INVESTIGATION ON NETWORK CODED MIMO-NOMA FOR TWO-WAY RELAY NETWORKS

NGU WAR HLAING

FACULTY OF ENGINEERING
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DECLARATION

I hereby declare that the material in this thesis is my own except for equations, summaries and references, which have been duly acknowledged. This thesis is submitted by me as a fulfilment of the requirement for the award of Master of Electrical and Electronic Engineering in Faculty of Engineering, Universiti Malaysia Sabah. This thesis may be made available within the University Malaysia Sabah's library and may be photocopied or loaned to other libraries for the purpose of consultation.

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ABSTRACT

The combination of Non-Orthogonal Multiple Access (NOMA) and Multi-input Multi-output (MIMO) approach has been considered as an assuring multiple access for the fifth generation (5G) technology. Without needing to sacrifice the spectral efficiency, the combination of MIMO-NOMA scheme with low-rate channel coding technique can be an assuring method for the requirement of the 5G network. The drawbacks for MIMO-NOMA based scheme is having interferences and problems in power control which can lead to bandwidth expansion. Precoding method during transmission can efficiently minimize the interferences and maximize the signal to noise ratio (SNR) at receiver. Thus, precoding method is proposed, and it has been applied MIMO-NOMA system. Most of the existing works on NOMA are based on the assumption of perfect Channel State Information (CSI) at the transmitter side which in reality, it is not easy due to either the estimation error or the feedback delay. Therefore, MIMO-NOMA system is investigated in imperfect CSI with Zero Forcing (ZF) and Maximum Ratio (MR). To fulfil the demands of higher rate of data transmission, power efficient forward-error correction (FEC) schemes which are Convolutional Codes, Reed-Solomon Codes (RS), Turbo Codes and Low-Density Parity Check (LDPC) codes are adopted as channel coding schemes. To obtain a more efficient system, Random Interleaved Differential Encoding with redundancy scheme with network coding (R-RIDE) is proposed for both sources and a relay node. LDPC decoding is done using bit-flipping, probability-domain, log-domain, and simplified Log-domain decoders. Simulation results shows that the MIMO-NOMA system has the greater performance than NOMA system alone. The proposed precoding method gives almost 28% higher capacity performance than the conventional scheme. Higher spectral efficiency is obtained by investigating MIMO-NOMA system with MR under imperfect CSI. Moreover, both Bit Error Rate (BER) and Average Mutual Information (AMI) of the proposed R-RIDE in LDPC codes greatly outperforms compared to the proposed R-RIDE of other codes. Furthermore, it can be concluded that LDPC-R-RIDE by using simplified log-domain decoding in MIMO-NOMA system yields approximately 47% better BER values than NOMA system alone. The transmission rate is increased 50% by applying two-way relay network.

ABSTRAK

INVESTIGASI PADA RANGKAIAN DIKODKAN MIMO-NOMA UNTUK RANGKAIAN RELAY DUA HALA.

Gabungan pendekatan capaian pelbagai bukan ortogonal (NOMA) dan pendekatan pelbagai masukan pelbagai keluaran (MIMO) telah dipertimbangkan sebagai suatu jaminan bagi pelbagai capaian untuk teknologi generasi kelima (5G). Tanpa perlu mengorbankan kecekapan spektrum, kombinasi skim MIMO-NOMA dengan teknik pengekod saluran kadar rendah boleh menjadi kaedah yang menjamin untuk keperluan rangkaian 5G. Kelemahan skim berasaskan MIMO-NOMA adalah mempunyai gangguan dan masalah dalam kawalan kuasa yang boleh menyebabkan pengembangan lebar jalur. Kaedah pengekalan semasa penghantaran dapat meminimumkan gangguan degan cekap dan memaksimumkan nisbah isyrat kepada ganguan (SNR) pada penerima. Oleh itu kaedah pengekalan telah dicadangkan dan ia telah menggunakan sistem MIMO-NOMA. Kebanyakan karya NOMA yang sedia ada adalah berdasarkan kepada anggapan Channel State Information (CSI) yang sempurna pada pemancar yang mana dalam realiti, ianya tidak mudah disebabkan oleh sama ada kesilapan anggaran atau kelewatan maklum balas. Oleh itu, sistem MIMO-NOMA disiasat dalam CSI yang tidak sempurna dengan paksaan sifar (ZF) dan nisbah maksimum (MR). Untuk memenuhi permintaan kadar penghantaran data yang lebih tinggi, kecekapan kuasa skim pembetulan ralat kehadapan (FEC) yang merupakan kod konvolutional, Kod Reed-Solomon (RS), kod-kod turbo dan kod-kod semakan pariti ketumpatan rendah (LDPC) adalah digunakan sebagai skim saluran pengekodan. Untuk mendapatkan sistem yang lebih cekap, pengkodan perbezaan penyambungan rawak dengan skim redundansi dengan pengekodan rangkaian (R-RIDE) dicadangkan untuk kedua-dua sumber dan nod geganti. Penyahkodan LDPC dilakukan dengan menggunakan penyahkod pembalikan bit, domain kebarangkalian, domain log, dan domain log yang dipermudahkan. Hasil simulasi menunjukkan bahawa gabungan sistem MIMO-NOMA mempunyai prestasi yang lebih tinggi daripada sistem NOMA sahaja. Kaedah pengekalan yang dicadangkan meberikan 28% prestasi kapasiti lebih tinggi daripada skim konvensional. Kecekapan spektrum yang lebih tinggi diperolehi engan menyiasat system MIMO-NOMA dengan Teknik-teknik pemprosesan linear. Selain itu, kedua-dua kadar ralat bit (BER) dan purata maklumat Bersama (AIM) bagi R-RIDE yang dicadangkan dalam kod-kod LDPC sangat baik berbanding dengan cadangan R-RIDE kod lain. Tambahan pula, ia boleh disimpulkan bahawa LDPC-R-RIDE dengan menggunakan penyahkodan domain log yang dipermudahkan dalam sistem MIMO-NOMA menghasilkan 47% nilai BER yang lebih baik daripada sistem NOMA sahaja. Kadar penghantaran meningkat sebanyak 50% dengan menggunakan rangkaian geganti dua hala.

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LIST OF ABBREVIATIONS

AM	-	Amplitude Modulation
AMC	-	Adaptive Modulation and Coding
AMI	-	Average Mutual Information
AWGN	-	Additive White Noise Gaussian
BCH	-	Bose–Chaudhuri–Hocquenghem
BER	-	Bit Error Rate
BF	-	Bit Flipping
BLAST	-	Bell Laboratories Layered Space-Time
BNC	-	Binary Network Coding
BP	-	Belief Propagation
BPSK	-	Binary Phase Shift Keying
BS	-	Base Station
CDMA	-	Code Division Multiple Access
CF	-	Compute and Forward
CSI	-	Channel State Information
CSIT	-	Channel State Information at Transmitter
DNC	-	Dynamic Network Coding
DPC	-	Dirty Paper Coding
ECC	-	Error Correction Code
EE	-	Energy Efficiency
FCQI	-	Feedback Channel Quality Indicator
FDMA	-	Frequency Division Multiple Access
FEC	-	Forward Error Correction
FRA	-	Future Radio Access

Gbps	-	Giga Bit Per Second
GDNC	-	Generalized Dynamic Network Coding
GE	-	Gaussian Elimination
GF	-	Galois field
HNC	-	High-layer Network Coding
IDMA	-	Interleaved Division Multiple Access
ISI	-	Inter Symbol Interference
JD	-	Joint Decoding
Kbps	-	Kilo Bit Per Second
LDPC	-	Low Density Parity Check
LDS	-	Low Density Signature
LLR	-	Log Likelihood Ratio
LNC	-	Linear Network Coding
LTE	-	Long-Term Evolution
MA	-	Multiple Access
MAP	-	Maximum A Posteriori
Mbps	-	Mega Bit Per Second
MI	-	Matrix Index
MIMO	-	Multi-input Multi-output
ML	-	Maximum Likelihood
MR	-	Maximum Ratio
MRC	-	Maximum Ratio Combining
MUSA	-	Multi-User Shared Access
NOMA	-	Non-Orthogonal Multiple Access
OFDMA	-	Orthogonal Frequency Division Multiple Access
OMA	-	Orthogonal Multiple Access

PA	-	Power Efficient
PDMA	-	Pattern Division Multiple Access
PF	-	Proportional Fair
PMI	-	Precoding Matrix Index
PNC	-	Physical layer Network Coding
PSMA	-	Power-domain Sparse Code Multiple Access
QAM	-	Quadrature Amplitude Modulation
QoS	-	Quality of Service
QPSK	-	Quadrature Phase Shift Keying
QOSTBC	-	Quasi-Orthogonal Space-Time Block Code
R	-	Redundancy
RF	-	Radio Frequency
RIDE	-	Random Interleaved Differential Encoding
RLNC	-	Random Linear Network Coding
RS	-	Reed-Solomon
SA	-	Signal Alignment
SC	-	Superposition Coding
SDMA	-	Spatial Dimension Multiple Access
SE	-	Spectral Efficiency
SIC	-	Successive Interference Cancellation
SISO	-	Single Input Single Output
SNR	-	Signal to Noise Ratio
SINR	-	Signal Interference to Noise Ratio
SOS	-	Second Order Statistics
SPA	-	Sum Product Algorithm
STBC	-	Space Time Block Code