Outage Probability of SC Receiver Operating in Both Microcell and Picocell Environment

Aleksandra Panajotović and Dragan Drača

Abstract - In this paper, the outage probability of selection combining (SC) receiver operating in different channel models, developed within IEEE 802.11n standard, is simulated. The presented results show in which extent an environment and a diversity influence on the outage performance of consider system.

Keywords – Diversity system, Outage probability, Simulation, Space-time-frequency-selective fading channel.

I. INTRODUCTION

Multiantenna techniques can be divided into two categories: diversity techniques and spatial-multiplexing 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. Among well known diversity techniques, selection combining (SC) has the least implementation complexity since it processes signal only from one of diversity antennas, which is selectively chosen, and no channel information is required. Normally, the SC receiver selects the antenna with the highest signal-to-noise ratio (SNR) or, equivalently, with the strongest signal assuming equal noise power among the antennas [2].

The set of metrics, used to estimate the performance of wireless system, can be roughly divided into two groups: first-order and second-order performance metrics. First-order performance metrics are: outage probability (OP), error probability, system capacity, average output signal, etc. Second-order performance metrics are important for an adaptive system in which first-order metrics do not provide enough information for the overall system design and configuration. Average level crossing rate (LCR) and average fade duration (AFD) are second-order performance metrics [3]. It is obviously that the application and other aspects of consider system dictate which performance metric is the most important for analysis. However, the OP has been traditionally the most common used performance metric and, moreover, it is necessary for evaluation of second-order performance metric.

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Depending on the wireless environment, an appropriate statistical model can be used to describe fading behaviour in a channel. For example, the Rice model is adequate for the propagation consists of one strong direct line-of-sight (LOS) component and many random weaker components, while the Rayleigh model can be used when the LOS component does not exist. The advance of the Nakagami-*m* model lays in control of the fading severity, from sever to light, adjusting parameter *m*. The Weibull model is applicable in both indoor and outdoor environments. The performance of SC receivers operating in previous mentioned environments are studied through simulation and numerical analysis in [4]-[7]. In this paper we go one step forward by considering the performance of SC receiver operating in stochastic Multiple-Input Multiple-Output (MIMO) channel suitable to IEEE 802.11n.

II. OUTAGE PROBABILITY

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

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

and represents the cumulative distribution function of μ. The wireless environment, in which diversity receiver operates, is characterized through the probability density function of output SNR, i.e. $p_\mu(\mu)$.

It is known that numerical analysis is not only easy and time-unconsumed but accurate way to estimate the system performance too. On the other hand, simulation presents good way to confirm the accuracy of already obtained numerical results. Moreover, simulation can also be used with scientific modelling of system to gain insight into its functioning.

In this paper, the simple stochastic MIMO channel model, empirically validated for both picocell and microcell environments, is applied for a link simulation. The main strength of this MIMO model is that it relies on small set of parameters to fully characterize communication scenario. These parameters are: power gain of the MIMO channel matrix, two correlation matrices describing the correlation properties of both ends of transmission link and the associated Doppler spectrum of the channel path. They all are extracted from measurement results [8].

The algorithm presented in Fig. 1 describes the process of modelling of L-branch SC receiver operating in environments compliant to IEEE 802.11n and the simulation of its outage probability.

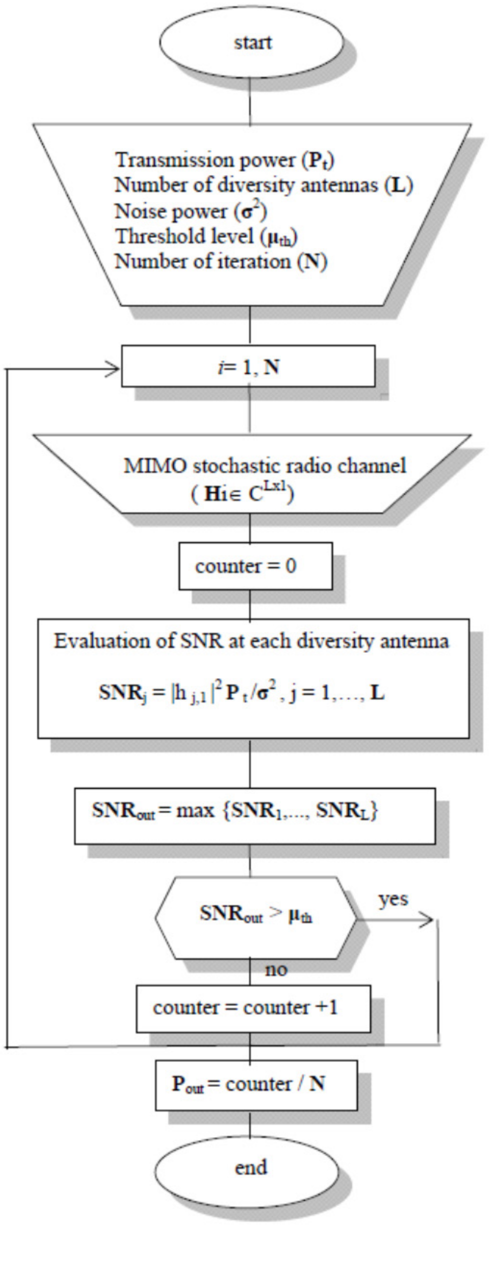

Fig. 1. Modelling and simulation of L-branch SC receiver.

III. Simulation Results

The figures presented in this section show simulation results of the OP of L-branch SC receiver operating in picocell (Fig. 2) and microcell environment (Fig. 3). The term picocell and microcell refer to indoor-to-indoor (E channel profile) and indoor-to-outdoor (B channel profile) [8]. Namely, B channel profile is indoor 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. E channel profile is very large open area as airports or modern open offices.

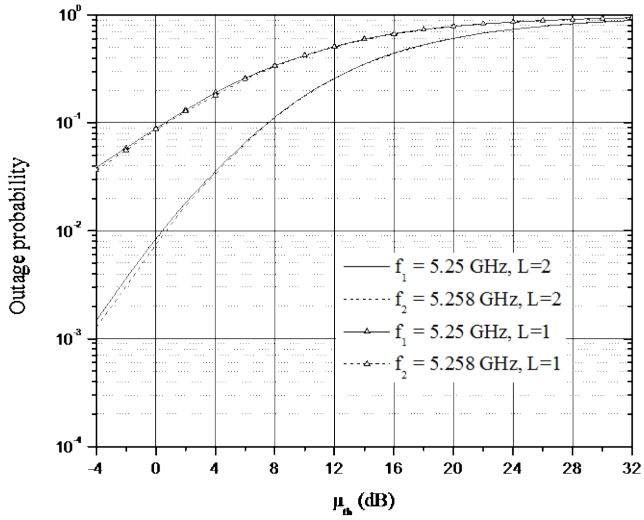

Fig. 2. Outage probability of dual SC receiver operating in picocell.

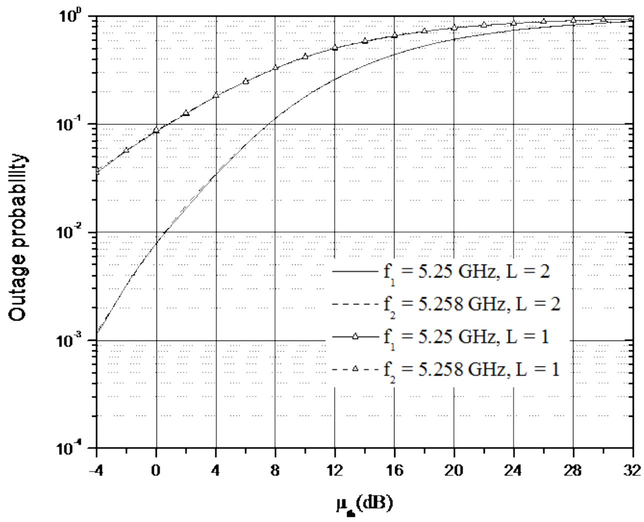

Fig. 3. Outage probability of dual SC receiver operating in microcell.

Figures 2 and 3 depict the OP versus SNR threshold. Note, in both figures there are outage probability curves for no-diversity and dual SC diversity systems evaluated for different frequencies. Since considered environments are compliant to IEEE 802.11n standard, carrier frequencies are f_1 = 5.25 GHz and f_2 = 5.258 GHz. It is obviously that B channel profile is not frequency-selective due to independence of outage system performance on the carrier frequency. Opposite to B channel profile, E channel profile is frequency-selective, especially for small threshold level, showing that for an orthogonal frequency division multiplexing (OFDM)-based wireless local area network (WLAN) system operating in this channel profile it have to be made difference between an antenna selection combining and a subcarrier selection combining, while it is not necessarily if the OFDM-based system operates in B channel profile. Moreover, SC system operating in small office experiences a bit better performance, i.e. less outage probability, than other one in large office. Note, the achieved diversity gain is independent on wireless environment, actually it provides same order-of-magnitude improvement of the outage performance.

IV. Conclusion

Since SC diversity technique is commonly adopted by WLAN systems [9], this paper presents simulation results for the outage performance of SC system operating in realistic, empirically validated, WLAN environment what emphasizes the contribution of presented results. This research can be extended to other performance metrics or other diversity techniques.

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References

[1] Cho, Y. S., Kim, J., Yang, W. Y., Kang, C. –G., "*MIMO-OFDM Wireless Communications with MATLAB*", Wiley, Singapore, 2010.

[2] Simon, M. K., Alouini, M. –S., "*Digital Communications over Fading Channels*", Wiley, New York, 2005.

[3] Guizani, M., "*Wireless Communications Systems and Networks*", Kluwer Academic, New York, 2004.

[4] Zogas, D. A., Karagiannidis, G. K., "*Infinite-Series Representations Associated with the Bivariate Rician Distribution and Their Applications*", IEEE Transactions on Communications, Vol. 53, No. 11, Nov., 2005, pp. 1790-1794.

[5] Tand, C. C., Beaulieu, N. C., "*Infinite-Series Representations of the Bivariate Rayleigh and Nakagami-m distribution*", Vol. 45, No. 10, Oct., 1997, pp. 1159-1161.

[6] Simon, M. K., Alouini, M. –S., "*A Simple Single Integral Representation of the Bivariate Rayleigh Distribution*", IEEE Communications Letters, Vol. 2, No. 5, May, 1998, pp. 128-130.

[7] Sagias, N. C., Karagiannidis, G. K., Zogas, D. A., Mathiopoulos, P. T., Tombras, G. S., "*Performance Analysis of Dual Selection Diversity in Correlated Weibull Fading Channels*", IEEE Transactions on Communications, Vol. 52, No. 7, Jul., 2004, pp. 1063-1067.

[8] Kermoal, J. P., Schumacher, L., Pedersen, K. I., Mogensen, P. E., Frederiksen, F., *"A Stochastic MIMO Radio Channel Model with Experimental Validation"*, IEEE Journal on Selected Areas in Communications, Vol. 20, No. 6, Aug., 2002, pp. 1211-1225.

[9] Korowajczuk, L., "*LTE, WiMAX and WLAN Network Design, Optimization and Performance Analysis*", Wiley, United Kingdom, 2011.