The performance of complex spreading codes within a Massive MIMO OFDM-based system with relays

Madalina-Georgiana Berceanu[1,2], Carmen Florea [1,2] and Razvan Craciunescu[1,2]
[1]Telecommunication Department, Electronics, Telecommunications & Information Technology Faculty, University "Politehnica" of Bucharest, Bucharest, Romania
[2]Academy of Romanian Scientsts, 3 Ilfov, 050044, Bucharest, Romania

Abstract

Our world is in a continuous evolution from all points of view, therefore there are new needs for which support must be provided and for which a series of new techniques have been proposed. In the field of wireless communications, we can talk about non-orthogonal multiple access (NOMA) technique, which is included in the 5G standard, that can offer an increased quality of service (QoS) to end users irrespective of their position within the cell or distortion factors. This paper presents a new set of complex spreading codes that fall in the coverage area of the 5G NOMA-based technique scheme and their creation starts from Walsh-Hadamard orthogonal spreading codes. Their performance will be tested using Monte Carlo Matlab simulations for bit error rate (BER) versus signal-to-noise ratio (SNR).

Introduction

The quality of the information that reaches the base station is very important, using different techniques from the 5G standard, considering that information is being transmitted over a wireless communication link that can be seriously affected by the conditions found on it. One such technique that could mitigate the effects of different distortion factors is Massive MIMO using the gain offered by spatial diversity. Another technique that can maintain and improve the advantages brought by Massive MIMO is NOMA that can support massive data traffic and achieve low latency. The information is sent to destination via a direct path, but besides it, another path is being considered – a regenerative relay is being implemented between source and destination using the decode-and forward (DF) protocol. Therefore, each of the technologies mentioned above are included in this paper.

System model

In this section, it is described the proposed system model used for the simulation part – an uplink wireless communication single-cell system using a multiple access technique with complex spreading codes obtained from orthogonal Walsh-Hadamard spreading codes, see Equation 1.
Figure 1 presents the proposed system model consisting of one base station (BS), one relay and K active users simultaneously, at a certain moment on the network. These K active users are multiplexed in code domain, the BS has N_r receive antennas, N_t transmit antennas, and the relay has Nr_r receive antennas and Nr_t transmit antennas. The DF protocol is implemented at the relay.

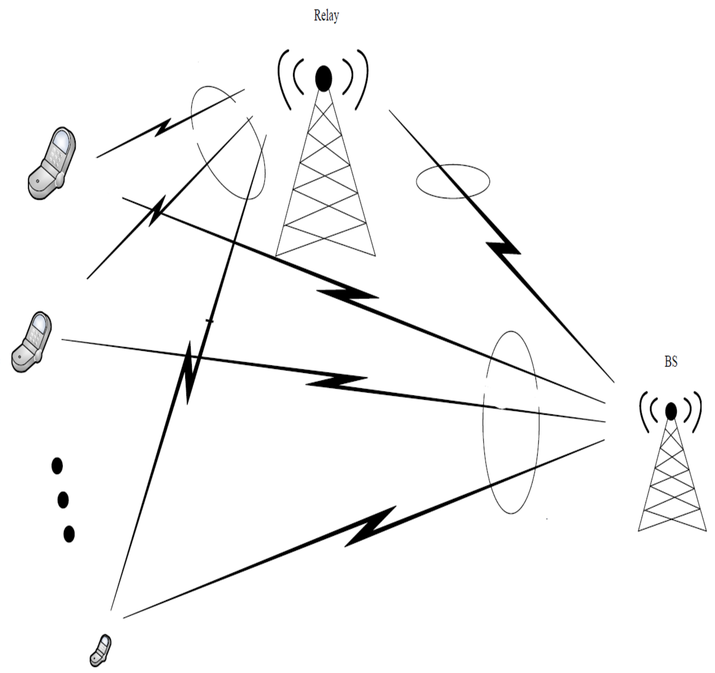

Figure 1 The architecture of the proposed system model

Results

The values that were being used for the simulations are summarized in Table 1.

Table 1 Simulation parameters

Parameter	Technique	Value
Modulation	BPSK	-
Channel	Rayleigh	-
FFT size	-	64
Number of data subcarriers	-	52
Multiple access	NOMA (complex Walsh-Hadamard spreading codes)	16 and 32 -length
Signal-to-Noise Ratio	-	-10-4dB
Number of users	-	9, 21
MIMO configurations	-	<10
Detectors	MMSE	-

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-1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 & -1
\end{bmatrix}$$

Equation (1)

Figure 2 represents the first two scenarios in which the performance of our proposed system is being evaluated. Walsh-Hadamard complex spreading codes of length 32 were used. Further, in Figure 3 it was simulated the situation where the number of antennas at the receiver is lower or higher than the number of antennas at the relay when the number of antennas is still 21 (as for Figure 2).

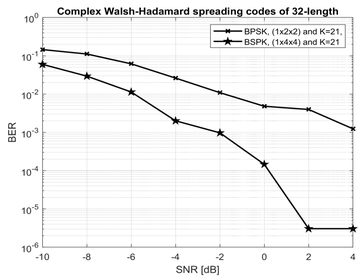

Figure 2 BER vs. SNR, (1x2x2) and (1x4x4) MIMO, 21 active users

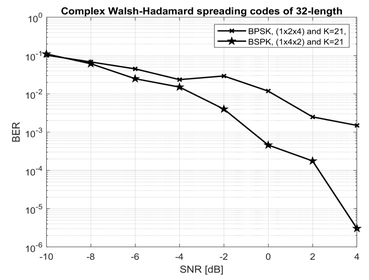

Figure 3 BER vs. SNR for (1x2x4) and (1x4x2) MIMO , 21 active users

Table 2. BER performance for BPSK modulation for different MIMO configurations, Rayleigh fading

SNR = -4dB	(1x2x2)	(1x2x4)	(1x4x2)	(1x4x4)
	0.0262454	0.0235958	0.0150733	0.0020085

Therefore, if the number of users is decreased from 21 to 9, the length of the code is 16 and not 32, Figure 4 is obtained. For a fixed SNR of -4dB, the BER for (1x2x2) MIMO configuration is 0.0354487 and for (1x4x4) MIMO configuration is 0.00212963.

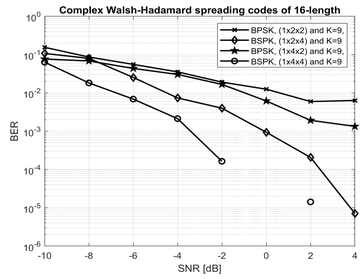

Figure 4 BER vs. SNR for different MIMO configurations, 9 active users

Conclusions

In this paper we have analyzed the performance obtained by complex Walsh-Hadamard orthogonal spreading codes (with zero correlation) in a MIMO OFDM-based system with a regenerative relay placed between source and destination (using DF protocol). Due to the orthogonality of Walsh-Hadamard codes it was observed that sustaining a good QoS for a high number of users with a small number of antennas at the receiver (both at the BS and relay) can offer a very good performance. As future development, we want to increase even more the number of users and to decrease the length of the code and to make the correlation with the number of antennas at the receiver to maintain what we aim for – a good QoS.

Contact

Madalina-Georgiana Berceanu
University "Politehnica" of Bucharest, Romania
Email: madalina.berceanu@radio.pub.ro,
madalina.berceanu@upb.ro