Enhance Radio Resource Allocation Techniques for Fractional Frequency Reuse Base Station in Mobile WiMAX Cellular Network

by

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DECLARATION OF THESIS

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Mohammed Khalid Salam Fadhil Al-Naimi

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LIST OF ABBREVIATIONS

I. Basic Units

Quantity	Unit	Symbol
Data Rate	Bit per second, Megabit per second	bps, Mbps
Frequency	Hertz, Kilohertz, Megahertz, Gigahertz	Hz, KHz, MHz, GHz
Distance	Meter, Kilometer	m, Km
Time	Second, Millisecond, Microsecond	s, ms, μs
Spectral Efficiency	Bit per second per hertz	bps/Hz
Subcarrier Efficiency	Bit per subcarrier per burst	b/subcarrier/burst
Channel Capacity	Bit per second	bps
Power	Watt, Milliwatt, Decibel, Decibel-Milliwatt	W, mW, dB, dBm
Antenna Gain	Decibel-isotropic	dBi
Thermal Noise Power	Decibel-Milliwatt per hertz	dBm/Hz

II. Abbreviations

3GPP	Third-Generation Partnership Project
AAS	Adaptive Antenna System
AFRF	Average Frequency Reuse Factor
AMC	Adaptive Modulation and Coding
AP	Access Point
APA	Adaptive Power Allocation
AT&T	American Telephone and Telegraph Company
Band-AMC	Band Adaptive Modulation and Coding
BE	Best Effort

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BP	Burst Profiles
BS	Base Station
BW	Band Width
BWE	Bandwidth Efficiency
CC	Convolutional Code
CC-FFR	Client-Centric Fractional Frequency Reuse
CCI	Co-Channel Interference
CDMA	Code Division Multiple Access
COST	European Cooperative for Scientific and Technical
CQI	Channel Quality Indicator
CSI	Channel State Information
CTC	Convolutional Turbo Codes
DC	Direct Current
DIUC	Downlink Interval Usage Code
DL	Down Link
DL-MAP	Down link MAP
DRA	Dynamic Resource Assignment
DSA	Dynamic Subcarriers Assignment
DSL	Digital Subscriber Line
E	Electronic
EBW	Effective Bandwidth
ertPS	Extended Real-Time Polling Service
FCH	Frame Control Header
FDD	Frequency Division Duplexing
FEC	Forward Error Correction

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FFR	Fractional Frequency Reuse
FFT	Fast Fourier Transform
FRF	Frequency Reuse Factor
FTP	File Transfer Protocol
FUSC	Full Usage of SubChannels
GSM	Global System for Mobile
H	High
HS	Highest
HTTP	Hyper Text Transfer Protocol
ICI	Inter-cell Interference
IE	Information Element
IEEE	Institute of Electrical and Electronics Engineers
IFCO	Interference Coordination
ISD	Intercell Spatial Demultiplexing
ISI	Inter Symbol Interference
L	Low
LAN	Local Area Network
LMSC	LAN MAN Standards Committee
LOS	Line-of-Sight
LS	Lowest
LTE	Long Term Evolution
MAC	Media Access Control
MAN	Metropolitan Area Network
MCS	Modulation and Coding Scheme
MPEG	Moving Pictures Experts Group

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MRC	Maximal Ratio Combining
MS	Mobile Station
MSINR	Maximum SINR
NLOS	Non-Line-of-Sight
nrtPS	Non-Real-Time Polling Service
OFDM	Orthogonal Frequency-division Multiplexing
OFDMA	Orthogonal Frequency-Division Multiple Access
PHY	Physical Layer
PL	Path Loss
PMP	Point-to-MultiPoint
PUSC	Partial Usage of SubChannels
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
QPSK	Quadrature phase-shift keying
RD	Radio Distance
REP-REQ	Report Request
REP-RSP	Report Response
RNC	Radio Network Controller
RR	Round Robin
RRA	Radio Resource Agent
RRC	Radio Resource Controller
RSSI	Received Signal Strength Indicator
RTG	Receive Transition Gap
rtPS	Real-Time Polling Service
SE	Spectral Efficiency

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Segments BC	Segment B and segment C in R3 zone
SINR	Signal-to-Interference-plus-Noise Ratio
SNR	Signal to Noise Ratio
SRA	Static Resource Assignment
TDD	Time Division Duplexing
TLPC	Two Level Power Control
TTG	Transmit Transition Gap
U	User
UGS	Unsolicited Grant Service
UIUC	Uplink Interval Usage Code
UL	Up Link
UL-MAP	Up link MAP
VOIP	Voice over Internet Protocol
WiMAX	Worldwide Interoperability for Microwave Access

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LIST OF SYMBOLS

R1 zone	First part in the DL sub-frame
R3 zone	Second part in the DL sub-frame
F1	Frequency band of segment A
F2	Frequency band of segment B
F3	Frequency band of segment C
N_{FFT}	Number of subcarriers
Δf	Subcarrier frequency spacing
Tb	Useful symbol time
Tg	Guard time (or cyclic prefix time)
G	Ratio of cyclic prefix time to useful symbol time
Ts	OFDMA symbol duration time
n	Sampling factor
N_{bin}	Number of bins per slot
M_{OFDM}	Number of OFDM symbols per slot
T1	Operational time of R1 zone
T2	Operational time of R3 zone
N_{MS}	Number of users require services
$SINR_{TH}$	Threshold SINR
$SINR(MS)$	Mobile station SINR value
r	Cell centre radius
R	Cell radius
No	Thermal noise power
l	Number of interfered base stations in the grid

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M	Target zone or segment name
τ	Operational time of a given OFDM symbols in the DL sub-frame
Trd. FFR	Traditional Fractional Frequency Reuse
Pro. FFR	Propose Fractional Frequency Reuse
Seg. BC	Segments BC
S_{frame}	Number of OFDM symbols in WiMAX frame
Tf	Frame duration time
γ	Number of slots per two successive OFDM symbols
$\mathrm{Kr}_{\mathrm{slot}}$	Number of subcarriers per slot
N_{Smb}^{UL}	Number of OFDM symbols in the UL sub-frame
DL/UL	Down link to up link OFDM traffic ratio
N_{MS}^{Gen}	Number of generated users
$N_{MS_{R1}}^{max}$	Maximum number of users in R1 zone
N_{MSR1}	Number of users in R1 zone
$N_{MS_{R3}}^{max}$	Maximum number of users in R3 zone
N_{MSR3}	Number of users in R3 zone
N_{MS}^{Extra}	Number of extra users require services
MS_x	User location in X-axis
MS_y	User location in Y-axis
ic1, ic2, ic3, and ic4	Users counter of Case 1, Case 2, Case 3, and Case 4
$ic1^{max}, ic2^{max}$ $ic3^{max}, ic4^{max}$	Maximum number of users that can be served in Case 1, Case 2, Case 3, and Case 4, respectively
N_{R1}	Users counter of R1 zone
$N_{MS}^{LA}, N_{MS}^{LB}, N_{MS}^{LC}, N_{MS}^{LD}$	Number of users per layer A, B, C, and D, respectively

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MSF	User index flag
N_{MS}^{ABCD}	Total number of users in all layers (A, B, C, and D)
N_{MS}^{max}	Hold the most crowded layer name (A, B, C, or D)
ia, ib, ic, id	Users counter of layer A, B, C, and D, respectively
$ia^{max}, ib^{max}, ic^{max}, id^{max}$	Maximum number of users in layer A, B, C, and D, respectively
Pr	Received power
Pt	Transmitted power
Gr	Receiver antenna gain
Gt	Transmitter antenna gain
f	Operating carrier frequency
h_{BS}	Base station antenna height
h_{MS}	Mobile station antenna height
A (h_{MS})	Mobile station antenna correction factor
d	Distance between base station and user (or mobile station)
C_F	Environment correction factor
X	Shadowing
BS_x	Base station location in X-axis
BS_y	Base station location in Y-axis
K	Boltzmann's constant
T	Kelvin temperature
Fs	Sampling frequency
Kr_{OFDM}	Number of Subcarriers per OFDM symbol
B	Number of data bits per subcarrier
Dr_{PHY}	Physical layer data rate

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Dr_{MAC}	MAC layer data rate
N_{OFDM}^{DL}	Number of OFDM symbols in the DL sub-frame
N_{OFDM}^{OH}	Number of OFDM symbols reserved for overhead (control messages) in the DL sub-frame
Cr	Code rate type
Q	Number of points in the constellation for particular modulation type
β	Number of slots reserved for user data load
α	Number of active users in the target zone or segment
P(u)	Binary expression (0 or 1)
$P_{SINR}^{min}(M)\ and\ P_{SINR}^{max}(M)$	SINR thresholds for target zone or segment
$R3_A$	Segment A in R3 zone
$R3_{BC}$	Segment BC in R3 zone
Dr_{MAC}^{Trd}	MAC data rate in traditional FFR
Dr_{MAC}^{Pro}	MAC data rate in proposed FFRs
Z	Number of trials
$\overline{Dr}_{MAC}^{Trd}$	Average MAC data rate in traditional FFR
$\overline{Dr}_{MAC}^{Pro}$	Average MAC data rate in proposed FFRs
Kr_E(M)	Normalized subcarrier efficiency per zone or segment
ω	Total number of subcarriers reserved for specific user load
$\overline{Kr_E}(M)$	Average normalized subcarrier efficiency per zone or segment
Kr_E^{Trd}	Arithmetic mean of traditional FFR subcarrier efficiency
Kr_E^{Pro}	Arithmetic mean of proposed FFRs subcarrier efficiency
DL_{SE}	Down link spectral efficiency
FRF_{R3}	Frequency reuse factor in R3 zone

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