The Application of IEEE 802.11 in the Wireless Networks

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ABSTRACT: *The application of IEEE 802.11 to the wireless networks is required to maintain the standard. In this work we have proposed the simulation of system outage probability and diversity algorithms for orthogonal frequency division multiplexing (OFDM)-based wireless local area network (WLAN_. The experimental results suggest the benefits of the SC diversity algorithms.*

Keywords: Diversity System, OFDM, Outage Probability, Simulation, Space-time-frequency-selective Fading

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1. Introduction

In last two decades, remarkable demand for reliable, highspeed wireless communications is evident. The new techniques which can answer to this demand are multiantenna and orthogonal frequency division multiplexing (OFDM) techniques. Multiantenna techniques can be divided into two categories: diversity techniques and spatialmultiplexing techniques. The first ones are based on receiving same information in the multiple antennas aiming to convert an unstable time-varying wireless fading channel into a stable additive white Gaussian noise (AWGN)-like channel [1]. That provides upgrading transmission reliability of wireless system without increasing transmission power. The traditional diversity techniques are maximal ratio combining (MRC), equal gain combining (EGC), and selection combining (SC). Among them, the last one has the least implementation complexity since it processes signal only from one of diversity antennas, which is selectively chosen, and consequently manifests the worst performance. Normally, a SC receiver selects the antenna with the highest signal-to-noise ratio (SNR) [2]. In OFDM-based systems, a selection process can be based on an entire OFDM symbol (wideband SC) or on an individual subcarrier (narrowband SC) [3].

In order to study influence of system and channel parameters on performance of wireless system, two groups of performance measures, first-order and second-order, should be considered. First-order performance measures are outage probability (OP), error probability, system capacity, average output signal, etc. Second-order performance measures, average level crossing rate (LCR) and average fade duration (AFD), are important for an adaptive system in which firstorder measures do not provide enough information for the overall system design and configuration [4]. The OP has been traditionally the most common used performance measure and, moreover, it is necessary for evaluation of the second order performance measure, i.e. AFD.

To describe fading behaviour in a channel, few statistical models can be found in open technical literature. The most frequently used models are Rice, Rayleigh, Nakagami-m, and Weibull. The performance of SC receivers operating in previous mentioned channels are studied through simulation and numerical analysis in [5]-[8]. In [3] and [9] the performance of OFDM-based systems with a space diversity applied on transmit and receive side are studied, while the performance of SC receiver operating in stochastic Multiple- Input Multiple-Output (MIMO) channel suitable to IEEE 802.11n is investigated in [10]. This paper analyzes the performance of selection diversity applied in Single-Input Multiple Output (SIMO)-OFDM system complaint to IEEE 802.11n standard.

2. Outage Probability

The OP is defined as probability that instantaneous error probability exceeds a specified value or, equivalently, probability that output SNR, μ, falls below a certain specified threshold, μ_{th}. Mathematically speaking, the OP is defined as [2]

$$P_{out} = \int_0^{\mu_{th}} p_\mu(\mu) d\mu, \tag{1}$$

where $p_\mu(\mu)$ represents an probability density function of output *SNR*, SNR_{out}, which form depends on wireless environment.

In OFDM-based system, an antenna selection process can be done on the individual subcarrier level or on the entire OFDM symbol level. The OFDM receiver with L diversity antennas is shown in Figure 1.

2.1. Wideband SC

The wideband SC system selects the antenna with the best OFDM symbol. Namely, selected antenna *j* is one which satisfing following condition

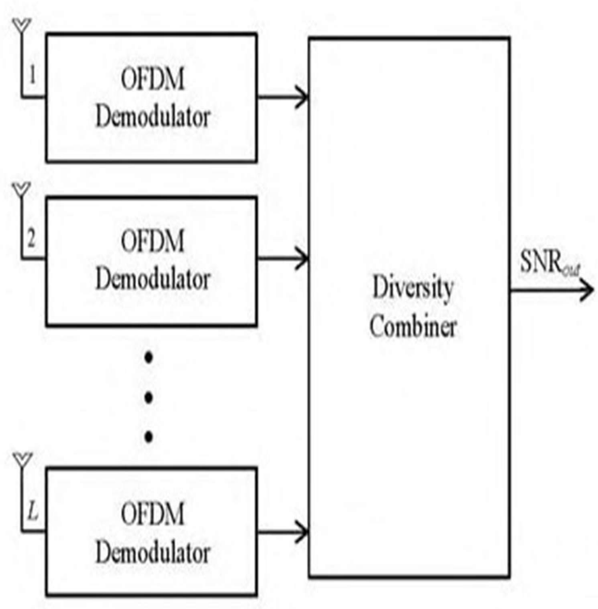

Figure 1. OFDM receiver with selection diversity

$$j = \arg\max_{i=\{1,\ldots,L\}} \{\sum_{k=1}^{N_c} \left| h_{i,1}\left[f_k\right] \right|^2\}, \quad (2)$$

The parameter f_k is kth subcarrier, N_c is number of subcarriers in the OFDM symbol, and $h_{i,1}$ $[f_k]$ is the channel gain between transmit and ith receive antenna on kth subcarrier.

2.2. Narrowband SC

The narrowband SC system makes a decision on each individual subcarrier. In this system, the selected antenna satisfies

$$j = \arg\max_{i=\{1,\ldots,L\}} \{\left| h_{i,1}\left[f_k\right] \right|^2\}. \quad (3)$$

Note that different antennas are selected on different subcarriers.

Numerical analysis is not only easy and time-unconsumed, but accurate way to estimate the system performance. Otherwise, a simulation is used with scientific modeling of system to gain insight into its functioning and also presents good way to confirm the accuracy of already obtained numerical results.

In this paper, the simple stochastic MIMO channel model [11] is applied for a link simulation of SIMO channel. The main strength of this MIMO model is that it relies on small set of parameters to fully characterize communication scenario and all those parameters are extracted from measurement results.

The algorithm presented in Figure 2 describes the process of modeling of L-branch OFDM receiver operating in environments compliant to IEEE 802.11n and the simulation of its outage probability.

3. Simulation Results

This section presents the simulation results for OP of SIMO-OFDM system with two receive antennas in which one of proposed selection diversity algorithms is applied. It is supposed that system operates in two different WLAN environments: microcell (Figure 3) and picocell (Figure 4). The term microcell refers to indoor-to-outdoor (B channel profile) propagation, characteristic for environment consists of small offices where distance between mobile station (MS) and base station (BS) is from 31 to 36 m with BS located outside. The picocell is term for indoor-to-indoor (E channel profile) propagation. The E channel profile represents very large open area as airports or modern open offices [11].

Figures 3 and 4 depict OP versus SNR threshold. In both channel profiles, using of narrowband SC diversity system is more recommended, what is confirmed through Figs. 3 and 4. Namely, the wideband SC selects the best OFDM symbol, even though some subcarriers on that symbol may be nonoptimal compared to the corresponding subcarrier on the other antenna. Greater number of subcarriers on OFDM symbol, more reasons for using the narrowband SC. However, the narrowband SC should realize L^*N_c measurements, instead of L (wideband SC), what makes it so impractical for realization. Let compare Figs. 3 and 4. Since the fact that E channel profile is more frequently-selective than B, it is expected that performance improvement provided by using narrowband SC is more significant for that channel profile. In addition, outage performance of system with narrowband SC is almost independent on WLAN environment.a

4. Conclusion

This paper investigates the influence of different selection diversity algorithms on outage performance of OFDM-based WLAN system complaint to IEEE 802.11n standard. It is evident that trading off between system performance and implementation complexity have to be done. This research can be extended to other performance metrics or other diversity techniques.

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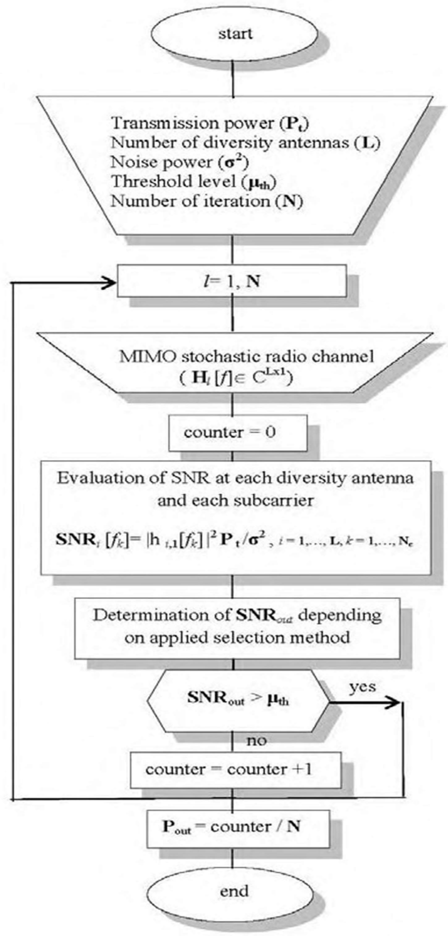

Figure 2. Modeling and simulation of SIMO-OFDM system with SC diversity

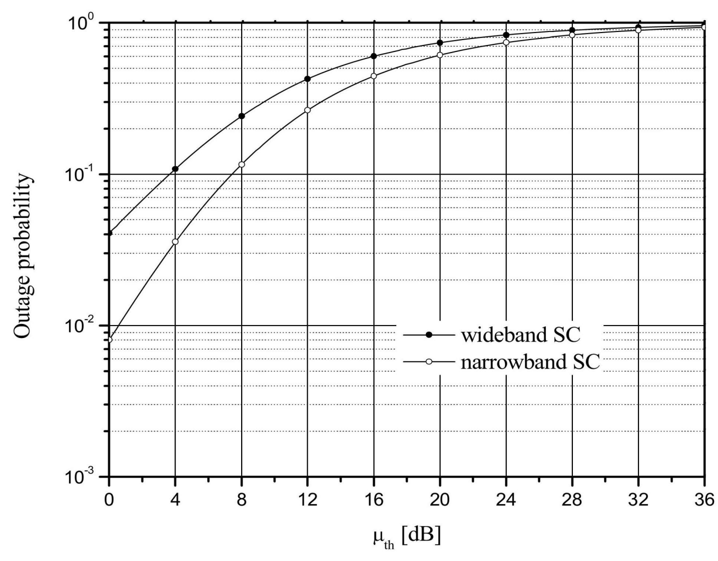

Figure 3. Outage probability of SIMO-OFDM system operating in microcell

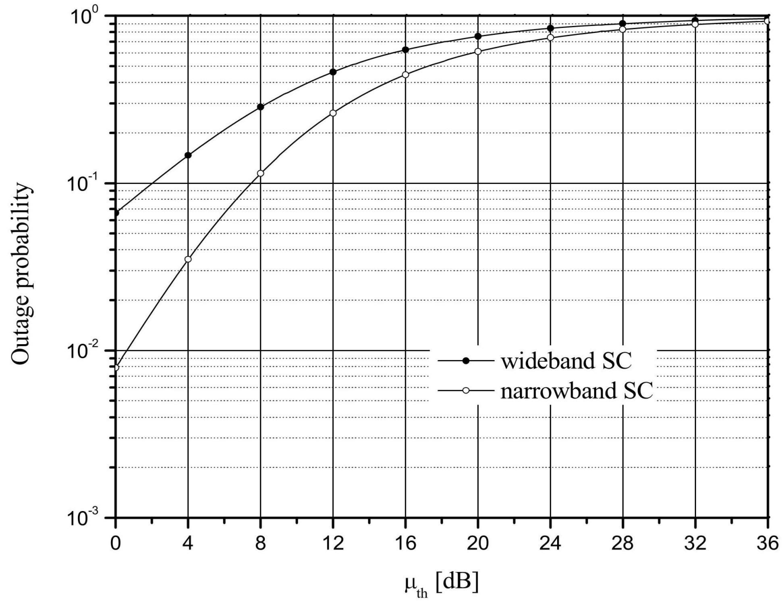

Figure 4. Outage probability of SIMO-OFDM system operating in picoocell

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