A Review on k- μ Fading Model

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Abstract **- The demand on modeling the transmission channels in nonhomogeneous and enclosed environments (namelyairplanes, trains, buses) is increased. To deal with the increased demand of adequately fit to experimental data observed in severalscenarios, and for approximating random phase noise, needs an efficient channel model. The k- μ general fading model is recent fading model introduced in 2001. This fading model includes most popular well defined fading as special cases. In this paper, we study the literature survey to review the evolution made so far in k- μ fading model. From study it's affirmedthat k- μ fading model gives better performance in many ways as compared to the traditional fading models.**

keywords **- k- μ fading model, probability density function, cumulative distribution function, moment generating function, outage probability and bit error rate.**

1. INTRODUCTION

In wireless communication, radio signal propagation through wireless channel is a complex aspect especially in the presence of multipath fading scenario and due to this requirement of accurate channel modeling in systems is raised. Initial work on modeling the channels was done by various fading models such as Rayleigh, Rician, Nakagami-m, and One- Sided Gaussian. All these predefined fading models propagates in homogenous and indoor environments [1-3]. From these papers, we came to know that a situation come across in all these models, where no pre-existing fading models seem to adequately fit experimental data, some models gives moderate fit. To overcome this problem, a general fading model was introduced. This k- μ fading model provides an enhanced fit to empirical data observed in different scenarios. This proposed model propagates in non-homogenous and enclosed environment such as airplanes, buses, trains. In this model two parameters are presents k and μ, parameter k is the ratio of power of dominant components to the ratio of power of scattered components and μ is the clustering parameter. One among the most appealing properties of this fading model is that it comprises most popular fading distributions as special cases by setting the parameters k and μ to specific positive values. By setting μ=1 and k=k we get Rice expression, μ=1 and k=0 obtain Rayleigh, and at k approaches to zero, μ= m obtain Nakagami-m expression. Due to the small number of parameters as well as the relatively simple mathematical tractability, much attention is rewarded to the present model.

2. LITERATURE REVIEW

A. Abdi et al. presented the k-distribution as a relevant alternate for Rayleigh-lognormal distribution in shadowed fading channel. The author replaces the complicated integral form which was existed in Rayleigh lognormal by using this k distribution. It was concluded from the result that by using this distribution, they obtained a closed form solutions in calculations of bit error rates, diversity effects [4].

M. D. Yacoub introduced a general fading distribution called as k-μ distribution. This general fading distribution comprises other predefined distributions as special cases, and may be used to exemplify the small scale variation of fading signal. From result it was concluded that k-μ distribution contributes a good match with empirical data [5].

J. C. S. S. Filho et al. proposed exact k- μ approximation to the sum of M independent non coherent Ricean random variables (RVs). These random variables had random mean power and fading parameters. In this paper by using the k- μ probability density function (PDF) authors approximate the PDF of the sum of M Ricean RVs. The calculated results used further in equal gain combining, signal detection, and outage probability analysis [6].

S.L.Cotton et al. derived a close form expressions for level crossing rate and average fade durations of k- μ distributed fading channel. It was observed that in earlier papers k- μ distribution limited only for first order statistics .These equations were verified by reducing them to the known special cases like Rayleigh, Rician. These derived results were further used in design of error correction codes [7].

M. Milisic et al. derived closed form interpretation for the outage probability (OP), bit error probability (BEP) and symbol error probability (SEP) of maximum ratio combining (MRC) in k- μ fading model. These derived results were verified by simulations methods [8].

G. S. Rabelo et al. proposed the k- μ extreme fading model for illustrating the wireless propagation under severe fading situations in enclosed environment .This extreme distribution derived from the original k- μ distribution when its parameter reaches to its extreme value. By using this extreme distribution with combining techniques author obtained a closed form formulas. It was concluded from results that selection combining (SC) contributes an admirable outage performance as compared to the equal gain combining (EGC) [9].

K. P. Peppas evaluated new expressions for probability density function (PDF) and cumulative distribution function (CDF) of sum of independent nonidetically distributed squared k- μ random variables by using generalized Laguerre polynomial extension .The derived results were used to determine the performance of the maximal ratio combining (MRC) receiver in term of outage probability (OP), the average bit error probability (ABEP) and channel capacity of digital modulation systems [10].
P. C. Sofotasios et al. calculated the analytical expression for the average probability of detection valid only for single user. These results were afterwards enlarged to the square law selection (SLS) diversity schemes. In this paper, author investigated the performance of energy detection in k- μ and k- μ extreme fading models. It was observed that by expanding the number of users or diversity branches, they achieved serious performance advancement [11].
R. F. Lopes et al. derived an expressions for calculating the pairwise error probability (PEP) of modulation diversity systems over the k—μ fading. The derived results were obtained by using numerical integration, lower or upper bounds. From results it was concluded that performance of digital communication systems especially under harsh fading cases, upgraded by modulation diversity [12].
J. F. Paris proposed a closed form expression for the probability density function (PDF) and cumulative distribution function (CDF) and moment generating function (MGF) of the k- μ shadowed distribution. It was observed that statistics of the sum and maximum distribution can also be present in closed form. These new statisticals results further used in the analysis of bit error probability of system applied selection combining (SC) and maximum ratio combining (MRC) technique over k- μ shadowed model [13].
C. G. Corrales et al. evaluated a definite closed form expression for the ergodic capacity of fading channels, following the k- μ shadowed distribution. These derived results were validated across numerical simulation. The effect of the fading parameters over the shadowing level also investigated. In future these outcomes were used for many applications like underwater acoustic communication, land mobile satellite systems [14].
S. Kumar estimated approximate expressions for outage probability (OP) and channel capacity in form of simple hyper geometric function. In this paper, both signal of interest (SOI) and interfering signal accomplished k- μ shadowed fading. From results it was concluded that obtained expressions are analogous with the simulation results [15].
F.J .L .Martinez et al. presented a new closed form expression for cumulative distribution function (CDF) in the form of Marcum Q functions. By using these closed form expressions, they accurately develop k- μ extreme distributed random variables. Ergodic capacity was examined in this new developed distribution. It was concluded from the results that capacity scales distinctively as compared to the typical fading model in the high signal to noise (SNR) region [16].
L. M .Pozas et al. evaluated k- μ shadowed fading model which includes n- μ fading model as a special case as like the k- μ fading model. A closed form expression for the ergodic capacity in the high signal to noise (SNR) was derived. By manipulating the unification available, closed form expression of capacity were also obtained for the special cases like k- μ, n- μ, and Rician shadowed models [17].
N. **Bhargav et al.** derived a systematic and close form solutions for the strictly positive secrecy capacity (SPSC) and secure outage probability (SOP) over k—μ fading model alongside integer values of parameters. These derived results were verified through devaluation to known special cases. Further these outcomes used to calculate outage probability (OP) of the system affected by the co- channel interference (CCI) and background noise (BN) [18].
N. Bhargav et al. computed analytical and closed expression for outage probability (OP) in the existence of co-channel interference (CCI) and background noise (BN) over k- μ fading model. Because of the flexibility of this model, these derived results unifies the OP expressions with BN, when applied to the Rayleigh, Rice, Nakagami –m and One- sided Gaussian fading model [19].
S. Kumar et al. developed the expression for outage probability (OP) in interference reserved systems where both signal of interest (SOI) and interrupting signals experienced k- μ shadowed fading. The derived results of the OP and rate expression were easy to evaluate because of the subsistence of Pochhammer integral and Lauricella's function. In this paper, they compare fractional frequency reuse (FFR) with soft frequency reuse (SFR). From results it was observed that FFR exceeds SFR [20].
F. J. L.Martinez et al. presented analytical characterization of the k-μ shadowed fading model with parameters. They derived the close form expressions of probability density function (PDF) and cumulative distribution function (CDF) in form of finite number of power and exponential. It was observed that complexity of the k- μ shadowed model was reduced by performing some limited restriction in case of flexibility [21].
P. R. Espinosa et al. proposed the correlated k- μ shadowed fading model, in which closed form expressions of the of probability density function (PDF), cumulative distribution function (CDF) and moment generating function (MGF) were derived in form of simple elementary functions. These derived results are further used for describing the multivariate Rayleigh, Rician, and Rician shadowed distribution [22].
N. Simmons et al. introduced a family of shadowed k- μ fading models and differentiated these models on the basis that k- μ experience either single or double shadowing. In this model, shadowing is induced by Nakagami-m random variables (RVs), an inverse Nakagami –m, or by using their mixture. In this paper, a comprehensive analysis for single and double type shadowed model were given. It was found that double shadowed model offer phenomenal flexibility [23].

3. CONCLUSION

This paper characterized a survey on the general k- μ fading model .In this paper, we have done a thorough analysis on the existing k- μ fading model. This fading model includes other well defined traditional fading models like Rayleigh, Rician, Nakagami-m, and One- Sided Gaussian as special cases. This model provides an improved fit to experimental data as compared to the predefined fading model. Because of the versatility and flexibility of this model, a lot of attention paid to this as compared to others. Further it can be possible to evaluate the error rate analysis for different modulation schemes in the presence of phase error over this fading model.

REFERENCE

[1] R. Prasad and A. Kegel, "Effects of Rician faded and Log-normal shadowed signals on spectrum efficiency in microcellular radio," *IEEE Trans. Veh. Technol.*, vol. 42, no. 3, pp. 274–281, 1993.

[2] B. A. B. Ii and K. Teori, "Rayleigh fading channels in mobile digital communication Systems, characterization," IEEE Commun. Magazine , vol. 35, pp. 90-100 ,1997.

[3] T. T. Tjhung and C. C. Chai, "Fade statistics in Nakagami -lognormal channels," *IEEE Trans. Commun.*, vol. 47, no. 12, pp. 1769–1772, 1999.

[4] A. Abdi, and M. Kaveh, " K-distribution, an appropriate substitute for Rayleigh-lognormal distributionin fading-shadowing wireless channels", *Electron. Lett* , vol. 34, no. 9, pp. 851–852, 1998.

[5] M. D. Yacoub, "The k- μ distribution, a general fading distribution," . *IEEE Veh. Technol. confere. ,* pp. 1427–1431, 2001.

[6] J. C. S. S. Filho, M. D. Yacoub, "Highly accurate k - μ approximation to sum of M independent non-identical Ricean variates," *Electron. Lett,* vol. 41, no. 6, pp. 0–2, 2005.

[7] S.L.Cotton and W.G .Scanlon, "Higher order stastics for k- μ distribution ," *Electron. Lett.*, vol. 43, no. 22, pp. 40–41, 2007.

[8] M. Milisic, M. Hamza, and M. Hadzialic, "BEP/SEP and outage performance analysis of L-branch maximal-ratio combiner for k-u fading," *Int. J. Digit. Multimed. Broadcast.*, vol. 2009, 2009.

[9] G. S. Rabelo and M. D. Yacoub, "The k-μ Extreme distribution," *IEEE Trans. Commun.*, vol. 59, no. 10, pp. 2776–2785, 2011.

[10] K. P. Peppas, "Sum of nonidentical squared k-μ variates and applications in the performance analysis of diversity receivers,". *IEEE Trans.Veh. Technol.*, vol. 61, no. 1, pp. 413–419, 2012.

[11] P. C. Sofotasios, E. Rebeiz, L. Zhang, T. A. Tsiftsis, D. Cabric, and S. Freear, "Energy detection based spectrum sensing over k-μ and k-μ extreme fading channels," *IEEE Trans. Veh. Technol.*, vol. 62, no. 3, pp. 1031–1040, 2013.

[12] R. F. Lopes, W. J. L. Queiroz, W. T. A. Lopes, and M. S. Alencar, "Performance of the modulation diversity technique for κ - μ fading channels," Eurasip J. Wirel. Commun. Networking , vol. 2013 , pp. 1–18, 2013.

[13] J. F. Paris, "Statistical characterization of κ-μ Shadowed fading," *IEEE Trans. Veh. Technol.*, vol. 63, no. 2, pp. 518–526, 2014.

[14] C. G. Corrales, F. J. Cañete, and J. F. Paris, "Capacity of κ - μ Shadowed Fading Channels," *Int. J. Antennas Propag.*, vol. 2014, pp. 1-8 , 2014.

[15] S. Kumar, "Approximate outage probability and capacity for κ-μ Shadowed fading," *IEEE Wirel. Commun. Lett.*, vol. 4, no. 3, pp. 301–304, 2015.

[16] F. J. L.Martinez, L. Moreno-Pozas, and E. Martos-Naya, "Novel results for the κ-μ extreme fading distribution , generation of white samples and capacity analysis," *IEEE Commun. Lett.*, vol. 19, no. 9, pp. 1580–1583, 2015.

[17] L. M .Pozas, F. J. Lopez-Martinez, J. F. Paris, and E. Martos-Naya, "The κ-μ Shadowed Fading Model, unifying the κ-μ and η-μ distributions," *IEEE Trans. Veh. Technol.*, vol. 65, no. 12, pp. 9630–9641, 2016.

[18] N. Bhargav, S. L. Cotton, and D. E. Simmons, "Secrecy capacity analysis over κ-μ fading channels, theory and applications," *IEEE Trans. Commun.*, vol. 64, no. 7, pp. 3011–3024, 2016.

[19] N. Bhargav, C. R. N. Da Silva, Y. J. Chun, S. L. Cotton, and M. D. Yacoub, "Co-channel interference and background noise in κ-μ fading channels," *IEEE Commun. Lett.*, vol. 21, no. 5, pp. 1215–1218, 2017.

[20] S. Kumar and S. Kalyani, "Outage probability and rate for κ-μ shadowed fading in interference limited scenario," *IEEE Trans. Wirel. Commun.*, vol. 16, no. 12, pp. 8289–8304, 2017.

[21] F. J. L.Martinez, J. F. Paris, and J. M. Romero-Jerez, "The κ-μ shadowed fading model with integer fading parameters," *IEEE Trans. Veh. Technol.*, vol. 66, no. 9, pp. 7653–7662, 2017.

[22] P. R. Espinosa, J. F. Paris, J. A. Cortes, and E. Martos-Naya, "The κ-μ shadowed fading model with arbitrary intercluster correlation," *Proc. Int. Symp. Wirel. Commun. Syst.*, vol. 2018-August, 2018.

[23] N. Simmons, C. R. N. Da Silva, S. L. Cotton, P. C. Sofotasios, S. K. Yoo, and M. D. Yacoub, "On shadowing the κ-μ fading model," *IEEE Access*, vol. 8, pp. 120513–120536, 2020.

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