JOINT CHANNEL - PHYSICAL LAYER NETWORK CODING IN MULTI-WAY WIRELESS RELAY SYSTEMS

by

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Declaration

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and to the best of my knowledge it does not contain any material which had been previously published by another person except where due reference is made in the text.

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Abstract

During the last two decades or so, physical layer network coding (PNC) has received a considerable attention as it provides superior spectral efficiency over conventional relaying, in wireless relay systems. However, error performance of the network coded relay systems is inferior to that of conventional relaying under poor quality channel conditions. On the other hand, channel coding provides improved error performance over noisy and fading channels. In channel and PNC coded wireless relay systems, a better performance can be achieved by performing channel decoding and network coding at the relay jointly compared to separately. However, the existing joint channel decoding and network coding algorithms cannot achieve a good trade-off between error performance and spectral efficiency when applied in a multi-way wireless relay system. This is mainly due to the fact that the existing algorithms operate the constituent sub-decoders independently. With the advancement of new trends such as Internet of Things (IoT), multi-way wireless relay system has been a popular network topology, hence joint channel decoding and network coding algorithms having very good spectral efficiency-error performance trade-offs are highly desired.

This thesis presents, as the key technical contribution to the existing body of knowledge, a joint channel-physical layer network coding (JCPNC) algorithm for multi-way wireless relay systems, which achieves an improved trade-off between error performance and spectral efficiency. This improved performance is a result of harnessing additional time diversity by exchanging information between constituent sub-decoders. Several diversity combining schemes are proposed and they are compared with each other. The thesis also presents an improved symbol value selection algorithm for the conventional non-binary symbol-flipping low density parity check decoder which is adopted to produce a low-complexity JCPNC algorithm. Moreover, a novel JCPNC algorithm which can be employed in asymmetric multi-way wireless relay systems, is developed. Finally, the convergence behaviour of the proposed JCPNC algorithm is analyzed using extrinsic information transfer (EXIT) characteristics of the constituent sub-decoders.

The error performance of the proposed algorithms is extensively investigated using computer simulations. The simulation results demonstrate that the proposed JCPNC algorithm and its variants achieve superior spectral efficiency-error performance trade-offs than the existing counterpart JCPNC algorithms.

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List of Abbreviations

ALLR	average log-likelihood ratio
AP	average probability
AWGN	additive white Gaussian noise
BAP	bit-wise average probability
BBP	bit-wise best probability
BER	bit error rate
BF	bit flipping
BP	belief propagation
BPS	best probability selection
BPSK	binary phase shift keying
BWSP	bit-wise weighted sum probability
CND	check node decoder
EXIT	extrinsic information transfer
FER	frame error rate
FG-LDPC	finite geometry-low density parity check
GF	Galois field
IoT	internet of things
JCPNC	joint channel-physical layer network coding
JCNC	joint channel-network coding
LDPC	low density parity check codes
LLR	log-likelihood ratio
MAC	medium access control
MIMO	multiple input-multiple output

MPSK	M-ary phase shift keying
MVA	multiple-vote symbol flipping algorithm
MVPSF	multiple-vote parallel symbol flipping
NOMA	non-orthogonal multiple access
PNC	physical layer network coding
PSF	parallel symbol flipping
QAM	quadrature amplitude modulation
QPSK	quadrature phase shift keying
RA	repeat accumulate
RBA	reliability-based symbol value selection algorithm
SNR	signal power to noise power ratio
UAV	unmanned aerial vehicle
VND	variable node decoder
WSN	wireless sensor network
WSP	weighted sum probability