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Technical Report

Bit Error Models

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Abstract

The use of bit error models in communication simulation has been widely studied. In this technical report we present three models: the Independent Channel Model; the Gilbert-Elliot Model and the Burst-Error Periodic Model.

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Bit Error Models

1.Introduction

The purpose of this technical report is to describe the Bit Error Model (BEM) supported by the Repeater-Based Hybrid Wired/Wireless PROFIBUS Network Simulator (RHW2PNetSim)[1] and Bridge-Based Hybrid Wired/Wireless PROFIBUS Network Simulator (BHW2PNetSim) [2]. These simulators support the following BEMs: Independent Channel Model [3]; the Gilbert-Elliot Channel Model [4, 5] and the Burst-Error Periodic Model [6].

The structure of this document is as follows. Section 2 presents the Independent Channel model. A detailed description of the Gilbert-Elliot Model is done in Section 3. In Section 4 we present the Burst-Error Periodic Model. Then Section 5 describes how to set the parameters of the RHW2PNetSim and the BHW2PNetSim to configure the BEM.

2.Independent Channel Model

This model is very simple and determines if a frame is correct or wrong, that is, there is a bit error in a frame. As there is no correlation between two consecutive errors, this model is called *Independent* Channel Model.

The result of this model is obtained using Bernoulli function [7] with parameter P_{fr_err} . This parameter is computed as follows:

$$P_{fr\_err} = 1-(1-p_{ber})^{L} \qquad (1)$$

where L is the length (in bits) frame and p_{ber} is the Bit Error Rate (BER) probability associated to the channel.

3.Gilbert-Elliot Channel Model

It is well known that transmission errors occur in bursts, that is, there is correlation between consecutive errors. The Gilbert-Elliot model [4, 5] takes into account this correlation. This model is a two-state discrete-time Markov chain as shown Figure 1.

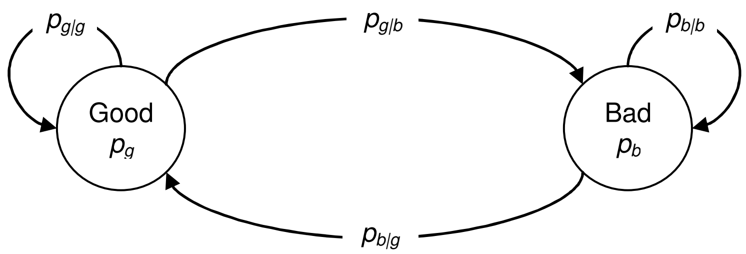

Figure 1 – Gilbert-Elliot model

One state represents a *good* channel conditions and the other one *bad* channel conditions. Each state is assigned a constant Bit Error Rate (BER) probability, p_g in good state and p_b in bad state. It is assumed that the bit errors occur independently from each other.

Let t_g and t_b the mean duration in good state and in bad state, respectively. The steady state probability for being in good state can be obtained as follows:

$$p_{g|g} = \frac{t_g}{t_g + t_b} \tag{2}$$

In same way, the steady state probability for being in bad state can be obtained as follows:

$$p_{b|b} = \frac{t_b}{t_g + t_b} \tag{3}$$

The mean BER is given by:

$$MeanBER = p_{g|g} * p_g + p_{b|b} * p_b \tag{4}$$

The probability of a transition occurs from good to bad state is computed as:

$$p_{b|g} = 1 - p_{g|g} \tag{5}$$

The probability of a transition occurs from bad to good state is computed as:

$$p_{g|b} = 1 - p_{b|b} \tag{6}$$

The Gilbert-Elliot model is computationally expensive, since for each frame's bit two uniform experiments have to be executed. The algorithm works by generating, for each bit in a frame a random number and compares it to the respective BER. A second random number is generated to determine whether the model stays in the actual state or changes into the other state for the next bit.

This will slow down the simulation performance. In order to overcome this drawback a simplified Gilbert-Elliot model can be used. This simplification is accomplished by assuming that in good state all frame's bit are correctly transmitted. Therefore, in good state there is the need to compute if state transition occurs. In context of this dissertation this model is called Simplified Gilbert-Elliot Channel Model.

4.Burst-Error Periodic Model

The Burst-Error Periodic Model assumes that the transmission errors occur in a periodic way. In this model it is assumed that there are a lower (T_{em}) and a higher (T_{eM}) period threshold. The burst length is also bounded by a minimum (N_{em}) and maximum (N_{eM}) number of bits. The T_{em} and T_{eM} parameters are set in milliseconds and the N_{em} and N_{eM} are set in bits.

Figure 2 shows a simplified timeline using this model. The transmission error period is computed using the Eq. 7 and burst length is computed using the Eq. 8.

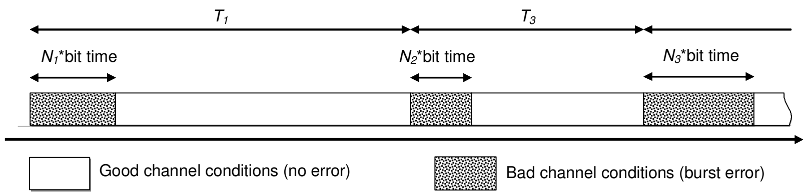

Figure 2 – Simplified timeline of Burst-Error Periodic Model

$$T_x = uniform(T_{em}, T_{eM}) \tag{7}$$

$$N_y = uniform(N_{em}, N_{eM}) \quad (8)$$

To compute the transmission error period and the burst length a uniform probability distribution function [7] is used (Eq. 8). This function was chosen because this model imposes thresholds, i.e., the transmission error period has to be enclosed within of the range [T_{em} , T_{eM}] and burst length has to be enclosed within of the range [N_{em}, N_{eM}]. On the other hand, is assumed that either period or burst lengths are uniformly distributed in their defined ranges.

5.Parameterization of the Bit Error Model Parameters Used in both Simulators

The RHW2PNetSim and BHW2PNetSim define a set of parameters to specify which BEM to use. The name of all these parameters uses the `_bem` prefix. The `_bem_type` is used to define the BEM and the other parameters (`_bem_par1`, `_bem_par2`, `_bem_par1`, `_bem_par3` and`_bem_par4`) are used to set the BEM parameter. Table 1 presents how the simulator parameters must be set according to the BEM to be used.

Table 1– Bit Error Model simulators parameters

		Bit Error Model			
Parameters	**No errors**	**Independent Channel Model**	**Gilbert-Elliot Channel Model**	**Simplified Gilbert-Elliot Channel Model**	**Periodic Burst Model**
`_bem_type`	0	1	2	3	4
`_bem_par1`	–	p_{ber}	$p_{g\|b}$	$p_{g\|b}$	T_{em}
`_bem_par2`	–	–	$p_{b\|g}$	$p_{b\|g}$	T_{eM}
`_bem_par3`	–	–	p_g	p_b	N_{em}
`_bem_par4`	–	–	p_b	–	N_{eM}

References

[1] P. Sousa and L. Ferreira, "Repeater-Based Hybrid Wired/Wireless PROFIBUS Network Simulator," Polytechnic Institute of Porto., Porto, Technical-Report Hurray-tr-060402, April 2006.

[2] P. Sousa and L. Ferreira, "Bridge-Based Hybrid Wired/Wireless PROFIBUS Network Simulator," Polytechnic Institute of Porto, Porto, Technical-Report Hurray-tr-050403, April 2005.

[3] A. Willig and A. Wolisz, "Ring Stability of the PROFIBUS Token-Passing Protocol Over Error-Prone Links", *IEEE Transactions on Industrial Electronics*, vol. 48, pp. 1025-1033, 2001.

[4] E. Elliot, "Estimates of error rates for codes on burst-nise channels", *Bell Systems Tech. Journal*, vol. 42, pp. 1977-1997, 1963.

[5] E. Gilbert, "Capacity of a burst-noise channel", *Bell Systems Tech. Journal*, vol. 39, pp. 1253-1266, 1960.

[6] S. Hazim, "Inaccessibility in PROFIBUS Due To Transient Faults," Electronics & Communications Dept., College of Engineering, University of Baghdad, Baghdad, Technical-Report June 2006.

[7] A. M. Law and W. D. Kelton, "Simulation Modeling and Analysis", 3rd ed. New York: McGraw-Hill, 2000.