Joint Detection and Decoding for Polar-Coded IDMA-MIMO Systems

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Abstract

The demand on data traffic and bandwidth requirements have continued to grow exponentially. Nevertheless, existing fourth generation (4G) networks are not capable of meeting those demands for high data rates and bandwidth requirements. Therefore, the fifth generation (5G) wireless access technology, which guarantees high spectral efficiency, low latency, and massive connectivity, was recently introduced. Non orthogonal multiple access (NOMA), which enables massive connectivity, was one of the key potential physical-layer technologies considered for 5G. Interleave division multiple access (IDMA) scheme is one of the promising NOMA schemes, with packet level interleavers to distinguish multiple access users. On the other hand, recently, polar codes have received increased attention as a capacity approaching code. Polar codes have already been adopted as the channel coding technique for the physical-layer control channel of 5G New Radio (NR) networks. In the literature, to date, there is only limited research on polar-coded IDMA systems. Multiple-Input Multiple Output (MIMO) enables the spatial degrees of freedom through use of multiple antennas at both the transmitter and the receiver. MIMO has been one of the key enabling technologies in recent standardized wireless communication systems including 3G HSPA and 4G LTE systems. The performance benefits of both IDMA and MIMO can be obtained by combining two technologies.

To this end, in this research study, an extension of conventional polar-coded IDMA to MIMO is considered for uplink communication. A polar-coded IDMA-MIMO uplink system model with QPSK modulation is proposed. An iterative receiver scheme is devised for polar-coded IDMA-MIMO systems. In the proposed receiver, likelihood messages are exchanged in each iteration between the soft multiuser MIMO detector and belief propagation (BP) algorithm-based decoder. The error performance of the proposed system is investigated using simulation for different system configurations. The simulation results confirm that polar coding offers significant performance improvement over the uncoded IDMA-MIMO system. Moreover, considerably improved error performance can be obtained by using the proposed iterative receiver scheme over single-pass multiuser MIMO detection and decoding. Further, higher the signal to noise ratio, the faster the convergence rate is.

Keywords:
5G, belief propagation (BP), interleave division multiple access (IDMA), joint detection and decoding (JDD), multiple input multiple output (MIMO), non-orthogonal multiple access (NOMA), polar codes (PC).

Declaration

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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NOMA	Non Orthogonal Multiple Access
OMA	Orthogonal Multiple Access
BER	Bit Error Rate
BICM	Bit Interleaved Coded Modulation
BP	Belief Propagation
CDMA	Code Division Multiple Access
CRC-SCL	Cyclic Redundancy Check Aided SCL
eMMB	Enhanced Mobile Broadband
FDMA	Frequency Division Multiple Access
IDMA	Interleave Division Multiple Access
ITU-R	International Telecommunication Union Radiocommunication
JDD	Joint Detection and Decoding
JIDD	Joint Iterative Detection and decoding
LDPC	Low Density Parity Check
LDS-CDMA	Low-Density Spreading CDMA
LLR	Log Likelihood Ratio
MIMO	Multiple Input Multiple Output
MLCM	Multilevel Coded Modulation
MPA	Message Passing Algorithm

MUSA	Multiuser Shared Access
NLP	New Logistic Map
NR	New Radio
OFDMA	Orthogonal Frequency Division Multiple Access
PC	Polar Codes
PC-NOMA	Polar Coded Noma
PDMA	Pattern Division Multiple Access
PI	Prime Interleaver
PRE	Physical Resource Element
SCAN	Soft Cancellation
SCD	Successive Cancellation Decoding
SC-FDMA	Single Carrier FDMA
SCH	Successive Cancellation Heap
SCL	Successive Cancellation List
SCMA	Sparse Code Multiple Access
SDD	Separate Detection and Decoding
SIC	Successive Interference Cancellation
SINR	Signal to Interference Noise Ratio
TBI	Tree Based Interleaver
TDMA	Time Division Multiple Access
URLLC	Ultra-Reliable Low Latency Communications