Computational Complexity Reduction in Taguchi Method Based Joint Optimization of Antenna Parameters in LTE-A Networks

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ABSTRACT

Long Term Evolution-Advanced (LTE-A) system is operated with cellular technology based on frequency reuse. Due to the co-channel interference between cells, one cell's performance is decided by not only its own configurations but also other cell's settings. Therefore, joint optimization of antenna parameters in LTE-A cellular networks is the key to maximizing coverage and capacity. This can be achieved by setting the antenna parameters such as azimuth orientations and tilts to the optimal values. Nevertheless, the large number of cell parameters and the interdependencies between these parameters make it difficult and time-consuming to optimize a cellular network. In practice, the joint setting of the parameters of all cells with irregular layout and coverage areas becomes an important and challenging task.

There are several methods to search for the optimal settings of a cellular network. One commonly used search method is Simulated Annealing (SA). SA can produce good results in cellular network optimization, but it takes a long time and its performance can easily be degraded if the input parameters are misconfigured. Other methods include the trial-and-error approach that requires manual selection of parameter values and has no guarantee for good results, and the brute-force approach that searches through all possible combinations of parameter values and is thus computationally prohibitive.

Among the various algorithms proposed for this time-consuming optimization task, the iterative approach based on the Taguchi method (TM) is a recent development that has been shown to be promising. This thesis presents some further improvements to the TM-based approach aiming at enhancing optimization performance and reducing computational complexity. The proposed improvements include the use of the mixed-level Nearly-Orthogonal Array (NOA) to cater for the different optimization ranges of different types of parameters, an improved mapping function to select testing values that are more representative of the optimization range, and a hybrid approach using multiple NOAs with decreasing number of experiments to exchange small degradation in optimization performance for significant reduction in computational complexity. The effectiveness of the proposed improvements is demonstrated by numerical examples.

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Abbreviations

3G	Third Generation
3GPP	Third Generation Partnership Project
3GPP2	Third Generation Partnership Project 2
AM	Arithmetic Mean
ANR	Automatic Neighbor Relation
ARQ	Automatic Repeat-reQuest
ATM	Asynchronous Transfer Mode
AWGN	Additive White Gaussian Noise
BCH	Broadcast Channel
BLER	Block Error Ratio
BS	Base Station
CA	Carrier Aggregation
CCO	Coverage and Capacity Optimization
CDD	Cyclic Delay Diversity
CDF	Cumulative Distribution Function
CDMA2000	Code Division Multiple Access 2000
CIO	Cell Individual Offset
CQI	Channel Quality Indicator
CRC	Cyclic Redundancy Check
CRS	Cell-specific Reference Signals
CS	Circuit Switch
CSI	Channel State Information
CSI-RS	Channel State Information Reference Signals
DCI	Downlink Control Information
DECT	Digital Enhanced Cordless Telecommunications
DFT	Discrete Fourier Transform
DL-SCH	Downlink Shared Channel
DM-RS	Demodulation Reference Signals
DNS	Domain Name System
DynaTAC	Dynamic Adaptive Total Area Coverage
EDGE	Enhanced Data rates for Global System for Mobile Communications Evolution
eNodeB	Enhanced NodeB
EPC	Evolved Packet Core

ETSI	European Telecommunications Standards Institute
FDD	Frequency Division Duplex
FFT	Fast Fourier Transform
FLMTS	Future Land Mobile Telecommunication System
FMCA	Fixed Mobile Convergence Alliance
GA	Genetic Algorithm
GCI	Global Cell Identity
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
HM	Harmonic Mean
HNB	Home Node B
HO	Hand Over
HSPA	High Speed Packet Access
HSS	Home Subscriber Server
ICIC	Inter-Cell Interference Coordination
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IFFT	Inverse Fast Fourier Transform
IMT	International Mobile Telecommunications
IMT-Advanced	International Mobile Telecommunications Advanced
IMS	IP Multimedia Subsystem
IP	Internet Protocol
IR	Incremental Redundancy
IRC	Interference Rejection Combination
ISP	Internet Service Provider
ITU	International Telecommunications Union
LD	Level Difference
LTE/LTE-A	Long Term Evolution/ Long Term Evolution Advanced
MAC	Medium Access Control
MBSFN	Multicast Broadcast Single Frequency Network
MCH	Multicast Channel
MIMO	Multiple-Input and Multiple-Output
MME	Mobility Management Entity
MRC	Maximum Ratio Combination
MRO	Mobility Robustness Optimization
MU-MIMO	Multi-User MIMO

NGMN	Next Generation Mobile Networks
NLoS	Non Line of Sight
NMT	Nordic Mobile Telephone
NOA	Nearly-Orthogonal Array
OA	Orthogonal Array
OFDM	Orthogonal Frequency-Division Multiplexing
OFDMA	Orthogonal Frequency-Division Multiple Access
OMA	Open Mobile Alliance
OPEX	Operational Expenditure
OSS	Operation Support System
PCFICH	Physical Control Format Indicator Channel
PCH	Paging Channel
PCI	Physical Cell ID
PDC	Personal Digital Cellular
PDCCH	Physical Downlink Control Channel
PDCP	Packet Data Convergence Protocol
PDN-G	Packet Data Network Gateway
PHICH	Physical Hybrid-ARQ Indicator Channel
PMI	Pre-coder Matrix Indication
POT	PCI Optimization Tool
PPT	PCI Planning Tool
PRBs	Physical Resource Blocks
PUCCH	Physical Uplink Control Channel
PUSCH	Physical Uplink Shared Channel
QAM	Quadrature Amplitude Modulation
QoE	Quality of Experience
QoS	Quality of Service
QPP	Quadrature Permutation Polynomial
QPSK	Quadrature Phase-Shift Keying
RACH	Random Access Channel
RAN	Radio Access Network
RAT	Radio Access Technology
RF	Radio Frequency
RFC	Request For Comments
RI	Rank Indication
RLC	Radio Link Control

RLF	Radio Link Failures
RM	Rate Matching
RNC	Radio Network Controller
RRC	Radio Resource Control
R-PDCCH	Relay Physical Downlink Control Channel
SA	Simulated Annealing
SAE	System Architecture Evolution
SDMA	Space Division Multiple Access
Serving-GW	Serving Gateway
SGSN	Serving General Packet Radio Services Support Node
SIC	Successive Interference Cancellation
SIP	Session Initiation Protocol
SNR	Signal to Noise Ratio
SINR	Signal to Interference and Noise Ratio
SON	Self- Organizing Network
SRS	Sounding Reference Signals
STBD	Space Time Block Coding
STTD	Space Time Transmit Diversity
TA	Traffic Area
TAI	TA Identifier
TAP	Tracking Area Planning
TAU	TA Updates
TM	Taguchi Method
TX	Transmitter
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TD-SCDMA	Time Division-Synchronous Code Division Multiple Access
TTI	Transmission Time Interval
TTT	Time-To-Trigger
UE	User Equipment
UL-SCH	Uplink Shared Channel
UMa	Urban Macro
UMTS	Universal Mobile Telecommunication System
VHE	Virtual Home Environment
VLAN	Virtual Local Area Network
WCDMA	Wideband Code Division Multiple Access

WiMAX	Worldwide interoperability for Microwave Access
WLAN	Wireless Local Area Network

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