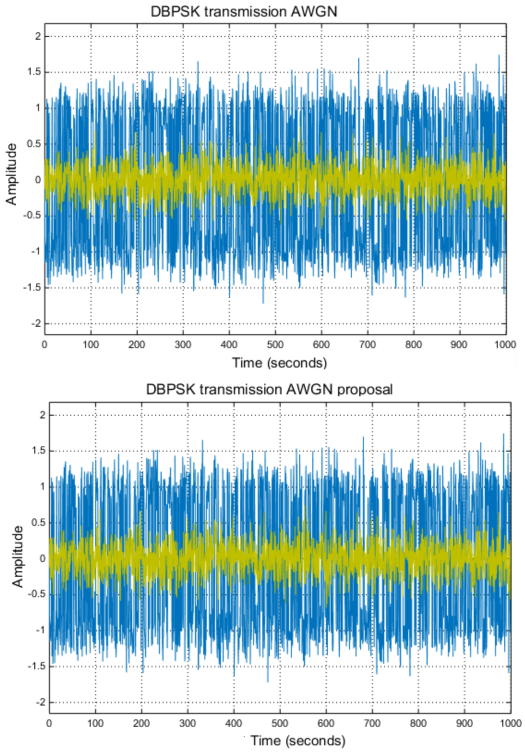

Figure 03 – Transmission Flow DBPSK

Was used the Constellation Diagram, to view the constellation of a modulated digital signal and useful for comparing the performance of one system with another.

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

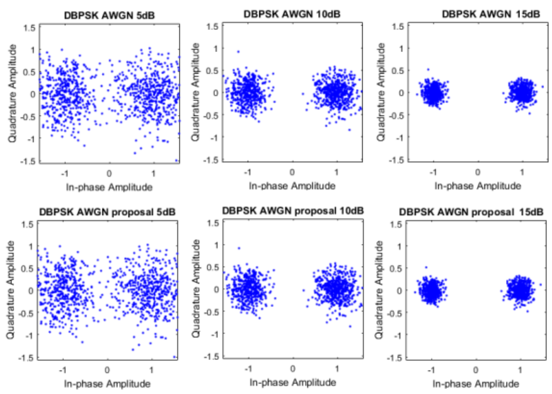

Figure 04 – Simulated DBPSK Constellation

IV. RESULTS

In this section, the results will be presented on the evaluations of the calculation of the time spent of the simulations. To obtain the same were performed 5 sequential simulations with the models presented previously, 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.

Was used the sldiagnostics function, that displays diagnostic information about the modeling system in Simulink, calculating the sum all of the memory consumption processes used in the model in simulation, by the ProcessMemUsage parameter, which counts the amount of memory utilized in each phase of the model, during the entire simulation, displaying the total amount in MB, according presented in the Figures 05 and 06.

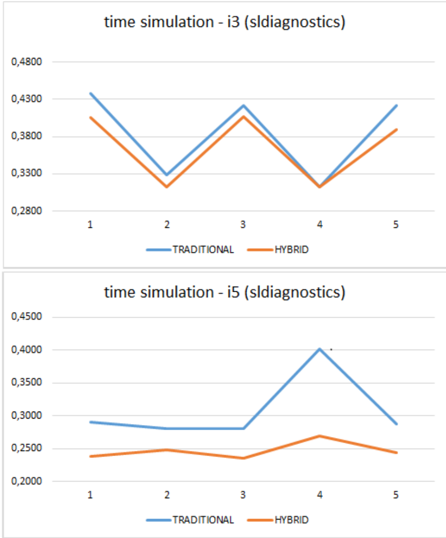

Figure 05 – time simulation

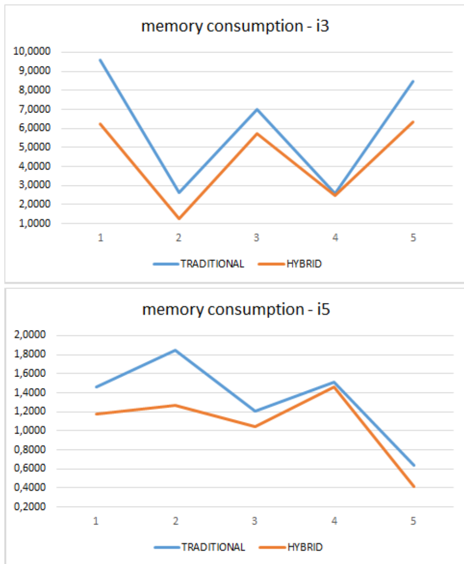

Figure 06 – Memory Consumption Simulation

Also was analyzed the first simulation of both models, because it is in the first that the variables are allocated and the memory reserved for the execution of the model, having a better performance as shown in Table 1 and related with the Figures 07 and 08.

Memory Consumption		
Machines	***i3***	***i5***
Modelo DBPSK	22,01%	9,22%

Table1: Computational Improvement

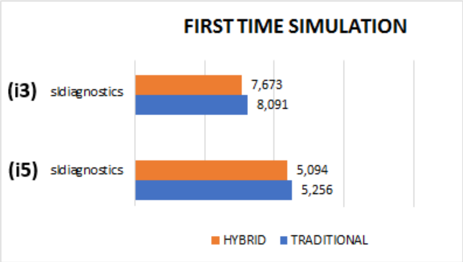

Figure 07 – first time simulation

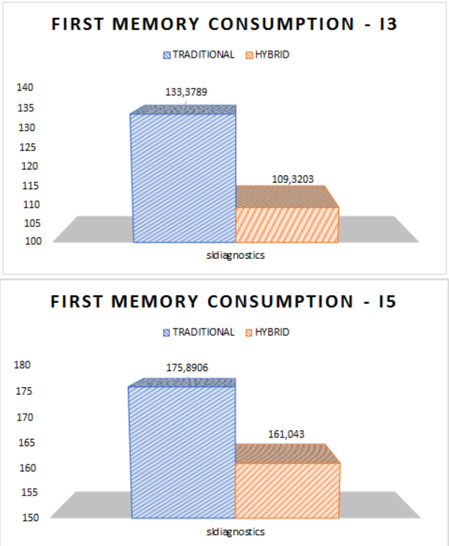

Figure 08 – First Memory Consumption Simulation

To analyze the relationship between the simulation methodology and the impact on the physical layer of the channel, scripts were made in the MATLAB® for processing of the graph relative to BER, that allows analyzing the performance of bit error rate (BER).

In the Figure 09, is displayed the performance of the models according to simulation methodologies under study, along with a transmission with noise ranging from 0 to 12 dB.

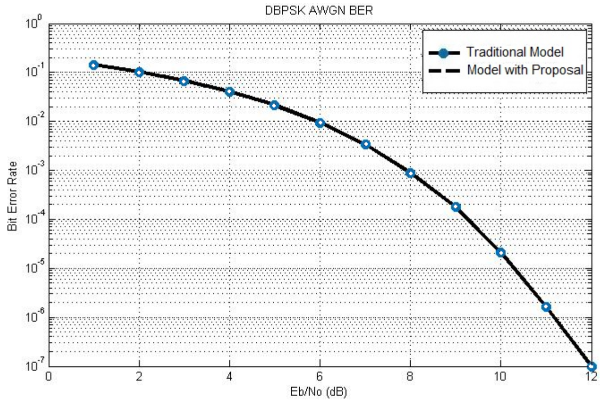

Figure 09 – Performance BER

V. CONCLUSIONS

In all scenarios analyzed, the simulation model of the system with discrete event methodology on both different hardware configurations, evaluated on memory consumption, obtained better results, when compared with the model with the traditional methodology, either in its first simulation or along the sequence of 5 simulations.

Thus, the use of discrete events applied in a low level of abstraction such as bit generation in telecommunication system model performed a treatment of the bits prior to the modulation process, functioning as a pre-coding process differentiated.

The extension of the results of this work, being the compression of the information, has a strong impact on the methods performed in higher layers, like MPEG-4 in a broadcasting system for example, as well as others, being able to improve them even more, since this proposal acts on the bits.

The purpose of this research, was the development of simulation models of telecommunication systems, taking a different approach from what is normally done and applying a concept of a methodology at a lower abstraction level than it is normally used, in which in the transmission in the channel were created discrete entities in the process of creation of the bit, as also following the orientation of the modeling of each technique studied, as also contribute to the study area.

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