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Performance analysis of Fading Channels

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Abstract: Radio wave propagation through wireless channel is a complicated phenomenon characterized by fading which is the result of multipath propagation. In wireless communication system, random process related with fading channels can normally analyzed by their PDF (Probability Density Function) and CDF (Cumulative Distribution Function). Signal fading can influence the execution of terrestrial communication systems. Several statistical models are available for describing the fading envelope of the received signal in which Rayleigh,Rician and Nakagami are the most frequently applied models. Higher-order statistics such as Level Crossing Rate(LCR) & Average Fade Duration render (AFD) insight into signals which is not always available at lower orders. These are used as metrics to analyze the fading in different models such as Rayleigh,Rician and Nakagami. Finally we show that Nakagami fading channel provides a better explanation to less and more severe conditions than the Rayleigh and Rician fading channels and provides a better fit to the mobile communication channel data because it has lowest level crossing rate and highest average fade duration corresponding to threshold value.

Keywords: fading, multipath propagation, LCR, AFD.

I. INTRODUCTION

The field of wireless communication has gained critical ground in making high speed and broader telecommunication. By looking for such an eager objective, wireless communication technology is confronting a definitive specialized test of accomplishing higher data exchange speeds.Since signal propagation happens in the atmosphere and close to the ground the most eminent impact of signal corruption is multipath propagation and this prompts multipath fading. Analysts have demonstrated that different propagation paths or multi paths have both slow and fast perspectives. The wireless channel can be depicted as a function of time and space and the received signal is the blend of numerous copies of the original signal impinging at recipient from a wide range of paths. The signal on these distinctive paths can constructively or destructively interfere with each other. This is alluded as multipath fading. On the off chance that either the transmitter or the recipient is moving, at that point this propagation wonders will be time varying, and fading happens. In particular the fading models can be partitioned into three classes by isolating the received signal in three scale of spatial variation, for example, fast fading, slow fading or shadowing and path loss. Moreover, a few models for small scale fading are viewed as such as Rayleigh, Rician, Nakagami and Weibull distributions [1].

In mobile communications with time-selective fading, the level crossing rate (LCR), how often the signal crosses a certain threshold, is an important dynamic characteristic of the channel. The average fade duration (AFD), how long the signal stays below a given threshold, can be calculated from LCR and appears in a variety of applications. Choosing the frame length of coded packetized systems [1] and also interleaver optimization, to efficiently combat the burst of errors due to long fades, need the AFD information . In adaptive modulation schemes, the average time that a particular constellation is continuously used is related to AFD . Average outage duration in multiuser cellular systems, where interference from other users restricts the performance, is another close relative of AFD. Throughput (efficiency) of communication protocols such as automatic repeat request (ARQ) schemes can be estimated using AFD . The transition probabilities between different states of a Markov model for fading channels has been calculated based on LCR at different levels.

The LCR at threshold ρ is the expected rate at which the normalized envelope passes the value ρ with a positive slope.We expect the highest rate around ρ =0 dB, tapering off gently for lower thresholds and abruptly for higher thresholds .The maximum Doppler frequency just scales the horizontal axis and therefore the rate. For Rayleigh fading and isotropic scattering (Clarke's Model), the LCR is given by

$\sqrt{2\pi}\, f_d\, \rho\, e^{-\rho 2}$
where fd is the maximum Doppler frequency

The average fade duration is the average period of time the normalized envelope is below a level ρThe interleave breaks up the fade so that forward error correction (FEC) codes can correct errors from fading.

The wireless environment is highly unstable and fading is due to multipath propagation. Multipath propagation leads to rapid fluctuations of the phase and amplitude of the signal. The presence of reflectors in the environment surrounding a transmitter and receiver create multiple paths that a transmitted signal can traverse. As a result, the receiver sees the superposition of multiple copies of the transmitted signal, each traversing a different path. Each signal copy will experience differences in attenuation, delay and phase shift while traveling from the source to the receiver.This can result in either constructive or destructive interference, amplifying or attenuating the signal power seen at the receiver. Fading may be large scale fading or small scale fading . Based on multipath time delay spread small scale fading is classified as flat fading and frequency selective fading. If bandwidth of the signal is smaller than bandwidth of the channel and delay spread is smaller than relative symbol period then flat fading occurs whereas if bandwidth of the signal is greater than bandwidth of the channel and delay spread is greater than relative symbol period then frequency selective fading occurs. Based on doppler spread small scale fading may be fast fading or slow fading. Slow fading occurs when the coherence time of the channel is larger relative to the delay constraint of the channel. The amplitude and phase change imposed by the channel can be considered roughly constant over the period of use. Slow fading can be caused by events such as shadowing, where a large obstruction such as a hill or large building comes in the main signal path between the transmitter and the receiver. Fast fading occurs when the coherence time of the channel is small relative to the delay constraint of the channel. The amplitude and phase change imposed by the channel varies considerably over the period of use. In a fast-fading channel, the transmitter may take advantage of the variations in the channel conditions using time diversity to help increase robustness of the communication. Nakagami fading model considers the instance for multipath scattering with relatively large delay-time spreads, with different clusters of reflected waves. Within any one cluster, the phases of individual reflected waves are random, but the delay times are approximately equal for all waves. As a result the envelope of each cumulated cluster signal is rayleigh distributed. The average time delay is assumed to differ significantly between clusters. If the delay times also significantly exceed the bit time of a digital link, the different clusters produce serious intersymbol interference, so the multipath self-interference then approximates the case of cochannel interference by multiple incoherent rayleigh-fading signals. Rayleigh fading model considers the fading is caused by multipath reception. Rayleigh fading model assumes that the magnitude of a signal that has passed through transmission medium will vary randomly, or fade, according to a Rayleigh distribution. Rayleigh fading is a reasonable model when there are many objects in the environment that scatter the radio signal before it arrives at the receiver. Rayleigh fading is most applicable when there is no dominant line-of-sight propagation between the transmitter and receiver. Rician model considers that the dominant wave can be a phasor sum of two or more dominant signals, e.g. the line-of-sight, plus a ground reflection. This combined signal is then mostly treated as a deterministic (fully predictable) process, and that the dominant wave can also be subject to shadow attenuation. This is a popular assumption in the modeling of satellite channels. Besides the dominant component, the mobile antenna receives a large number of reflected and scattered waves.[10]

II. EFFECT OF LCR &AFD ON THE FADING CHANNEL

The lower order statistics sometimes inadequate to investigate the signals in detail or describe, so higher order statistics such as LCR and AFD are more gainful in light of the fact that they provide better investigative platform for fading channels.Additionally, Gaussiandistributed signals have the intriguing normal for disappearing at higher orders. Since of the noise and interference condition is Gaussian distributed, higher order statistics subsequently offers an additional method of noise reduction and interference mitigation and can be used to generate a filtering algorithm.

LCR and AFD have found an assortment of applications in the modeling and design of wireless communication systems LCR is defined as the quantity of times per unit duration that the envelope of a fading channel crosses a given value in the negative direction.AFD corresponds to the average length of time the envelope stays under the threshold value when it crosses it in the negative direction. These quantities reflect correlation properties, and therefore the second orderstatistics, of a fading channel.

LCR and AFD of the signal envelope are two important second order channel statistics,which pass on helpful information about the dynamic temporal behavior of multipath fading channels.In 2000 the Level Crossing Rate and Average Fade Duration of Rayleigh, Rice, and Nakagami Fading Models with Portable Channel Data were compared . Visual correlation of the theoretical outcomes with measured data uncovers that all the models, for example, the straightforward Rayleigh model with isotropic scattering show sensible fit as far as LCR and AFD for the greater part of the records, independent of the CDF fits. This suggests that the goodness of fit for second order statistics (LCR and AFD) do not seem, by all accounts, to be dependent on the exactness of fit for fi rst order statistics (CDF) Cyril Daniel Iskanderappeared in 2002 that the level crossing rates (LCRs) and average fade durations (AFDs) of a fading channel find diverse applications in the evaluation and design of wireless communication systems. Generalizations of articulations for the LCR of a diversity received signal in Rayleigh fading, in order to handle the more broad Nakagami fading distribution are derived [3]. In 2003 it was analyzed and simulated the statistical performances of Nakagami Fading Channel utilizing MATLAB including the complex encompass of received signal, the Level Crossing Rates and Average Fade Durations on the Maximal Ratio Combining diversity. By changes every parameter, a little change in the fading channel can be observed that it is valuable to understand the fundamental idea of radio channel [4]. The second order statistical signal properties at the yield of the dual diversity choice joining (SC) system analyzed and exposed in 2007 to the combined impact of the co channel interference (CCI) and the warm noise (AWGN) in Nakagami fading channel. The systematic outcomes reduce to known arrangements in the instances of an interference limited system in Rayleigh fading and an AWGN limited system in Nakagami fading.[5] In 2008 Nikola Zlatanovdescribed the novel correct articulations and accurate closed form approximations for LCR and AFD of the Double Nakagamim Random Process and these are valuable in study of the second order statistics of different information numerous yield (MIMO) keyhole fading channels with space time square coding. [6] Researchers described In 2012 the applications and novel logical framework for the calculation of the higher Order Statistics LCR and AFD of Sampled Fading Channels as far as CDF and its bivariate CDF. As a direct application correct closed form articulations for the LCRs of the comparable recurrence domain sampled random process associated with a multipath Rayleigh fading channel are calculated. It demonstrates that as the testing rate of the randomprocess is reduced, the actual LCR is lower than the LCR of the associated constant random process and subsequently, the real AFD is bigger [7]. In 2013 the PDF of diagnostic Nakagami fading parameter in dependent noise channel utilizing copula theory which breaks down the noise behavior much superior to other traditional procedures estimated. In this a more extensive situation about the noise destruction is in low signal to noise ratios and the parametric bootstrap method for theprecision of the diagnostically estimated PDF considered.

In this way simulation comes about give superior performance over ordinary estimators. [8] Vidhi Sharma provided a novel expository platform for evaluating the basic second order statistical boundaries, as the average fade duration and level crossing rate of Rayleigh and Nakagami fading channels in 2014 . An articulation is derived for the average LCR and AFD for discrete fading channels. Modeling and simulation is done in the proposed work for Rayleigh, and Nakagami channel and then the LCR and AFD for each channel is calculated. Results for all the discrete channels showed that the genuine values of LCR and AFD are much comparative as calculated by utilizing the proposed approach than the customary theoretical formula [9][10][11][12].

In this paper, comparison of the method of calculation such as theoretical and discrete second order statistic parameters i.e. LCR and AFD in the different types of fading channels such as Rayleigh, Rician & Nakagami is done. After comparison it is found that in discrete process LCR and AFD provide good response as compared to theoretical process.

III. PROPOSED METHODOLOGY

In this paperRayleigh, Rician and Nakagami multipath fading channel objects and the channel visualization tools are used to model a fading channel. These channels are useful models of real world phenomena in wireless communication. A channel object is created that describes thechannel that is desired to use Properties of the channel object are adjusted, if necessary, to tailor it to channel's need. For example, change in the path delays or average pathgains can be done.Then the channel object is applied to the signal using the filter function, which has been overloaded to work with channel objects. The characteristics of a channel can be plotted using the channel visualization tool.

IV. CONCLUSION

This review paper shows that higher order statistics namely level crossing rate and average fade duration led to the evolution of fading channels mostly Rayleigh, Ricianand Nakagami. Alsothese higher order statistics have been used in wide range of applications. So, there is scope that these parameters can be used to estimate the spectral characteristics of fading channels in real time applications.After comparison, it is shownthat Nakagami fading channel provides a better explanation to less and more severe conditions than the Rayleigh and Rician fading channels and provides a better fit to the mobile communication channel data because it has lowest level crossing rate and highest average fade duration corresponding to threshold value.

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