Performance Analysis of Maximal-Ratio Combining and Space-Time Block Codes with Transmit Antenna Selection over Nakagami-m Fading Channels

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Abstract

The latest wireless communication techniques such as high speed wireless internet application demand higher data rates and better quality of service (QoS). However, transmission reliability is still degraded by harsh propagation channels. Multiple-input multiple-output (MIMO) systems can increase the system capacity and improve transmission reliability. By transmitting multiple copies of data, a MIMO system can effectively combat the effects of fading. Due to the high hardware cost of a MIMO system, antenna selection techniques have been applied in MIMO system design to reduce the system complexity and cost. The Nakagami-m distribution has been considered for MIMO channel modeling since a wide range of fading channels, from severe to moderate, can be modeled by using Nakagami-m distribution. The Rayleigh distribution is a special case of the Nakagami-m distribution. In this thesis, we analyze the error performance of two MIMO schemes: maximal-ratio combining with transmit antenna selection (the TAS/MRC scheme) and space-time block codes with transmit antenna selection (the TAS/STBC scheme) over Nakagami-m fading channels. In the TAS/MRC scheme, one of multiple transmit antennas, which maximizes the total received signal-to-noise ratio (SNR), is selected for uncoded data transmission. First we use a moment generating function based (MGF-based) approach to derive the bit error rate (BER) expressions for binary phase shift keying (BPSK), the symbol error rate (SER) expressions for M-ray phase shift keying (MPSK) and M-ray quadrature amplitude modulation (MQAM) of the TAS/MRC scheme over Nakagami-m fading channels with arbitrary and integer fading parameters m. The asymptotic performance is also investigated. It is revealed that the asymptotic diversity order is equal to the product of the Nakagami fading parameter m, the number of transmit antenna L_t and the number of receive antenna L_r as if all transmit antenna were used. Then a Gaussian Q-functions approach is used to investigate the error performance of the TAS/STBC scheme over Nakagami-m fading channels. In the TAS/STBC scheme, two transmit antennas, which maximize the output SNR, are selected for transmission. The exact and asymptotic BER expressions for BPSK are obtained for the TAS/STBC schemes with three and four transmit antennas. It is shown that the TAS/STBC scheme can provide a full diversity order of mL_tL_r.

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Statement of Originality

The research work in this thesis was conducted by myself under the supervision of Professor Branka Vucetic and Dr Zhuo Chen at the School of Electrical and Information Engineering, The University of Sydney, Australia.

The material in this thesis has not been submitted previously for a degree in any university, and to the best of my knowledge contains no material previously published or written by another person except where appropriate acknowledgement is made in the thesis.

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List of Acronyms

3G	Third Generation
AM	Amplitude Modulation
AWGN	Additive White Gaussian Noise
BER	Bit Error Rate
BPSK	Binary Phase-Shift Keying
cdf	cumulative distribution function
CDMA	Code-Division Multiple-Access
CSI	Channel State Information
EGC	Equal Gain Combining
FM	Frequency Modulation
HS/MRC	Hybrid Selection/Maximal-Ratio Combining
i.i.d.	independent identically distributed
MGF	Moment Generating Function
MIMO	Multiple-Input Multiple-Output
MLD	Maximum Likelihood Decoding
MLSE	maximum likelihood sequence estimation
MPSK	M-ray Phase-Shift Keying
MQAM	M-ray Quadrature Amplitude Modulation
MMSE	Minimum Mean Square Error
MRC	Maximal-Ratio Combining
MRRC	Maximal-Ratio Receiver Combining
pdf	probability density function
PM	Phase Modulation
PSK	Phase-Shift Keying

QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
RF	Radio-Frequency
SC	Selection Combining
SEP	Symbol Error Probability
SER	Symbol Error Rate
SNR	Signal-to-Noise Ratio
STBC	Space-Time Block Code
STTC	Space-Time Trellis Code
TAS/MRC	Transmit Antenna Selection/Maximal-Ratio Combining
TAS/STBC	Transmit Antenna Selection/Space-Time Block Code
WCDMA	Wideband Code-Division Multiple-Access
WIMAX	Worldwide Interoperability for Microwave Access