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Nakagami Fading Channel for Radio Frequency on Wireless Communication

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Abstract— Mathematical Analytic tools for measuring system performance, quantify the tradeoff between performance and complexity for all possible fading conditions and system implementations for accurate system design, improvement, and optimization. The time varying multipath fading nature of wireless channels encouraged extensive research in ways to alleviate its harmful consequences. Among the most promising of these solutions is the introduction of diversity, which relies on the model of multichannel reception. With the ever increasing demand of multimedia services, future wireless generations aim to achieve higher data rates and more reliable communications for Quality of Service (QoS) provision. However, due to multipath fading, severe shadowing, pathloss, and co-channel interference (CCI), communication in single-hop wireless networks has faced some fundamental limits. Fading affects the signals transmitted through wireless channels and causes the short-term signal variations. In Nakagami distribution model of the amplitude and signal power can be used to find probabilities on signal outages.

Keywords— **QOS, CCI, Pathloss**

1. INTRODUCTION

Digital wireless systems have been growing in popularity, complexity and capabilities over the last decade, and there are now mobile as well as fixed wireless networks, personal area networks as well as metropolitan area networks. Each of these systems has unique requirements and constraints, but they share at least one key feature: Digital signals should be transmitted over physical channels, which are usually subject to fading[1-2].

Multi-path fading is one of the most common phenomena in wireless systems. It is due to the constructive and destructive combination a number of multi-paths received at the receiver with random attenuations and delays. This type of fading affects the signals transmitted through wireless channels and causes the short-term signal variations. There are various models to describe statistical behavior of this phenomenon. Three common models are Rayleigh, Rice and Nakagami fading channels[3].

The Rayleigh distribution models multi-path fading with no line-of-sight (LOS) while Rice distribution models fading channel in the presence of LOS. In Nakagami distribution model of the amplitude and signal power can be used to find probabilities on signal outages. The fading channels that information is transmitted over may change over time, or the bandwidth occupied by these channels may be large enough that the frequency response of the channel varies over that range [4]. We call the former class of channels time-selective fading channels, while the latter is called frequency-selective or inter-symbol-interference (ISI) channels. Channels can be both time- and frequency-selective[5-6].

2. NAKAGAMI-DISTRIBUTION

The Nakagami-m distribution is a versatile statistical model because it can model fading amplitudes that experience either less or severe fading than that of Rayleigh variates. The Nakagami-m distribution is suitable for describing statistics of mobile radio transmission in complex media such as the urban environment [7]. The Nakagami distribution is related to the gamma distribution. The Nakagami distribution can be generated from the chi distribution. The Nakagami distribution or the Nakagami-*m* distribution is a probability distribution related to the gamma distribution. It has two parameters: a shape parameter m and a second parameter controlling spread, Ω. The Nakagami-m random process is defined as an envelope of the sum of 2m independent Gauss random processes, the Nakagami-m distribution is described by the pdf

$$p_z(z,\Omega) = \frac{2}{\Gamma(m)}\left(\frac{m}{\Omega}\right)^m z^{2m-1}\exp\left(-\frac{m}{\Omega}z^2\right),$$
$$z > 0, m \ge \frac{1}{2} \quad (1)$$

where z is the received signal level, Γ(.) is the gamma function, m is the parameter of fading depth, defined as:

$$m = \frac{E^2[z]}{Var[z^2]} \quad (2)$$

while Ω is average signal power:

$$\Omega = E[z^2]$$

Amount of Fading

The AoF is defined as the ratio of the variance to the square average SNR per symbol.

$$A_F = \prod_{i=1}^{N} \left(1 + \frac{1}{m_i}\right) - 1 \tag{3}$$

From the above equation, it may be concluded that, since m_l >1/2, then

$$0 < A_F \leq 3^N - 1 \tag{4}$$

Outage Probability

The outage probability, P_{out}, is defined as the probability that the received SNR per symbol falls below a given threshold-Y_{th}. This probability can be obtained as

$$P_{out}\left(\gamma_{th}\right) = F_{\gamma}\left(\gamma_{th}\right). \tag{5}$$

Where

$$F_{\gamma}(\gamma) = \frac{1}{\prod_{i=1}^{N}\Gamma(m_i)} G_{1,N+1}^{N,\,1}\left[\frac{\gamma}{\bar{\gamma}}\prod_{i=1}^{N} m_i \,\middle|_{m_1,\, m_2,\ldots,\, m_N,\, 0}^{\;1}\right],$$

(5.9)

Average Symbol Error Probability

The most straightforward approach to obtain the ASEP, $\overline{P}_{se}$, is to average the conditional symbol error probability $P_{se}(\gamma)$ over the PDF is

$$\overline{P}_{se} = \int_0^{\infty} P_{se}(\gamma)\, f_{\gamma}(\gamma)\, d\gamma \tag{6}$$

log Normal Distribution

The log normal is a continuous distribution in which the logarithm of a variable is normally distributed. A log normal distribution results if the variable is the product of a large number of independent, identically distributed variables in the same way that a normal distribution results if the variable is the sum of a large number of independent, identically distributed variables [8]. The log-normal distribution has probability density function.

$$f(x;\mu,\sigma) = \frac{1}{x\sigma\sqrt{2\pi}} e^{-(\ln x-\mu)^2/2\sigma^2} \tag{7}$$

3. SIMULATION RESULT

Outage probability Analysis with changing channel variance

In this experiment, we considered outage probability of the nakagami fading channel to analysis the performance of the system. Fig. 1 shows the Outage probability analysis of gamma-gamma distribution of Nakagami fading channel with channel variance=0.1. Fig. 2 demonstrates the Outage probability analysis of gamma-gamma distribution of Nakagami fading channel with channel variance=0.2. . Fig. 3 demonstrates the Outage probability analysis of gamma-gamma distribution of Nakagami fading channel with channel variance=0.3. Fig. 4 demonstrates the Outage probability analysis of gamma-gamma distribution of Nakagami fading channel with channel variance=0.4. Fig. 5 demonstrates the Outage probability analysis of gamma-gamma distribution of Nakagami fading channel with channel variance=0.5. Fig. 6 demonstrates the Outage probability analysis of gamma-gamma distribution of Nakagami fading channel with channel variance=0.04. Fig. 7 shows the comparative Outage probability analysis of gamma-gamma distribution of Nakagami fading channel with changing value of channel variance.

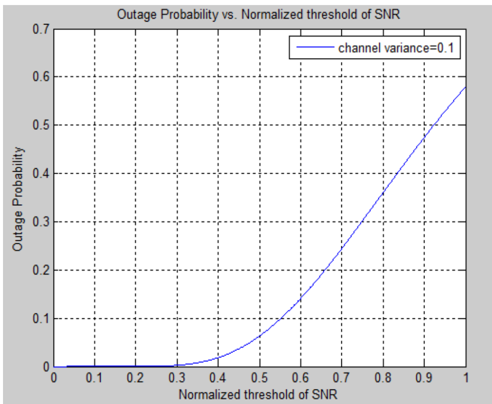

Fig. 1 Outage probability analysis of gamma-gamma distribution of Nakagami fading channel with channel variance=0.1

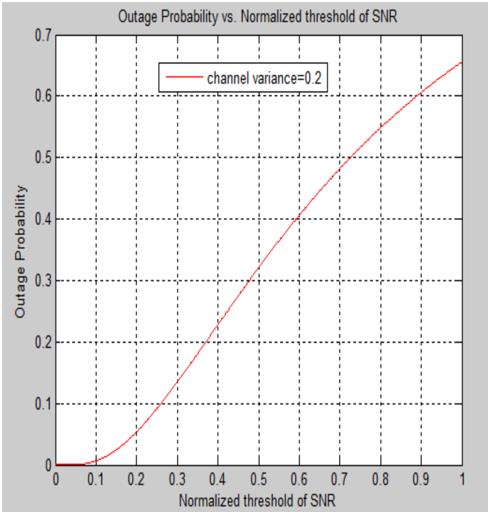

Fig. 2 Outage probability analysis of gamma-gamma distribution of Nakagami fading channel with channel variance=0.2

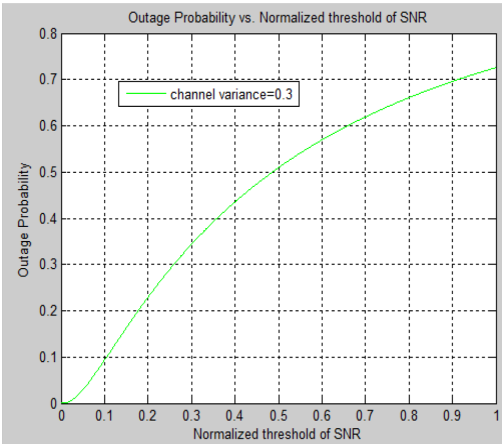

Fig. 3 Outage probability analysis of gamma-gamma distribution of Nakagami fading channel with channel variance=0.3

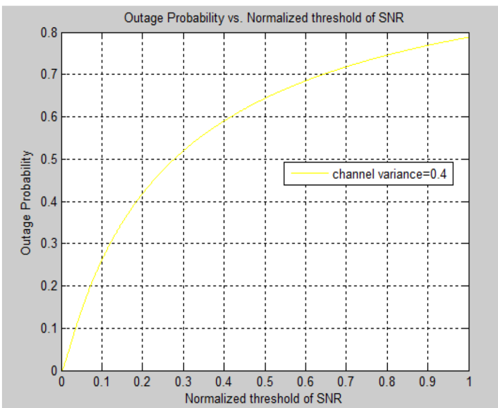

Fig. 4 Outage probability analysis of gamma-gamma distribution of Nakagami fading channel with channel variance=0.4

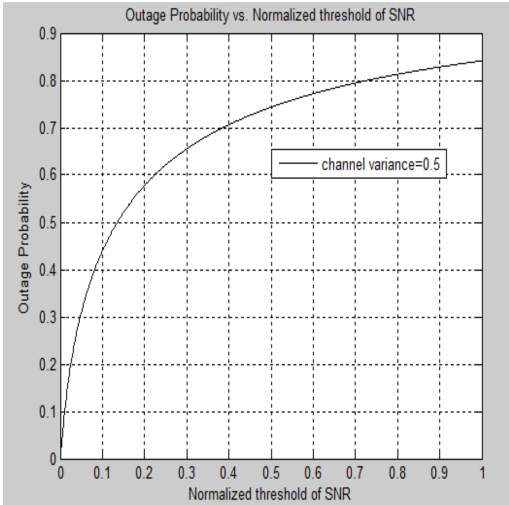

Fig. 5 Outage probability analysis of gamma-gamma distribution of Nakagami fading channel with channel variance=0.5

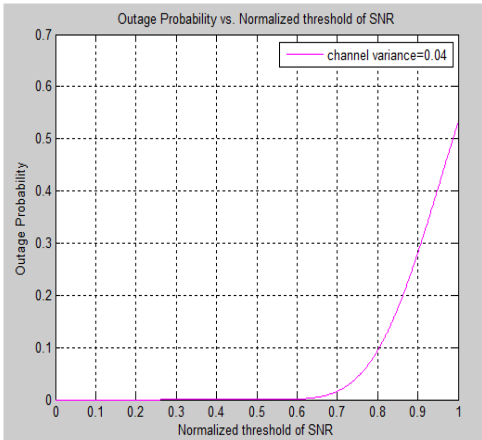

Fig. 6 Outage probability analysis of gamma-gamma distribution of Nakagami fading channel with channel variance=0.04

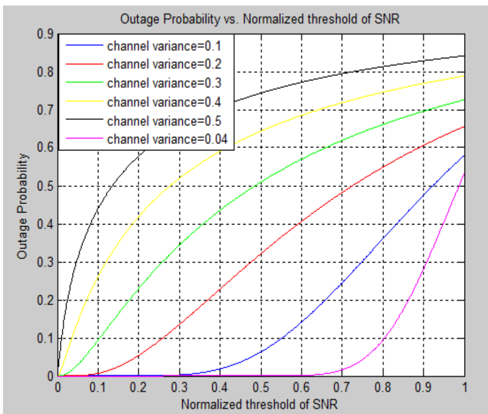

Fig. 7 comparative Outage probability analysis of gamma-gamma distribution of Nakagami fading channel with changing value of channel variance

4. CONCLUSION

The weak turbulence is modelled as log normal distribution of nakagami fading channel. On the other hand, strong turbulence is modelled as gamma-gamma distribution of nakagami fading channel. Simulation results are presented for nakagami fading channel for different level of channel turbulence. Bite error rate (BER) analysis is presented for the nakagami fading channel and compared with the theoretical BER. Results also shows that as the signal to noise ratio increase BER goes on decreasing and try to approaches the theoretical value.

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