A Detailed Review on Beaulieu-Xie Fading Model

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***Abstract* - The increasing demand for authentic and high data rates in high-speed railways(HSRs) and future femtocells requires efficient channel models for wireless channels undergoing various dominant specular components. A new fading model known as the Beaulieu-Xie fading model provides a better characterization for such channels. The aim of this paper is to survey the advancement made in designing wireless Beaulieu-Xie fading channels.**

***keywords* - Beaulieu-Xie fading model, probability density function, cumulative distribution function, average symbol error probability and outage probability**

I. INTRODUCTION

A number of channel models (like Rayleigh, Ricean, Nakagami) are presented [1]-[4] for studying the performance of telecommunication systems. In the case of femtocells and high-speed railways (HSRs), the signal characteristics cannot be modeled by the traditional models of fading and shadowing. The Nakagami-m fading channel model is the most significant model [5] for representing a received signal made of both diffuse scatter components and a line-of-sight component (or specular component) [6]. However, ongoing empirical and hypothetical studies have demonstrated that the LOS wireless channels cannot be correctly represented by the commonly used Nakagami-m fading model[7]. Beaulieu and Saberali [7] assert that the Nakagami-m distribution characterizes only a diffuse scatter component and can't represent LOS component. The Nakagami-m distribution is a normalized version of the central chi-distribution (central chi-distribution can't represent a channel with a LOS component) and hence it can't represent a channel with LOS component. As such, a new fading model derived from the non-central chi distribution (k-u distribution) is introduced [8]. The new fading model is simple and flexible representing both diffuse and multiple specular components and will find applications in the investigation of high-speed railways (HSRs) and future femtocells. The new Beaulieu-Xie fading model is related to the Ricean model as the Nakagami-m model is related to the Rayleigh model, and is related to the Nakagami-m model as the Ricean model is said to the Rayleigh model.

II. LITERATURE REVIEW

N. C. Beaulieu et al.[8] proposed a new fading model in closed-form extraordinarily appropriate for modeling practical LOS fading channels, representing both diffuse scatter component and LOS components. The probability density function (PDF), the cumulative distribution function (CDF), the K-factor and the nth moment was derived for this new model. It was concluded that the new model holds up an alike relationship to the Nakagami-m model as does the Ricean model to the Rayleigh model. In addition, the new model exhibits an alike relationship to the Ricean model as does the Nakagami-m model to the Rayleigh model.

A. Olutayoet al.[9] computed tight lower and upper bounds for the bit error rate (BER) and the outage probability of selection combining over the new Beaulieu-Xie fading model. The impact of the presence of more than one line-of-sight (LOS) was also observed (analytically) on the performance. It was found that as the SNR increases, the bounds of the outage probability get tighter.

A. Olutayo et al. [10] derived the tight lower and upper bounds for the outage probability and the bit error rate (BER) of the equal gain combining over the new Beaulieu-Xie fading model. Employing the exponent component of the Gaussian PDF, the presence of more than one LOS component was seen (analytically) on the performance. It was concluded that the new Beaulieu-Xie fading model can be productive in modeling modern wireless communication links with both LOS and non-LOS components.

V. Kansal et al. [11] obtained an accurate analysis of effective capacity over the new Beaulieu-Xie fading model. For analyzing the effective capacity of this fading channel, closed-form expressions were obtained. In addition, for the cases of high and low SNR, asymptotic analysis was done. It was concluded from the results that the effective capacity of the wireless fading channel can be increased by decreasing the delay factor.

A. Olutayo et al. [12] investigated the level crossing rate (LCR) and the average fade duration (AFD) of a recently developed (Beaulieu-Xie) fading model. To compute the LCR for a diversity scheme utilizing maximum ratio combining

(MCR), the characteristic function (CF) method was used. It was concluded that the LCR and AFD of this new fading model show advancement past the performance levels of the Nakagami-m and Ricean fading models

V. Kansal et al.[13] obtained the new closed-form expressions for the average symbol error probability (ASEP) of M-ary differential phase-shift keying (MFSK), coherent M-ary phase-shift keying (MPSK) and non-coherent M-ary frequency shift keying (MFSK) over the Beaulieu-Xie fading channel. It was found that the fading severity decreases with an increase in the order of modulation.

V. Kansal et al. [14] derived the average bit error rate (ABER) expressions of BPSK and DPSK over the recently developed Beaulieu-Xie fading. The final expressions were obtained in the form of infinite series and elementary functions for BPSK and QPSK respectively. It was found from the results that ABER decreases with an increase in specular power and/or fading severity parameter.

J. Hu et al. [15] analyzed the outage probability of an amplify-and-forward (AF) based mixed Beaulieu-Xie/Gamma-Gamma transmission system (hybrid RF/FSO system). The mathematical results were derived for probability density function (PDF), cumulative distribution function (CDF), and moment generating function (MGF) of the system. It was concluded that there is a powerful impact on the outage performance of the hybrid RF/FSO transmission system with atmospheric turbulence.

J. Hu et al. [16] presented the performance analysis for a decode-and-forward based hybrid Beaulieu-Xie/Málaga (M) transmission system (hybrid RF/FSO system). Novel analytical expressions were obtained for the probability density function (PDF), the cumulative distribution function (CDF),moment generating function(MGF), average bit-error rate, outage probability, and average channel capacity.

A. Olutayo et al. [17] analyzed the performance of the Beaulieu-Xie fading model using bounds. The results for error rate performance and outage probability of equal-gain combining, selection combining, and maximal ratio combining were considered.

M. Kaur et al. [18] computed the exact analytical expressions over the Beaulieu-Xie fading channel with MRC diversity. The results for the outage probability, channel capacity, amount of fading and ASEP (both coherent and non-coherent) were obtained for the fading channel. It was observed that the deteriorating impact of fading is reduced as the number of diversity branches increases.

V. Kansal et al. [19] derived the closed-form expressions for the exact analysis of capacity over the Beaulieu-Xie fading channel along the maximum ratio combining scheme. It was found that the system capacity increases with an increase in the number of diversity branches and in addition, greater specular power prompts greater capacity.

A. Olutayo et al. [20] introduced a new fading model referred to as the shadowed Beaulieu-Xie model. The amplitude of the line-of-sight (LOS) component was assumed to be Nakagami-m distributed. Closed-form results for OP and BER were obtained.

H. S. Silvaet al. [21] presented a mathematical characterization for the cascaded double Beaulieu-xie fading model. For the probability density function (PDF) and the cumulative distribution function (CDF) of the envelope that characterizes the product of two random variables (independent and non-identically distributed random variables) modeled by Beaulieu-Xie fading, exact mathematical expressions were obtained. Besides, accurate mathematical expressions were calculated for the PDF and the CDF of the received signal-to-noise ratio, considering the cascaded double Beaulieu-Xie fading model.

III. CONCLUSION

This paper presented the survey on the recently introduced Beaulieu-Xie fading model. We reviewed this fading model, which is flexible and best to characterize conditions in which there is the presence or absence of line-of-sight components. The new model bears the same relationship to the Ricean model as does the Nakagami-m model to the Rayleigh model. In addition, the new model bears the same relationship to the Nakagami-m model as does the Ricean model to the Rayleigh model. We concluded that this new fading model lays the groundwork in the modeling of high- speed railway (HSRs) and future femtocells.

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