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An Application of Space Shift Keying for Non-Orthogonal Multiple Access to Improve Spectrum Efficiency

Yuchen Yang and Xin Su[1]
College of IOT Engineering, Changzhou Key Laboratory of Robotics and Intelligent Technology

Abstract. Non-orthogonal multiple access (NOMA) achieved the high throughput by introducing the power domain multiplexing. To improve the spectral efficiency of conventional NOMA scheme, we introduce the spatial domain to NOMA and the proposed scheme is proved has superior performance in spectral efficiency, compared with conventional space shift keying (SSK). The result of simulation confirms that the proposed scheme effectively improve the performance in the aspect of spectral efficiency.

Keywords. NOMA, Space Shift Keying, spectral efficiency

1. Introduction

Despite the current 5G standards are still under construction, non-orthogonal multiple access (NOMA) has been considered as a promising candidate for next generate communication system, it introduces the power domain to improve the system throughput. In NOMA downlink, non-orthogonality is achieved by power domain multiplexing, either in time, frequency or code domains, receivers obtain de-multiplexing by the application of SIC. In this case, all receivers share a same transmission bandwidth, which improves the spectrum efficiency and system throughput. The core idea of NOMA is to improve the complexity of receiver in exchange for spectral efficiency [1-3]. Spectral efficiency is the major key performance indicator of cellular networks. However, few articles discuss abort how to improve the spectral efficiency in NOMA system and apply it to the 5G communication system. In this paper, we introduce the space shift keying (SSK) to NOMA (NOMA-SSK) to further increase the spectrum efficiency of NOMA system. We also evaluate the performance of the proposed scheme via link-level simulations (LLS).

[1] Corresponding Author, Hohai University, Changzhou, China; E-mail: leosu8622@163.com

2. TRANSMISSION SCHEME IN NOMA DOWNLINK AND NOMA-SSK SCHEME

2.1. Transmission scheme in NOMA downlink

Fig. 1 describes the basic NOMA scheme applying SIC in downlink, the base station (BS) transmit information s_i via signal xi to UE_i with power pi. For UE_1, it receive stronger signal because UE_1 is closer to the BS. Therefore, UE_1 execute SIC process for UE_2 signal, decode the signal x_2 and cancel it from the received signal first, then UE_1 could decode the signal for itself (x_1). For UE_2, it can decode x_2 directly without SIC because the power of x_2 is larger than x_1, so that x_2 has the first decode order.

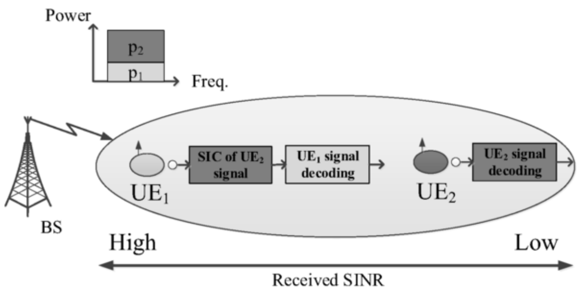

Figure 1. NOMA scheme applying SIC in cellular downlink.

2.2. NOMA-SSK scheme

Refer to [4], SSK is proposed as a modulation strategy for MIMO channels to exploit the spatial domain at transmitter side. Fig. 2 describes the SSK modulation system model combining with NOMA in NOMA downlink. b_i and c_i, which are random sequences of independent bits to be transmitted to UE_1 and UE_2 respectively, enter a channel encoder with output d_k and e_k, which is the source for UE_1 and UE_2. We assume that UE_1 is the user near the BS and hence UE_1 is utilized lower power p_1, on the contrary, UE_2 is utilized higher power p_2. d_k' and e_k' then enters an SSK mapper with output an antenna index. We note that the transmitted symbols themselves do not convey information, but an antenna index does.

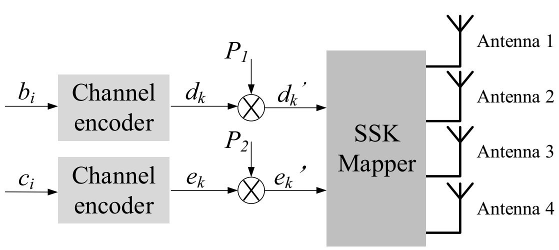

Figure 2. Proposed NOMA-SSK transmitter structure

As mentioned in [4], although four antennas are applied in the scheme, only one antenna is activate, and the antenna index changes depending on the transmitted sequences. In conventional SSK scheme, 2 bits could be transmitted via four antennas according to the antenna index. An example of NOMA-SSK modulation is given in Table. 1. In proposed NOMA-SSK scheme, antenna index applied to convey information for UE_1 has two antenna positions with lower power, antenna index used for UE_2 has two antenna positions with higher power and therefore, the proposed NOMA-SSK scheme could convey 4 bits simultaneously, compare with 2 bits in conventional SSK with the same number of antennas.

Table 1. NOMA-SSK DATA MAPPING

Source of UE1: bi = [b1, b2]	Antenna index	Antenna Used with P1	Source of UE1: bi = [b1, b2]	Antenna index	Antenna Used with P1
00	1	Antenna 1	00	1	Antenna 1
01	2	Antenna 2	01	2	Antenna 2
10	3	Antenna 3	10	3	Antenna 3
11	4	Antenna 4	11	4	Antenna 4

3. PERFORMANCE ANALYSIS

In this section, we present link-level simulation (LLS) results on proposed NOMA-SSK scheme performance. We note that minimum mean square error (MMSE) SIC proposed by [5] is employed at receiver side. Table. 2 lists the other simulation parameters. Base on the package error rate (PER), the system throughput can be calculate by

$$Data\ rate = \frac{(1-PER)\times n_{bit/packet}}{T_{packet}(s)} \tag{1}$$

Where the number of bits is transmitted per packet, and is the time duration for one packet. NOMA-SSK's performance improvements is clearly shown in Fig. 3, where we observe that when the signal-to-noise ratio (SINR) is greater than about 9db, the proposed NOMA-SSK scheme has higher spectral efficiency than the traditional SSK scheme. Note that the system reliability would drop while the mobile terminal apply practical SIC. Note that the system reliability would drop while the mobile terminal applies practical SIC.

Table 2. SIMULATION PARAMETERS FOR NOMA-SSK

Number of Tx (BS) Antennae	4
Number of Rx (UE) Antennae	1
Number of Symbols / Packet	10
Channel	4×1 independent Rayleigh fading channel
Modulation	SSK
Power Allocation for NOMA	P1=0.2, P2=0.8 [5]
Channel Estimation	MMSE

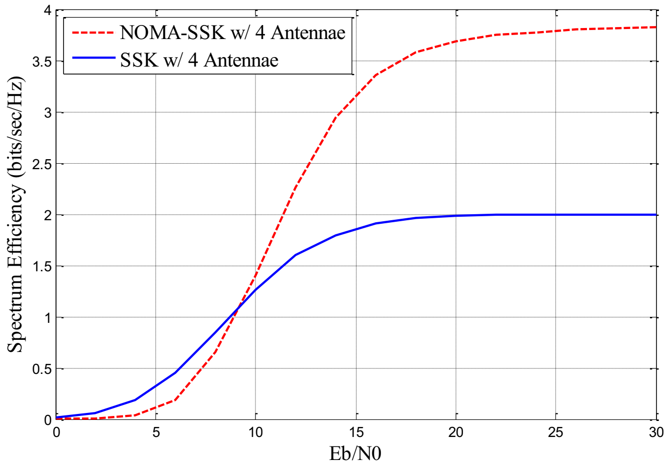

Figure 3. Spectrum efficiency comparison for NOMA-SSK and conventional SSK

4. CONCLUSION

In this paper, we introduce additional spatial domain to improve the spectral efficiency in NOMA system. The analysis results shows that even if the BER and PER of proposed NOMA-SSK scheme is slightly worse than conventional SSK, it shows greater performance in terms of spectral efficiency.

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References

[1] X. Su and H.F. Yu, "Non-orthogonal multiple access with practical interference cancellation for MIMO systems," IT Convergence Practice (INPRA), Vol. 3, No. 4, pp. 34-40, Dec. 2015.

[2] X. Su, C.C Liang, D.M. Choi, and C. Choi, "Power allocation schemes for femto-to-macro downlink interference reduction for smart devices in ambient intelligence," Mobile Information Systems, vol. 2016, Article ID 7172515, 10 pages, 2016.

[3] Y. Saito, Y. Kishiyama, A. Benjebbour, T. Nakamura, A. Li, and K. Higuchi, "Non-orthogonal multiple access (NOMA) for cellular future radio access," in Proc. of IEEE VTC, June 2013, pp. 1-5.

[4] J. Jeganathan, A. Ghrayeb, L. Szczecinski, and A. Ceron, "Space shift keying modulation for MIMO channels," IEEE Transactions on Wireless Communications, vol. 8, no. 7, pp. 3692-3704, July. 2009.

[5] X. Su, H.F. Yu, W.S. Kim, C. Choi, and D.M. Choi, "Interference cancellation for non-orthogonal multiple access used in future wireless mobile networks," EURASIP Journal on Wireless Communications and Networking, (2016) 2016: 231, doi: 10.1186/s13638-016-0732-z.