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Turbo Coding over Nakagami-m Fading Channels

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***Abstract*—Nakagami-*m* channels are communication channels that can be modeled using the Nakagami-*m* distribution. The Nakagami-*m* distribution provides a wide range of models for channels exhibiting fading (fluctuating channels). By suitably choosing the *m* parameter, a certain fading intensity/strength can be simulated. This paper aims to assess the performance of different types of turbo-codes (TC) over Nakagami channels.**

***Keywords*—comunication sistems, turbo codes; Nakagami-*m* distribution; flat fading channels; bit error rate**

I. Introduction

Most current wireless communication systems face the problem of fading. A typical radio channel exhibits multipath reception, which causes fading [1]. If the channel transfer function is sufficiently constant over the signal bandwidth then we are dealing with flat fading (or frequency nonselective fading). This corresponds to the assumption that intersymbol interference does not play a major role in the performance of the radio links. The presence of fading diminishes the quality of transmissions. Methods to combat frequency selective fading are based on (turbo-)equalization [2]. Protection coding (forward error correction – FEC coding) is an effective method to combat the flat fading effect. Coding gains tens of dB. This paper takes into consideration flat fading.

Coding optimization for fading channels involves simulations and, implicitly, fading modeling. Purely fluctuating channel modeling is based on Rayleigh's distribution. A purely fluctuating channel is a channel in which the received signal is composed only of the reflected waves that can be modeled by random independent and identically distributed (i.i.d.) variables. A channel without fading (non-fluctuating) provides a direct path (line of sight) between the transmitter and receiver. In most actual cases, the received signal contains comparable proportions of both the fluctuating and non-fluctuating component. Modeling this situation calls for Rice's distribution.

Rician fading assumes a dominant line-of-sight component and a large set of i.i.d. reflected waves. Reflected waves arrive with a random phase offset and the accumulation can be modeled as a phasor addition of signals with random amplitude and phase [3]. The received signal amplitude has the probability density function (pdf):

$$f_{Rice}(x)=\frac{2(K+1)x}{\Omega}\cdot \\ \cdot\exp\left(-K-\frac{(K+1)x^2}{\Omega}\right)\cdot I_0\left(2\sqrt{\frac{K(K+1)}{\Omega}}x\right). \quad (1)$$

where K is the ratio between the power in the direct path and the power in the other, scattered, paths; Ω is the total power from both paths and acts as a scaling factor to the distribution; and $I_0(.)$ is the 0th order modified Bessel function of the first kind.

An alternative to Rician channel modeling with varying degrees of (intensity of) fading is using Nakagami's distribution [4]. The Nakagami-*m* distribution can be used to model fading channel conditions that are either more or less serve than the Rayleigh distribution, and it includes the Rayleigh distribution as a special case (m=1). For analytical and numerical evaluation of system performance, the expressions for Rician fading are less convenient, mainly due to the occurrence of a Bessel function in the Rician probability density function of received signal amplitude. Approximations by a Nakagami distribution, with simpler mathematical expressions have become popular.

In the present study, we investigated by means of simulations the performance of turbo coding over the Nakagami channel with different degrees of fading (identified by parameter m – the fading figure).

We used single-binary, duo-binary and multi-non-binary turbo codes.

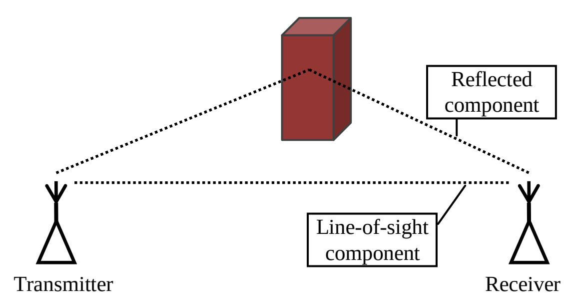

Figure 1. Example of multipath propagation in transmission radio channel.

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