RESOURCE ALLOCATION AND OPTIMIZATION OF MULTI USER COMMUNICATION FOR NEXT GENERATION NETWORK

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Abstract

Existing wireless networks use orthogonal access that serves users as per the number of available resources. On the other hand, Next Generation Networks (NGNs) use the concept of non-orthogonality that serves multiple users on a single resource which consequently enhances device connectivity and spectral efficiency. Non-Orthogonal Multiple Access (NOMA) scheme employs power division multiple access which is sensitive to interferences and noises. This research presents a composite multiple access scheme that is developed by a combination of Power Domain NOMA (PD-NOMA) and Orthogonal Beamforming (OBF) to improve the spectral efficiency and reduce the interference between beams in the presence of Impulse Noise (IN). Furthermore, a novel IN mitigation and classification technique is presented using deep learning methods which efficiently minimizes the harmful effects of IN from PD-NOMA-based communication systems. This research can be divided into three phases.

The first phase of the research encompasses a new composite multiple access scheme based on PD-NOMA and OBF for exchanging information between smart grid, smart meters (SMs), and other communication units in the presence of IN. In the proposed scheme a cell is divided into sectors and OBF is implemented between sectors to reduce inter beams interference using orthogonalization. Within these sectors, the PD-NOMA scheme is implemented to utilize maximum bandwidth with the help of the successive interference cancellation scheme. According to the simulation and numerical findings, the proposed scheme offers a 3 Mbit/sec higher data rate and 0.24 Mbit/joule greater energy efficiency than the traditional orthogonal frequency division multiple access scheme, leading to better system performance in

the case of 10 SMs/users in a sector of a cell. Another significant achievement of the proposed scheme is that it does not cause inter beam interference and provides 17 Mbit/sec higher data rate by using OBF compared to conventional beamforming in the case of 60 SMs/users in 12 sectors of a cell.

The second phase deals with the analysis of performance degradation of the link due to the IN-contaminated wireless channel. Statistical formation i.e. the Probability Density Function (PDF) and Cumulative Distribution Function (CDF) is formulated for the channel to estimate the effect of IN. Moreover, two closed-form expressions are derived i.e. instantaneous Signal to Noise Ratio (SNR) by using the PDF and CDF for IN-contaminated wireless channel and Bit Error Rate (BER) by using instantaneous SNR for IN-contaminated PD-NOMA-based system.

Finally, in the last phase of the research, a novel IN mitigation and classification technique is presented using deep learning methods for PD-NOMA-based communication systems. The IN detection is performed by first identifying the IN occurrences using a Deep Neural Network (DNN) that learns statistical traits of noisy samples, followed by removal of the harmful effect of IN in the detected occurrences. Compared to the existing IN detection methods, the proposed DNN provided an enhanced BER performance. The proposed method is further tested for high and low IN and weak and strong IN occurrence probabilities. The proposed DNN method detected approximately 0.1 Mbits more true symbols out of 1 Mbits compared to conventional methods. The DNN identified high IN in the incoming noisy PD-NOMA symbols with an accuracy of 99% and low impulses with an accuracy of 87% respectively.

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HDM	High-Dimensional Modulation
HetNet	Heterogeneous Network
HSPA	High Speed Packet Access
IDD	Iterative Detection and Decoding
IN	Impulse Noise
JPPA	Assignment and Power Allocation
LCQ-ML	Low Complexity Quasi-ML
LDS	Low Density Spreading
LTE	Long Term Evolution
LTE-A	Long Term Evolution Advanced
MAI	Multiple Access Interference
MCCD	Multicode Complex Domain
MCMC	Monte Carlo Markov Chain
MDM	Multidimensional Modulation
MIMO	Multiple Input Multiple Output
MMSE	Minimum Mean Square Error
MP-WFRFT	Multiple Parameter Weighted Fractional Fourier Transform
MU-MIMO	Multi User Multiple Input Multiple Output
MUSA	Multiuser Shared Access
NAN	Neighborhood Area Networks
NB-PLC	Narrowband PLC
NGN	Next Generation Network
NIST	National Institute of Standard and Technology
NOMA	Non-orthogonal Multiple Access
OBF	Orthogonal Beamforming

OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
OMA	Orthogonal Multiple Access
OPA	Optimum Power Allocation
PAIN	Periodic Asynchronous Impulsive Noise
PAPR	Peak to Average Power Ratio
PDF	Probability Density Function
PDM	Power Domain Multiple Access
PDMA	Pattern Division Multiple Access
PD-NOMA	Power Domain NOMA
PD-SCMA	Power Domain SCMA
PLC	Power Line Communication
PSIN	Periodic Synchronous Impulsive Noise
QoS	Quality of Service
RE	Resource Element
ROAD	Rank Ordered Absolute Differences
SCA	Successive Convex Approximation
SCMA	Sparse Code Multiple Access
SE-EE	Spectral Efficiency and Energy Efficiency
SG	Smart Grid
SIC	Successive Interference Cancellation
SIC/PIC-MMSE	Successive/Parallel Interference Cancellation with Minimum Mean Square Error
SM	Smart Meter
SNR	Signal to Noise Ratio
SS	Spreading Sequences

SU-MIMO	Single User Multiple Input Multiple Output
TDMA	Time Division Multiple Access
UE	User Equipment
WAN	Wide Area Networks
WLAN	Wireless Local Area Network
WCDMA	Wideband Code Division Multiple Access

List of Symbols

af	Activation Function
b	Bernoulli Random Sequence
B	Total Bandwidth
$B_{k,l}$	Fraction Bandwidth of l_{th} User in k_{th} beam
dr	Disturbance Ratio
E	Transmitted Signal Energy
f	Subcarrier Index
h	Channel Gain Coefficient
M	Length of the SCMA Codeword
m	m_{th} moment
n	Complex Noise Sample/Level of Gaussian Noise
n_0	Number of Bit Samples
n_1	Neurons in Layers 1
n_2	Neurons in Layers 2
n_3	Neurons in Layers 3
N	AWGN Noise Power
N_0	AWGN Noise Density
N_b	Number of Resource Blocks
n_G	AWGN Noise Level without Impulse
N_G	AWGN Noise Power without Impulse
n_I	AWGN Noise Level with Impulse

N_I	AWGN Noise Power with Impulse
N_r	Number of Receive Antennas
N_t	Number of Transmit Antennas
O	Number of the Nonzero Elements
p	Impulse Probability
P	Total Power
P_C	Constant Power Consumption of Circuit
$P_{k,l}$	Fraction Power of l_{th} User k_{th} in Beam
P_{SIC}	SIC Power Consumption for One Iteration
P_t	Actual Consumed Transmitting Power
R	Distance of User from BS
$R_{Composite}$	Sum-Rate of Composite System
R_{NOMA}	Sum-Rate of NOMA System
R_{OFDMA}	Sum-Rate of OFDMA System
s	User Symbols Vector
T_1 & T_2	Blanking/Clipping Thresholds
T_B	Blanking Threshold
T_C	Clipping Threshold
T_{Tol}	Total Number of Impulses
t_w	Width of the Impulse
w	Weight Vector
x	User Data Vector
α	Power Allocation Coefficient
β	Bandwidth Allocation Coefficient
$\bar{\gamma}$	Average SNR
γ	Instantaneous SNR

θ	Angle of Arrival
λ_{Avg}	Average Impulse Rate
λ	Regularization Parameter
η	Learning Rate
ξ	Combined Noise Level (Additive White Gaussian Noise and Impulsive Noise)
ξ_0	Combined Noise Power (Additive White Gaussian Noise and Noise)
σ	AWGN Variance
χ	Inter-cell Interference Level
χ_0	Inter-cell Interference Power
ψ	Precoding Vector
ω	Weighting Coefficient