

IEEE Std 802.16™-2022

(Amendment to
IEEE Std 802.16™-2017)

IEEE Standard for Air Interface for Broadband Wireless Access Systems-

Amendment t: Fixed and Mobile Wireless Access in Narrowband Channels

Sponsor

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of the

IEEE Computer Society

and the

IEEE Microwave Theory and Techniques Society

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IEEE-SA Standards Board



Abstract: This standard specifies the air interface, including the medium access control layer (MAC) and physical layer (PHY), of combined fixed and mobile point-to-multipoint broadband wireless access (BWA) systems providing multiple services. The MAC is structured to support multiple PHY specifications, including WirelessMAN-SC, WirelessMAN-OFDM, and WirelessMAN-OFDMA PHY specifications, each suited to a particular operational environment.

Keywords: broadband wireless access, BWA, cellular layer, fixed broadband wireless access, IEEE 802.16™, IMT-2000, MAN, management information base, MIB, microwave, mobile broadband, mobile broadband wireless access, OFDM, OFDMA, radio, standard, WAS, wireless access systems, WirelessMAN®, wireless metropolitan area network

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IEEE 802.15.16t Working Group Officers

Tim Godfrey, *Chair*

Harry Bims, *Vice Chair, Technical Editor*

The following members of the IEEE 802.16 Working Group on Broadband Wireless Access participated in the Working Group Letter Ballot in which this standard was prepared and finalized for IEEE Ballot:

Harry Bims

Tim Godfrey

Menashe Shahar

Guy Simpson

The following members of the individual balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

Thomas Alexander
Lai King Anna Tee
Mathilde Benveniste
Harry Bims
Nancy Bravin
Demetrio Bucaneg
William Byrd
Juan Carreon
Charles Cook
Sourav Dutta
Robert Finch
Avraham Freedman
Tim Godfrey
Eric W. Gray
Randall Groves
Michael Gundlach
Marco Hernandez
Werner Hoelzl

Noriyuki Ikeuchi
Sergiu Iordanescu
Akio Iso
Atsushi Ito
Raj Jain
Piotr Karocki
Stuart Kerry
Brian Kiernan
Yongbum Kim
Yasushi Kudoh
Thomas Kurihara
Hyeong Ho Lee
Arthur H. Light
Elvis Maculuba
Roger B. Marks
Jeffery Masters
Michael McInnis

Ronald Murias
Nick S. A. Nikjoo
Paul Nikolich
John Notor
Satoshi Oyama
Clinton Powell
Venkatesha Prasad
Maximilian Riegel
Robert Robinson
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Thomas Starai
Walter Struppler
Mark-Rene Uchida
Dmitri Varsanofiev
John Vergis
Khurram Waheed
Andreas Wolf
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Robby Robson
Dorothy Stanley
Adrian Stephens
Mehmet Ulema
Phil Wennblom
Howard Wolfman
Yu Yuan

*Member Emeritus

The following members of the IEEE 802.16 Working Group on Broadband Wireless Access participated in the Working Group Letter Ballot in which the draft of IEEE Std 802.16-2001 was approved:

Song An	Michael Hamilton	Lou Olsen
Jori Arrakoski	Baya Hatim	Yunsang Park
Arun Arunachalam	Srinath Hosur	Brian Petry
Eli Avivi	Coleman Hum	Wayne Pleasant
C. R. Baugh	Wayne Hunter	Moshe Ran
Carlos Belfiore	Eric Jacobsen	Stanley Reible
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Mary Condie	Allan Klein	Vito Scaringi
José Costa	Jay Klein	Randall Schwartz
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Phil Guillemette	Jim Mollenauer	Huanchun Ye
Zion Hadad	William Myers	Chaoming Zeng
Baruch Halachmi		Juan Carlos Zúñiga

The following members of the IEEE 802.16 Working Group on Broadband Wireless Access participated in the Working Group Letter Ballot in which the draft of IEEE Std 802.16c-2002 was prepared and finalized for IEEE Ballot:

Aditya Agrawal	Wayne Hunter	Manish Patel
Song An	David Husson	Kenneth Peirce
Gordon Antonello	Hamadi Jamali	Subbu Ponnuswamy
Reza Arefi	Jacob Jorgensen	Moshe Ran
S. Lek Ariyavisitakul	Tal Kaitz	Gene Robinson
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G. Jack Garrison	Apurva Mody	Philip Whitehead
Marianna Goldhammer	Ronald Murias	Curt Wise
Zion Hadad	Robert Nelson	Vladimir Yanover
Yoav Hebron	Kim Olszewski	Heejung Yu

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Song An	Tal Kaitz	Gene Robinson
Gordon Antonello	Mika Kasslin	Shane Rogers
Reza Arefi	Phil Kelly	Amir Sarajedini
S. Lek Ariyavisitakul	Ofer Kelman	Octavian Sarca
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Yoav Hebron	Kim Olszewski	Vladimir Yanover
Wayne Hunter	Mike Paff	Huanchun Ye
David Husson	Manish Patel	Heejung Yu
Hamadi Jamali	Kenneth Peirce	Wenhan Zhang
	Subbu Ponnuswamy	

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Aditya Agrawal
Gordon Antonello
Reza Arefi
Eli Avivi
Dean Chang
Naftali Chayat
Rémi Chayer
Brian Eidson
Carl Eklund
Marc Engels
Avraham Freedman
G. Jack Garrison
Marianna Goldhammer
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Aditya Agrawal	Yung Hahn	Ronald Murias
Baraa Al-Dabagh	Jun Han	Robert Nelson
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Gordon Antonello	Moo Ryong Jeong	Shlomo Ovadia
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	James Mollenauer	

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Zion Hadad	Andrew Middleton	Vladimir Yanover
David Johnston	Ronald Murias	Choong-il Yeh
Panyuh Joo	Robert Nelson	Chulsik Yoon

The following participated as nonmembers in the Working Group Letter Ballot for IEEE Std 802.16e-2005:

Chang-Jae Lee	Jeffrey Mandin	Jose Puthenkulam
---------------	----------------	------------------

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Ray Abrishami	Jiho Jang	Gunnar Nitsche
Aditya Agrawal	Jaeho Jeon	Paul Odlyzko
Baraa Al-Dabagh	Moo Ryong Jeong	Min Seok Oh
Mario Aliotta	Yong Seok Jin	Masoud Olfat
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Sanjeev Athalye	David Johnston	Joonho Park
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Kevin Baum	Ravi Kalavakunta	Trevor Pearman
Izhar Bentov	Samuel Kang	Greg Phillips
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David Castelow	Beomjoon Kim	Kamlesh Rath
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Kihyoung Cho	Havish Koorapaty	Yossi Segal
Seokheon Cho	Lalit Kotecha	Radu Selea
Hyoung-Jin Choi	Denesh Krishnasamy	N.K. Shankaranarayanan
Joey Chou	Dongseung Kwon	Eli Shasha
Jin Young Chun	Margaret LaBrecque	James Simkins
Jin Yong Chung	Jonathan Labs	Jung Je Son
Kyuhyuk Chung	Jules Pierre Lamoureux	Yeong Moon Son
José Costa	Chang-jae Lee	Kenneth Stanwood
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Frank Draper	Sungjin Lee	Wen Tong
Lester Eastwood	Yigal Leiba	Rainer Ullmann
Carl Eklund	Barry Lewis	Mano Vafai
Yigal Eliaspur	Jun Li	Eyal Verbin
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Yonggang Fang	Hyoung Kyu Lim	Guo Qiang Wang
Mo-Han Fong	Hyoungsoo Lim	Irving Wang
Bogdan Franovici	Erik Lindskog	Jing Wang
Avraham Freedman	Titus Lo	Lei Wang
Nikhil Goel	Hui-Ling Lou	Stanley Wang
Mariana Goldhamer	Heinz Lycklama	Alfred Wiecezorek
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Zion Hadad	David Maez	Ran Yaniv
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Jeff Harrang	Russell McKown	Kunmin Yeo
Haixiang He	Scott Migaldi	Chulsik Yoon
Zhaoyun (Laura) Huang	James Mollenauer	Wenzhong Zhang
John Humbert	Ollivier Mont-Reynaud	Keqiang Zhu
Seung Ku Hwang	Ronald Murias	Peiying Zhu
	K. S. Natarajan	

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Ray Abrishami	Pieter-Paul Giesberts	Yongmao Li
Edward Agis	Nikhil Goel	Gaspard Licitra
Aditya Agrawal	Mariana Goldhamer	Aeri Lim
Siavash Alamouti	Reza Golshan	Geunhwi Lim
Murtaza Ali	David Grandblaise	Hyoung Kyu Lim
Mario Aliotta	Qiang Guo	Hyoungsoo Lim
Dov Andelman	Zion Hadad	Zhibin Lin
Gordon Antonello	Jun Han	Titus Lo
Eli Avivi	Jung Ho Han	Hui-Ling Lou
Phillip Barber	Seishi Hanaoka	Heinz Lycklama
Kevin Baum	Jeff Harrang	Michael Lynch
Rajesh Bhalla	Haixiang He	Steve Ma
Yufei Blankenship	Gregory Scott Henderson	Seung Joo Maeng
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Dean Chang	Jaeho Jeon	Willem Mulder
Jae Hwan Chang	David Johnston	Ronald Murias
Sungcheol Chang	Panyuh Joo	Kenichi Nakamura
Yong Chang	Hyunjeong Kang	K.S. Natarajan
Naftali Chayat	Ivy Kelly	Mitsuo Nohara
RÉmi Chayer	Ofer Kelman	Paul Odlyzko
Jennifer Chen	Brian Kiernan	Shlomo Ovardia
Yuehua (Lucy) Chen	Beomjoon Kim	David Paranchych
Aik Chindapol	Bong Ho Kim	Youngsoo Park
Hua (Mary) Chion	Byoung-Jo Kim	Roger Peterson
Jahee Cho	Dae-Joong Kim	Bonnie Petti
Jaeweon Cho	Jaeyoel Kim	Greg Phillips
Kihyoung Cho	Jung Won Kim	Paul Piggin
Seiji Cho	Min Sung Kim	Ambroise Popper
Seokheon Cho	Ronny (Yong-Ho) Kim	Scott Probasco
Hyoung-Jin Choi	Youngho Kim	Jose Puthenkulam
Yang-Seok Choi	Itzik Kitroser	Nanjian (Jeff) Qian
Joey Chou	Chris Knudsen	Hongyun Qu
Jin Young Chun	Changhoi Koo	Shyamal Ramachandran
JosÉ Costa	Havish Koorapaty	Frank Rayal
Mark Cudak	Lalit Kotecha	Eric Reifsnider
Shujun Dang	Toshiyuki Kuze	Francis Retnasothie
Wim Diepstraten	Dong Seung Kwon	Maximilian Riegel
Frank Draper	Jonathan Labs	Wonil Roh
Krzysztof Dudzinski	Kari Laihonen	Herbert Ruck
Lester Eastwood	Jules Pierre Lamoureux	Kiseon Ryu
Tomas Edler	Chang-jae Lee	Andrew Sago
Carl Eklund	Chi-Chen Lee	Yousuf Saifullah
Yigal Eliaspur	Jae Hak Lee	Kenji Saito
Frank Exeler	Mihyun Lee	Atul Salvekar
Torsten Fahldieck	Sungjin Lee	J'rg Schmidt
Yonggang Fang	Yigal Leiba	Christian Seagren
Peretz Feder	Jia-Ru Li	Yossi Segal
Dazi Feng	Jiang Li	Radu Selea
Mo-Han Fong	Kemin Li	N.K. Shankaranarayanan
Avraham Freedman	Li Li	Eliyahu Shasha
Yan Fu	Thomas Li	Gang Shen
Mike Geipel	Xiaodong Li	Yabing Shen

James Simkins
Sten Sjoberg
Jung Je Son
Yeong Moon Son
Kenneth Stanwood
Kyungjoo Suh
Xiangguo Tang
Yongjoo Tcha
Wen Tong
Shiau-He Tsai
Rainer Ullmann
Mano Vafai
Lucia Valbonesi
Richard Van Leeuwen
Eyal Verbin
Dorin Viorel
Frederick Vook

Arthur Wang
Fan Wang
Guo qiang Wang
Irving Wang
Lei Wang
Stanley Wang
Mattias Wennstrom
Alfred Wiczorek
Geng Wu
Jun Wu
Xuyong Wu
David Xiang
Ling Xu
Shanshan Xu
Hassan Yaghoobi
Weidong Yang

Yunsong Yang
Ran Yaniv
Vladimir Yanover
Choong Il Yeh
Hujun Yin
Chulsik Yoon
Soon Young Yoon
Aeran Youn
Jungnam Yun
Mi-Young Yun
Nader Zein
Wenfeng Zhang
Zhijian Zhang
Ruobin Zheng
Qun Zhou
Peiying Zhu
Ilan Zohar

The following members of the IEEE 802.16 Working Group on Broadband Wireless Access participated in the Working Group Letter Ballot in which IEEE Std 802.16g-2007 was prepared and finalized for IEEE Ballot:

Ray Abrishami	Nikhil Goel	Aeri Lim
Edward Agis	Mariana Goldhamer	Geunhwi Lim
Aditya Agrawal	Reza Golshan	Hyoung Kyu Lim
Siavash Alamouti	David Grandblaise	Hyoungsoo Lim
Murtaza Ali	Qiang Guo	Zhibin Lin
Mario Aliotta	Zion Hadad	Titus Lo
Dov Andelman	Jun Han	Hui-Ling Lou
Gordon Antonello	Jung Ho Han	Heinz Lycklama
Eli Avivi	Seishi Hanaoka	Michael Lynch
Phillip Barber	Jeff Harrang	Steve Ma
Kevin Baum	Haixiang He	Seung Joo Maeng
Rajesh Bhalla	Gregory Scott Henderson	David Maez
Yufei Blankenship	Michael Hoghooghi	Mahesh Makhijani
Eckard Bogenfeld	Chang-Lung Hsiao	Jeffrey Mandin
Achim Brandt	Haiming Huang	Roger B. Marks
Thomas Brown	John Humbert	David McGinniss
Sean Cai	Yerang Hur	Scott Migaldi
James Carlo	InSeok Hwang	James Mollenauer
Giulio Cavalli	Bin-Chul Ihm	Roland Muenzner
Jaesun Cha	Jiho Jang	Willem Mulder
Chan-Byoung Chae	Jaeho Jeon	Ronald Murias
Dean Chang	David Johnston	Kenichi Nakamura
Jae Hwan Chang	Panyuh Joo	K.S. Natarajan
Sungcheol Chang	Hyunjeong Kang	Mitsuo Nohara
Yong Chang	Ivy Kelly	Paul Odlyzko
Naftali Chayat	Ofer Kelman	Shlomo Ovadia
Rémi Chayer	Brian Kiernan	David Paranchych
Jennifer Chen	Beomjoon Kim	Youngsoo Park
Yuehua (Lucy) Chen	Bong Ho Kim	Roger Peterson
Aik Chindapol	Byoung-Jo Kim	Bonnie Petti
Hua (Mary) Chion	Dae-Joong Kim	Greg Phillips
Jaehye Cho	Jaeyoel Kim	Paul Piggin
Jaeweon Cho	Jung Won Kim	Ambrose Popper
Kihyoung Cho	Min Sung Kim	Scott Probasco
Seiji Cho	Ronny (Yong-Ho) Kim	Jose Puthenkulam
Seokheon Cho	Youngho Kim	Nanjian (Jeff) Qian
Hyoung-Jin Choi	Itzik Kitroser	Hongyun Qu
Yang-Seok Choi	Chris Knudsen	Shyamal Ramachandran
Joey Chou	Changhoi Koo	Frank Rayal
Jin Young Chun	Havish Koorapaty	Eric Reifsnider
José Costa	Lalit Kotecha	Francis Retnasothie
Mark Cudak	Toshiyuki Kuze	Maximilian Riegel
Shujun Dang	Dong Seung Kwon	Wonil Roh
Wim Diepstraten	Jonathan Labs	Herbert Ruck
Frank Draper	Kari Laihonen	Kiseon Ryu
Krzysztof Dudzinski	Jules Pierre Lamoureux	Andrew Sago
Lester Eastwood	Chang-jae Lee	Yousuf Saifullah
Tomas Edler	Chi-Chen Lee	Kenji Saito
Carl Eklund	Jae Hak Lee	Atul Salvekar
Yigal Eliaspur	Mihyun Lee	Jörg Schmidt
Frank Exeler	Sungjin Lee	Christian Seagren
Torsten Fahldieck	Yigal Leiba	Yossi Segal
Yonggang Fang	Jia-Ru Li	Radu Selea
Peretz Feder	Jiang Li	N.K. Shankaranarayanan
Dazi Feng	Kemin Li	Eliyahu Shasha
Mo-Han Fong	Li Li	Gang Shen
Avraham Freedman	Thomas Li	Yabing Shen
Yan Fu	Xiaodong Li	James Simkins
Mike Geipel	Yongmao Li	Sten Sjoberg
Pieter-Paul Giesberts	Gaspard Licitra	Jung Je Son

Yeong Moon Son
Kenneth Stanwood
Kyungjoo Suh
Xiangguo Tang
Yongjoo Tcha
Wen Tong
Shiau-He Tsai
Rainer Ullmann
Mano Vafai
Lucia Valbonesi
Richard Van Leeuwen
Eyal Verbin
Dorin Viorel
Frederick Vook
Arthur Wang
Fan Wang

Guo qiang Wang
Irving Wang
Lei Wang
Stanley Wang
Mattias Wennstrom
Alfred Wiczorek
Geng Wu
Jun Wu
Xuyong Wu
David Xiang
Ling Xu
Shanshan Xu
Hassan Yaghoobi
Weidong Yang
Yunsong Yang

Ran Yaniv
Vladimir Yanover
Choong Il Yeh
Hujun Yin
Chulsik Yoon
Soon Young Yoon
Aeran Youn
Jungnam Yun
Mi-Young Yun
Nader Zein
Wenfeng Zhang
Zhijian Zhang
Ruobin Zheng
Qun Zhou
Peiying Zhu
Ilan Zohar

The following members of the IEEE 802.16 Working Group on Broadband Wireless Access participated in the Working Group Letter Ballot in which IEEE Std 802.16j-2009 was prepared and finalized for IEEE Ballot:

Edward Agis	Peretz Feder	Itzik Kitroser
Sassan Ahmadi	Shulan Feng	Ali Koc
Dong Hyun Ahn	Mo-Han Fong	Havish Koorapaty
JunBae Ahn	Avraham Freedman	Thanasis Korakis
Dov Andelman	I-Kang Fu	Gokhan Korkmaz
Reza Arefi	Dan Gal	Toshiyuki Kuze
Phillip Barber	Pieter-Paul Giesberts	Byung-Jae Kwak
Kevin Baum	Rob Glassford	Jin Sam Kwak
Adrian Boariu	Mariana Goldhamer	Dong Seung Kwon
Eckard Bogenfeld	Reza Golshan	Yeong-Hyeon Kwon
Achim Brandt	David Grandblaise	Jonathan Labs
Dale Branlund	Daqing Gu	Pierre Lamoureux
Terri Brooks	Zion Hadad	Hyun Lee
Sean Cai	GeneBeck Hahn	Hyunjeong Lee
James Carlo	Shkumbin Hamiti	Jin Lee
Jaesun Cha	Jung Ho Han	Ki-Dong Lee
Suchang Chae	Seishi Hanaoka	Kyu Ha Lee
Jae Hwan Chang	Keisuke Higuchi	Mi Hyun Lee
Sungcheol Chang	Minnie Ho	Sang-Ho Lee
Remi Chayer	Chang-Lung Hsiao	Seung Joon Lee
David Chen	Ching-Tarn Hsieh	Sukwoo Lee
Wei-Peng Chen	Yu-Tao Hsieh	Wookbong Lee
Paul Cheng	Hsien-Tsung Hsu	Yong Su Lee
Aik Chindapol	Yuan-Ying Hsu	Youn-Tai Lee
Hua (Mary) Chion	Teck Hu	Yung-Ting Lee
Jaehee Cho	Cancan Huang	Matty Levanda
Jaeweon Cho	Junhong Hui	Guangjie Li
Kihyoung Cho	John Humbert	Jiang Li
Myeon-Gyun Cho	Yerang Hur	Jun Li
Hokyu Choi	In Seok Hwang	Richard Li
Hyung-Jin Choi	Bin-Chul Ihm	Shaohua Li
Hyung-Nam Choi	Tetsu Ikeda	Thomas Li
In-Kyeong Choi	Tetsushi Ikegami	Aeri Lim
Jinsoo Choi	Jaehyuk Jang	Geunhwi Lim
Joonyoung Choi	Klutto Milleth Jeniston Deviraj	Hyoung Kyu Lim
Yang-Seok Choi	Hyung Joon Jeon	Kwangjae Lim
Yong-Hoon Choi	Moo Ryong Jeong	Tzu-Ming Lin
Chie Ming Chou	Sunggeun Jin	Zhibin Lin
Joey Chou	Brian Johnson	Stefan Lindgren
Jerry Chow	Kerstin Johnsson	Hang Liu
Jimmy Chui	David Johnston	Michael Livschitz
Takafumi Chujo	Panyuh Joo	Titus Lo
Jin Young Chun	Young-Ho Jung	Kanchei Loa
Young-Uk Chung	Takeo Kanai	Jianmin Lu
Erik Colban	Hyunjeong Kang	Yanling Lu
David Comstock	Seung Hyun Kang	Michael Lynch
Jose Costa	Ofer Kelman	Mohammad Madihian
Steven Crowley	Brian Kiernan	David Maez
Mark Cudak	Bong Ho Kim	Giovanni Maggi
George Cummings	Changkyoon Kim	Shashikant Maheshwari
Pranav Dayal	Hyung Kee Kim	Ronald Mao
Carlos De Segovia	Kyeongsoo Kim	Djamal-Eddine Meddour
Upkar Dhaliwal	Ronny (Yong-Ho) Kim	Scott Migaldi
Yoshiharu Doi	Sang Youb Kim	Chan Ho Min
Lester Eastwood	Sungkyung Kim	Shantidev Mohanty
Carl Eklund	Young Kyun Kim	Andreas Molisch
Per Elmdahl	Young-Il Kim	James Mollenauer
Michael Erlihson	Young-jae Kim	Ollivier Mont-Reynaud
Yu-Chang Eun	Youngho Kim	Sungho Moon
Torsten Fahldieck	Takaaki Kishigami	Willem Mulder

Yukimasa Nagai
Ayman Naguib
Kenichi Nakamura
Michiharu Nakamura
Eric Njedjou
Minseok Noh
John Norin
Paul Odlyzko
Changyoon Oh
Min-Seok Oh
Masato Okuda
Kim Olszewski
Philip Orlik
David Paranchych
D. S. Park
Jeongho Park
Vijay Patel
Roger Peterson
Paul Piggini
Robert Popoli
Darcy Poulin
Scott Probasco
Xin Qi
Nanjian (Jeff) Qian
Fei Qin
Hongyun Qu
Arvind Raghavan
Shyamal Ramachandran
Ranga K. Reddy
Fang-Ching Ren
Maximilian Riegel
Kwanhee Roh
Wonil Roh
Zhigang Rong
Adel Rouz
Philip Rubin
Herbert Ruck
Kiseon Ryu
Aryan Saed
Yousuf Saifullah
Kenji Saito
Summeet Sandhu

Ioannis Sarris
Joerg Schaepperle
Gary Schlanger
Gamini Senarath
Jigar Shah
Zheng Shang
Ariel Sharon
Wern-Ho Sheen
Peretz Shekalim
Gang Shen
Matthew Sherman
Jaejeong (Brian) Shim
D. J. Shyy
James Simkins
Kathiravetpillai Sivanesan
Sten Sjoberg
Jung Je Son
Yeongmoon Son
Ting-Chen (Tom) Song
Young Seog Song
Roshni Srinivasan
Kenneth Stanwood
David Steer
Aram Sukiasyan
Sheng Sun
Yong Sun
Jaroslav J. Sydir
John Sydor
Mineo Takai
Yukihiro Takatani
Pek Yew Tan
Jeffrey Tao
Rakesh Taori
Shawn Taylor
Koon Hoo Teo
Timothy Thome
Wen Tong
Arnaud Tonnerre
Shiau-He Tsai
Rainer Ullmann
David Urban
Sunil Vadgama

Lucia Valbonesi
Richard van Leeuwen
Rath Vannithamby
Muthaiah Venkatachalam
Dorin Viorel
Eugene Visotsky
Frederick Vook
Arthur Wang
Guo Qiang Wang
Lei Wang
Michael Wang
Shu-Shaw Wang
Stanley Wang
Yanhong Wang
Fujio Watanabe
Alfred Wiczorek
Geng Wu
Xuyong Wu
Yingzhe Wu
David Xiang
Chengjie Xie
Hua Xu
Ling Xu
Akiyoshi Yagi
Jen-Shun Yang
Rongzhen Yang
Xiangying Yang
Yunsong Yang
Vladimir Yanover
Hua-Chiang Yin
Hujun Yin
Chulsik Yoon
Aeran Youn
Jungnam Yun
Sangboh Yun
Masaaki Yuza
Jinyun Zhang
Kaibin Zhang
Hongming Zheng
Hua Zhou
Yuefeng Zhou
Chenxi Zhu

The following members of the IEEE 802.16 Working Group on Broadband Wireless Access participated in the Working Group Letter Ballot in which IEEE Std 802.16h-2010 was prepared and finalized for IEEE Ballot:

Edward Agis	Hyung Joon Jeon	Changyoon Oh
Sassan Ahmadi	Sunggeun Jin	Min-Seok Oh
JunBae Ahn	Panyuh Joo	Philip Orlik
Dov Andelman	Young-Ho Jung	David Paranchych
Reza Arefi	Hyunjeong Kang	DS Park
Phillip Barber	Ofer Kelman	Jeongho Park
Kevin Baum	Brian Kiernan	Vijay Patel
Adrian Boariu	Changkyoon Kim	Roger Peterson
Terri Brooks	Sang Youb Kim	Paul Piggin
Sean Cai	Young Kyun Kim	Jose Puthenkulam
James Carlo	Young-jae Kim	Nanjian (Jeff) Qian
Jaesun Cha	Youngho Kim	Fei Qin
Suchang Chae	Takaaki Kishigami	Hongyun Qu
Jae Hwan Chang	Itzik Kitroser	Shyamal Ramachandran
Naftali Chayat	J. Klutto Millette	Ranga Reddy
Rémi Chayer	Ali Koc	Fang-Ching Ren
Wei-Peng Chen	Changhoi Koo	Maximilian Riegel
Paul Cheng	Thanasis Korakis	Kwanhee Roh
Aik Chindapol	Toshiyuki Kuze	Wonil Roh
Jaehee Cho	Jin-Sam Kwak	Zhigang Rong
Jaeweon Cho	Yeong-Hyeon Kwon	Adel Rouz
Myeon-Gyun Cho	Jonathan Labs	Kiseon Ryu
Hokyu Choi	Pierre Lamoureux	Yousuf Saifullah
Hyoung-Jin Choi	Hyun Lee	Ioannis Sarris
Joonyoung Choi	Ki-Dong Lee	Joseph Schumacher
Yang-Seok Choi	Kyu Ha Lee	Gamini Senarath
Chie Ming Chou	Mi Hyun Lee	Zheng Shang
Joey Chou	Sang-Ho Lee	Ariel Sharon
Takafumi Chujo	Seung Joon Lee	Wern-Ho Sheen
Jin Young Chun	Sukwoo Lee	Peretz Shekalim
Erik Colban	Youn-Tai Lee	Jaejeong (Brian) Shim
David Comstock	Yung-Ting Lee	D. J. Shyy
José Costa	Jiang Li	Kathiravetpillai Sivanesan
Mark Cudak	Jun Li	Jung Je Son
Upkar Dhaliwal	Richard Li	Yeongmoon Son
Yoshiharu Doi	Aeri Lim	Ting-Chen (Tom) Song
Lester Eastwood	Geunhwi Lim	Roshni Srinivasan
Carl Eklund	Hyoung Kyu Lim	Kenneth Stanwood
Michael Erlihson	Kwangjae Lim	Aram Sukiasyan
Yu-Chang Eun	Tzu-Ming Lin	Sheng Sun
Shulan Feng	Hang Liu	Yong Sun
Mo-Han Fong	Michael Livschitz	Jaroslav J Sydir
Avraham Freedman	Jianmin Lu	John Sydor
I-Kang Fu	Yanling Lu	Mineo Takai
Pieter-Paul Giesberts	Michael Lynch	Yukihiro Takatani
Rob Glassford	Mohammad Madihian	Jeffrey Tao
Mariana Goldhamer	David Maez	Rakesh Taori
David Grandblaise	Giovanni Maggi	Shawn Taylor
Zion Hadad	Shashikant Maheshwari	Wen Tong
Jung Ho Han	Roger B. Marks	Arnaud Tonnerre
Keisuke Higuchi	Scott Migaldi	Rainer Ullmann
Chang-Lung Hsiao	Shantidev Mohanty	David Urban
Ching-Tarn Hsieh	James Mollenauer	Sunil Vadgama
Yu-Tao Hsieh	Ollivier Mont-Reynaud	Lucia Valbonesi
Hsien-Tsung Hsu	Sungho Moon	Richard van Leeuwen
Yuan-Ying Hsu	Yukimasa Nagai	Dorin Viorel
In Seok Hwang	Kenichi Nakamura	Eugene Visotsky
Bin-Chul Ihm	Michiharu Nakamura	Frederick Vook
Tetsushi Ikegami	Mitsuo Nohara	Arthur Wang
Jaehyuk Jang	John Norin	Guo Qiang Wang

Lei Wang
Michael Wang
Stanley Wang
Yanhong Wang
Alfred Wiczorek
Geng Wu
Xuyong Wu
David Xiang

Chengjie Xie
Hua Xu
Ling Xu
Akiyoshi Yagi
Rongzhen Yang
Xiangying Yang
Yunsong Yang
Vladimir Yanover
Hua-Chiang Yin

Aeran Youn
Sangboh Yun
Masaaki Yuza
Jinyun Zhang
Hua Zhou
Yuefeng Zhou
Chenxi Zhu
Peiying Zhu

The following members of the IEEE 802.16 Working Group on Broadband Wireless Access participated in the Working Group Letter Ballot in which IEEE Std 802.16m-2010 was prepared and finalized for IEEE Ballot:

Rajni Agarwal	Chengyan Feng	Sangheon Kim
Anil Agiwal	Mo-Han Fong	Sungkyung Kim
Sassan Ahmadi	I-Kang Fu	Taeyoung Kim
Hassan Al-Kanani	Jong-Kae (JK) Fwu	Won Ik Kim
Xavier Ambroise	Dan Gal	Takaaki Kishigami
Dov Andelman	Mariana Goldhamer	J. Klutto Milletth
Ramesh Annavajjala	Yanfeng Guan	Ali Koc
Tsuguhide Aoki	Michael Gundlach	Thanasis Korakis
Reza Arefi	Zion Hadad	Gokhan Korkmaz
Youngkyo Baek	GeneBeck Hahn	Kiran Kumar Kuchi
Phillip Barber	Seishi Hanaoka	Ping-Heng Kuo
Harry Bims	Tom Harel	Jin-Sam Kwak
Erez Biton	Shigenori Hayase	Dong Seung Kwon
Adrian Boyer	William Hillery	Young Hoon Kwon
Sean Cai	Nageen Himayat	Jonathan Labs
Jaesun Cha	Chieh Yuan Ho	Byung Moo Lee
Suchang Chae	Chung-Lien Ho	Howon Lee
Sung-Cheol Chang	Ying-Chuan Hsiao	Hyun Lee
YoungBin Chang	Ching-Tarn Hsieh	HyunWoo Lee
Yu-Hao Chang	Yu-Tao Hsieh	Jeong Julie Lee
Naftali Chayat	Chun-Yen Hsu	Jin Lee
Cheng-Ming Chen	Chung-Hsien Hsu	Ju Seung Lee
Chiu-Wen Chen	Jen-Yuan Hsu	Ki-Dong Lee
Mei-Dai Chen	Yi Hsuan	Mi Hyun Lee
Wei-Peng Chen	Cancan Huang	Sukwoo Lee
Whai-En Chen	Din Hwa Huang	Sungjin Lee
Yih-Shen Chen	Lei Huang	Wookbong Lee
Yung-Han Chen	Jie Hui	Yang-Han Lee
Yuqin Chen	Junhong Hui	Youn-Tai Lee
Paul Cheng	Yerang Hur	Yung-Ting Lee
Ray-Guang Cheng	Bin-Chul Ihm	Guangjie Li
Shih-Yuan Cheng	Tetsu Ikeda	Ying Li
Hua (Mary) Chion	Satoshi Imata	Zexian Li
Chun-Yuan Chiu	Yih Guang Jan	Pei-Kai Liao
HanGyu Cho	Jaehyuk Jang	Junsung Lim
Jaehye Cho	Junghoon Jee	Kwangjae Lim
Jaeweon Cho	Baowei Ji	Chih-Yuan Lin
Youngbo Cho	Lei Jin	Hsin-Piao Lin
Hokyu Choi	Sunggeun Jin	Kuhn-Chang Lin
Jinsoo Choi	Kerstin Johnsson	Yi-Ting Lin
Joonyoung Choi	Kaushik Josiam	Hang Liu
Yang-Seok Choi	Rong-Terng Juang	Yang Liu
Chao-Chin Chou	Inuk Jung	Michael Livschitz
Chie Ming Chou	Soojung Jung	Kanchei Loa
Ching-Chun Chou	Heewon Kang	Jianmin Lu
Joey Chou	Hyunjeong Kang	Kaiying Lv
Jerry Chow	Minsuk Kang	Mohammad Madihian
Ming-Hsueh Chuang	Seunghyun Kang	Andreas Maeder
Jin Young Chun	Hajime Kanzaki	Alexander Maltsev
Russell Chung	Chien-Yu Kao	Ronald Mao
Bruno Clerckx	Tsuguo Kato	Roger B. Marks
Steven Crowley	Mohammad Khojastepour	Gerard Marque-Pucheu
Mark Cudak	Alexey Khoryaev	Arif Maskatia
Alexey Davydov	Brian Kiernan	Wataru Matsumoto
Kamran Etemad	Eunkyung Kim	David Mazzarese
Yu-Chang Eun	Jeong Gon Kim	Sean McBeath
Linghang Fan	Jihyung Kim	Djamal-Eddine Meddour
Huiying Fang	Juhee Kim	Scott Migaldi
Yu-Chuan Fang	Namgi Kim	Shantidev Mohanty
Peretz Feder	Ronny (Yong-Ho) Kim	Andreas Molisch

Sungho Moon
Ronald Murias
Keiichi Nakatsugawa
Huaning Niu
Mitsuo Nohara
Min-Seok Oh
Masato Okuda
Kim Olszewski
Ryoji Ono
Philip Orlik
Apostolos Papathanassiou
Giwon Park
Hyungho Park
Jeongho Park
Jisoo Park
Sung-Eun Park
Zhouyue Pi
Kevin Power
Scott Probasco
Jose Puthenkulam
Hongyun Qu
Sudhir Ramakrishna
Rong Ran
Ranga Reddy
Fang-Ching Ren
Maximilian Riegel
Kwanhee Roh
Wonil Roh
Zhigang Rong
Herbert M. Ruck
Kiseon Ryu
Yousuf Saifullah
Luciano Sarperi
Shahab Sayeedi
Joerg Schaepperle
Joseph Schumacher
Ji-Yun Seol
Ahmed Shalash
Peretz Shekalim
Jaejeong (Brian) Shim

Wooram Shin
Takashi Shono
Sten Sjoberg
Tricci So
Jung Je Son
Yeongmoon Son
Ting-Chen (Tom) Song
Young Seog Song
Roshni Srinivasan
Kenneth Stanwood
Bo Sun
Hongmei Sun
Li-Hsiang Sun
Yong Sun
Doo-hyun Sung
Jaroslaw J Sydir
Anup Talukdar
Yang Tang
Jeffrey Tao
Ming-Hung Tao
Rakesh Taori
Shawn Taylor
Yongjoo Tcha
Arnaud Tonnerre
Chang-Lan Tsai
Jiann-An Tsai
Tsung-Yu Tsai
Yi-Hsueh Tsai
Fan Shuo Tseng
Hsien-Wei Tseng
Stavros Tzavidas
Sunil Vadgama
Rath Vannithamby
Muthaiah Venkatachalam
Frederick Vook
Kenneth Walker
Arthur Wang
Chun-Yen Wang
Hai Wang
Jiacheng Wang
Lei Wang

Li Wang
Ping Wang
Yanhong Wang
Fujio Watanabe
Yoshikazu Watanabe
Hung-Yu Wei
Ciouping Wu
Jia-Hao Wu
Qi Wu
Changlong Xu
Hua Xu
Jin Xu
Ling Xu
Hassan Yaghoobi
Chang Feng Yang
Chih-Cheng Yang
Feng-Ming Yang
Rongzhen Yang
Xiangying Yang
Yunsong Yang
Vladimir Yanover
Hua-Chiang Yin
Hujun Yin
Hwasun Yoo
Isamu Yoshii
Hyunkyu Yu
Young Soo Yuk
Jungnam Yun
Nader Zein
Eldad Zeira
Jie Zhang
Zheng Zhao
Xufeng Zheng
Yan-Xiu Zheng
Hua Zhou
Lei Zhou
Chenxi Zhu
Jing Zhu
Peiying Zhu
Yuan Zhu

The following members of the IEEE 802.16 Working Group on Broadband Wireless Access participated in the Working Group Letter Ballot in which the draft of IEEE Std 802.16-2012 was prepared and finalized for IEEE Ballot:

Anil Agiwal	Brian Kiernan	Fei Qin
Hanan Ahmed	Eunkyung Kim	Sudhir Ramakrishna
Hassan Al-Kanani	Hokyung Kim	Wonil Roh
Youngkyo Baek	Jeongki Kim	Kiseon Ryu
Phillip Barber	Namgi Kim	Sam Sambasivan
Inbar Bratspiess	Ronny (Yong-Ho) Kim	Ji-Yun Seol
Jaesun Cha	Sangheon Kim	Peretz Shekalim
Sungcheol Chang	Seokki Kim	Matthew Sherman
YoungBin Chang	Taeyoung Kim	Takashi Shono
Chiu-Wen Chen	Jin Sam Kwak	Jung Je Son
HanGyu Cho	Eunjong Lee	Yeongmoon Son
Hee Jeong Cho	Hyun Lee	Mineo Takai
Jaeweon Cho	Jin Lee	Ming-Hung Tao
Youngbo Cho	Yang-Han Lee	Joseph Teo
Jinsoo Choi	Honggang Li	Alessandro Triglia
Ching-Chun Chou	Ying Li	Tsung-Yu Tsai
Jin Young Chun	Chiwoo Lim	Hsien-Wei Tseng
Yu-Chuan Fang	Yi-Ting Lin	Arthur Wang
Dan Gal	Lu Liru	Hai Wang
Tim Godfrey	Andreas Maeder	Haiguang Wang
Anh Tuan Hoang	Ronald Mao	Lei Wang
Vinh-Dien Hoang	Shantidev Mohanty	Limei Wang
Ying-Chuan Hsiao	Ronald Murias	Hung-Yu Wei
Chun-Yen Hsu	Anshuman Nigam	Xiangying Yang
Satoshi Imata	Mitsuo Nohara	Wai Leong Yeow
Yih Guang Jan	Masayuki Oodo	Hyunkyu Yu
Kaushik Josiam	Giwon Park	Nader Zein
Inuk Jung	Jeongho Park	Eldad Zeira
Soojung Jung	Jisoo Park	Xin Zhang
Heewon Kang	Jaya Shankar Pathmasuntharam	Lei Zhou
Hyunjeong Kang	Jose Puthenkulam	Mingtuo Zhou

The following members of the IEEE 802.16 Working Group on Broadband Wireless Access participated in the Working Group Letter Ballot in which IEEE Std 802.16p-2012 was prepared and finalized for IEEE Ballot:

Anil Agiwal	Hyunjeong Kang	Fei Qin
Hanan Ahmed	Brian Kiernan	Sudhir Ramakrishna
Hassan Al-Kanani	Eunkyung Kim	Wonil Roh
Youngkyo Baek	Hokyung Kim	Kiseon Ryu
Phillip Barber	Jeongki Kim	Sam Sambasivan
Harry Bims	Namgi Kim	Ji-Yun Seol
Inbar Bratspiess	Ronny (Yong-Ho) Kim	Peretz Shekalim
Jaesun Cha	Sangheon Kim	Matthew Sherman
Sungcheol Chang	Seokki Kim	Takashi Shono
YoungBin Chang	Taeyoung Kim	Jung Je Son
Chiu-Wen Chen	Jin Sam Kwak	Yeongmoon Son Son
HanGyu Cho	Eunjong Lee	Mineo Takai
Hee Jeong Cho	Hyun Lee	Ming-Hung Tao
Jaeweon Cho	Jin Lee	Rakesh Taori
Youngbo Cho	Honggang Li	Joseph Teo
Jinsoo Choi	Ying Li	Alessandro Triglia
Ching-Chun Chou	Chiwoo Lim	Tsung-Yu Tsai
Jin Young Chun	Yi-Ting Lin	Arthur Wang
Erik Colban	Lu Liru	Hai Wang
Yu-Chuan Fang	Andreas Maeder	Haiguang Wang
Dan Gal	Ronald Mao	Lei Wang
Tim Godfrey	Roger Marks	Limei Wang
Anh Tuan Hoang	Shantidev Mohanty	Hung-Yu Wei
Vinh-Dien Hoang	Ron Murias	Wai Leong Yeow
Ying-Chuan Hsiao	Anshuman Nigam	Hyunkyu Yu
Chun-Yen Hsu	Mitsuo Nohara	Nader Zein
Satoshi Imata	Masayuki Oodo	Eldad Zeira
Kaushik Josiam	Giwon Park	Xin Zhang
Inuk Jung	Jeongho Park	Yan-Xiu Zheng
Soojung Jung	Jisoo Park	Lei Zhou
Heewon Kang	Jaya Shankar Pathmasuntharam	Mingtuo Zhou
	Jose Puthenkulam	

The following members of the IEEE 802.16 Working Group on Broadband Wireless Access participated in the Working Group Letter Ballot in which IEEE Std 802.16n-2013 was prepared and finalized for IEEE Ballot:

Hassan Al-Kanani	Hyunjeong Kang	Takashi Shono
Phillip Barber	Brian Kiernan	Rakesh Taori
Harry Bims	Eunkyung Kim	Joseph Teo
Inbar Bratspiess	Seokki Kim	Alessandro Triglia
Jaesun Cha	Anseok Lee	Arthur Wang
Sung-Cheol Chang	Hyun Lee	Hanguang Wang
Erik Colban	Honggang Li	Lei Wang
Yu-Chuan Fang	Lu Liru	Hung-Yu Wei
Dan Gal	Andreas Maeder	Wai Leong Yeow
Tim Godfrey	Roger B. Marks	Nader Zein
Anh Tuan Hoang	Shantidev Mohanty	Eldad Zeira
Vinh Dien Hoang	Ron Murias	Xin Zhang
Ying-Chuan Hsiao	Masayuki Oodo	Shoukang Zheng
Chun-Yen Hsu	Jisoo Park	Yan-Xiu Zheng
Satoshi Imata	Jaya Shankar Pathmasuntharam	Lei Zhou
Soojung Jung	Fei Qin	Ming-Tuo Zhou
	Sam Sambasivan	

The following members of the IEEE 802.16 Working Group on Broadband Wireless Access participated in the Working Group Letter Ballot in which IEEE Std 802.16q-2015 was prepared and finalized for IEEE Ballot:

Antonio Bovo	Tim Godfrey	Eunkyung Kim
Jaesun Cha		Jisoo Park

The following members of the IEEE 802.16 Working Group on Broadband Wireless Access participated in the Working Group Letter Ballot in which IEEE Std 802.16s-2017 was prepared and finalized for IEEE Ballot:

Robert Finch	Doug Gray	Menashe Shahar
Tim Godfrey	Walter Pienciak	Guy Simpson

Introduction

This introduction is not part of IEEE Std 802.16t-2022, IEEE Standard for Air Interface for Broadband Wireless Access Systems.

This standard specifies the air interface, including the medium access control layer (MAC) and physical layer (PHY), of combined fixed and mobile point-to-multipoint broadband wireless access (BWA) systems providing multiple services. The MAC is structured to support the WirelessMAN-SC, WirelessMAN-OFDM, and WirelessMAN-OFDMA PHY specifications, each suited to a particular operational environment. The standard enables rapid worldwide deployment of innovative, cost-effective, and interoperable multi-vendor broadband wireless access products, facilitates competition in broadband access by providing alternatives to wireline broadband access, encourages consistent worldwide spectrum allocation, and accelerates the commercialization of broadband wireless access systems.

This standard is a revision of IEEE Std 802.16-2017.

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IEEE Standard for Air Interface for Broadband Wireless Access Systems

1. Overview

1.1 Scope

This standard specifies the air interface, including the medium access control layer (MAC) and physical layer (PHY), of combined fixed and mobile point-to-multipoint broadband wireless access (BWA) systems providing multiple services. The MAC is structured to support multiple PHY specifications, including WirelessMAN-SC, WirelessMAN-OFDM, and WirelessMAN-OFDMA PHY specifications, each suited to a particular operational environment.

This project specifies operation in licensed spectrum with channel bandwidths greater than or equal to 5 kHz and less than 100 kHz. The project specifies a new PHY, and changes to the MAC as necessary to support the PHY. The amendment is frequency independent but focuses on spectrum less than 2 GHz. The range and data rate supported by the narrower channels are commensurate with those of the base standard, as scaled by the reduced channel bandwidth. The project also amends IEEE Std 802.16 as required to support aggregated operation in adjacent and non-adjacent channels.

This document describes the technical approach for IEEE 802.16 operation in channels less than 100 kHz bandwidth.

1.2 Purpose

This standard enables rapid worldwide deployment of innovative, cost-effective, and interoperable multivendor broadband wireless access products, facilitates competition in broadband access by providing alternatives to wireline broadband access, encourages consistent worldwide spectrum allocation, and accelerates the commercialization of broadband wireless access systems.

1.3 Variants and frequency bands

Several conforming variants of this standard are specified. The appropriate variant depends on the radio frequency band in which it operates. The primary bands of interest are described in 1.3.1 through 1.3.6. The variants are listed in 1.3.7.

1.3.1 160 MHz licensed bands

Frequencies below 11 GHz provide a physical environment where, due to the longer wavelength, LOS is not necessary and multipath may be significant. The ability to support near-LOS and non-LOS (NLOS) scenarios requires additional PHY functionality, such as the support of advanced power management techniques, interference mitigation/coexistence, and multiple antennas.

1.3.2 450 MHz licensed bands

Frequencies below 11 GHz provide a physical environment where, due to the longer wavelength, LOS is not necessary and multipath may be significant. The ability to support near-LOS and non-LOS (NLOS) scenarios requires additional PHY functionality, such as the support of advanced power management techniques, interference mitigation/coexistence, and multiple antennas.

1.3.3 700 MHz licensed bands

Frequencies below 11 GHz provide a physical environment where, due to the longer wavelength, LOS is not necessary and multipath may be significant. The ability to support near-LOS and non-LOS (NLOS) scenarios requires additional PHY functionality, such as the support of advanced power management techniques, interference mitigation/coexistence, and multiple antennas.

1.3.4 900 MHz licensed bands

Frequencies below 11 GHz provide a physical environment where, due to the longer wavelength, LOS is not necessary and multipath may be significant. The ability to support near-LOS and non-LOS (NLOS) scenarios requires additional PHY functionality, such as the support of advanced power management techniques, interference mitigation/coexistence, and multiple antennas.

1.3.5 VHF/UHF licensed bands

Frequencies below 11 GHz provide a physical environment where, due to the longer wavelength, LOS is not necessary and multipath may be significant. The ability to support near-LOS and non-LOS (NLOS) scenarios requires additional PHY functionality, such as the support of advanced power management techniques, interference mitigation/coexistence, and multiple antennas.

1.3.6 ??? MHz licensed bands

Frequencies below 11 GHz provide a physical environment where, due to the longer wavelength, LOS is not necessary and multipath may be significant. The ability to support near-LOS and non-LOS (NLOS) scenarios requires additional PHY functionality, such as the support of advanced power management techniques, interference mitigation/coexistence, and multiple antennas.

1.3.7 Air interface nomenclature and compliance

Table 1-1 summarizes the nomenclature for the various air interface variants in this standard.

Table 1-1—Air interface variant nomenclature and compliance

Designation	Applicability	PHY specification	System features	Duplexing alternative
WirelessMAN-SC Release 1.0	10–66 GHz	8.1	12.1	TDD FDD
Fixed WirelessMAN-OFDM™	Below 11 GHz licensed bands	8.3	12.3	TDD FDD
Fixed WirelessMAN-OFDMA	Below 11 GHz licensed bands	8.4	12.4	TDD FDD
WirelessMAN-OFDMA TDD Release 1.0	Licensed bands below 11 GHz	8.4	12.5	TDD
WirelessMAN-OFDMA TDD Release 1.5	Licensed bands below 11 GHz	8.4	12.6	TDD
WirelessMAN-OFDMA FDD Release 1.5	Licensed bands below 11 GHz	8.4	12.7	FDD
WirelessMAN-OFDMA MR	Licensed bands below 11 GHz	8.4	—	TDD

All implementations of this standard shall comply with the requirements of Clause 5 and Clause 7.

Implementations of this standard for licensed frequencies below 11 GHz (such as those listed in B.1) shall comply with the WirelessMAN-OFDM PHY as described in 8.3, the WirelessMAN-OFDMA PHY as described in 8.4, or the WirelessMAN-SC PHY as described in 8.1 for licensed frequencies above 10 GHz.

1.4 Reference models

Figure 1-1 illustrates the reference model and scope of this standard.

The MAC comprises three sublayers. The service-specific convergence sublayer (CS) provides any transformation or mapping of external network data, received through the CS service access point (SAP), into MAC service data units (SDUs) received by the MAC common part sublayer (CPS) through the MAC SAP. This includes classifying external network SDUs and associating them to the proper MAC service flow identifier (SFID) and connection identifier (CID). It may also include such functions as payload header suppression (PHS). Multiple CS specifications are provided for interfacing with various protocols. The

internal format of the CS payload is unique to the CS, and the MAC CPS is not required to understand the format of or parse any information from the CS payload.

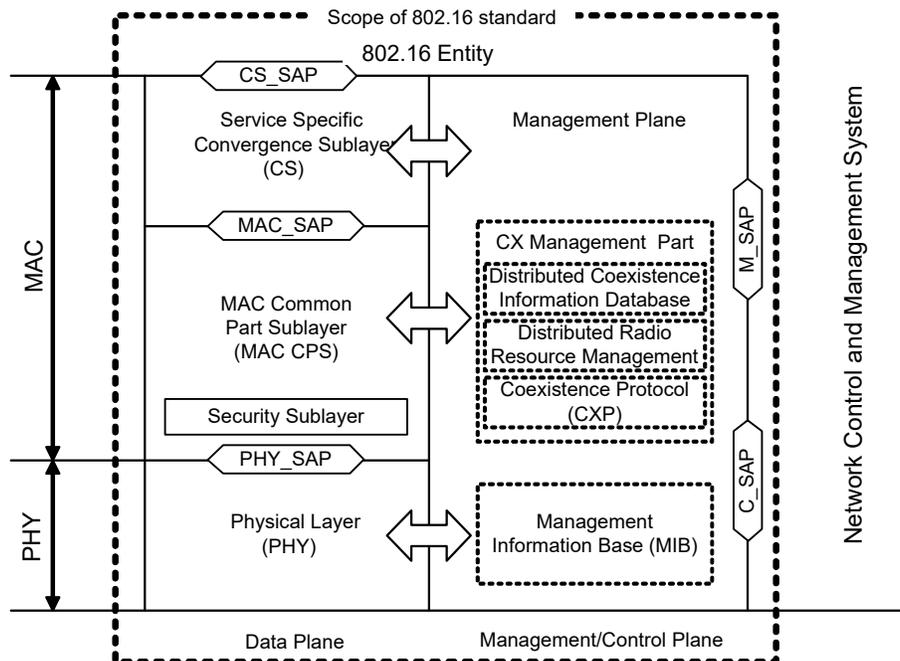


Figure 1-1—IEEE 802.16 protocol layering, showing SAPs

The MAC CPS provides the core MAC functionality of system access, bandwidth allocation, connection establishment, and connection maintenance. It receives data from the various CSs, through the MAC SAP, classified to particular MAC connections. An example of MAC CPS service definition is given in Annex C. Quality of service (QoS) is applied to the transmission and scheduling of data over the PHY.

The MAC also contains a separate security sublayer providing authentication, secure key exchange, and encryption.

Data, PHY control, and statistics are transferred between the MAC CPS and the PHY via the PHY SAP (which is implementation specific).

The PHY definition includes multiple specifications, each appropriate to a particular frequency range and application. The various PHY specifications supported are discussed in Clause 8. The Management/Control Plane may also include the “CX Management part” of WirelessMAN-CX composed of the “Distributed Coexistence Information Database,” “Distributed Radio Resource Management,” and “Coexistence Protocol (CXP).” All these parts are supported at the MAC level.

The IEEE 802.16 devices can include Subscriber Stations (SS) or Mobile Stations (MS), or Base Stations (BS). As the IEEE 802.16 devices may be part of a larger network and therefore would require interfacing with entities for management and control purposes, a Network Control and Management System (NCMS) abstraction has been introduced in this standard as a “black box” containing these entities. The NCMS abstraction allows the PHY/MAC layers specified in IEEE Std 802.16 to be independent of the network architecture, the transport network, and the protocols used at the backend and therefore allows greater flexibility. NCMS logically exists at BS side and SS/MS side of the radio interface, termed NCMS(BS) and NCMS(SS/MS), respectively. Any necessary inter-BS coordination is handled through the NCMS(BS).

This specification includes a Control SAP (C-SAP) and Management SAP (M-SAP) that expose control plane and management plane functions to upper layers. The C_SAP and M-SAP interfaces are described in Clause 7 The NCMS uses the C-SAP and M-SAP to interface with the IEEE 802.16 entity. In order to provide correct MAC operation, NCMS shall be present within each SS/MS. The NCMS is a layer independent entity that may be viewed as a management entity or control entity. General system management entities can perform functions through NCMS and standard management protocols can be implemented in the NCMS.

1.4.1 Management reference model

Figure 1-2 shows a management reference model of BWA networks. It consists of a network management system (NMS), managed nodes, and a Network Control System. Managed nodes, such as BS, MS and SS, collect and store the managed objects in the format of WirelessMAN Interface MIB (e.g., wmanIfMib) and Device MIB (e.g., wmanDevMib) that are made available to NMSs via management protocols, such as Simple Network Management Protocol (SNMP). A Network Control System contains the service flow and the associated QoS information that have to be populated to BS when a SS or MS enters into a BS network.

The management information between SS/MS and BS will be carried over the secondary management connection for managed SS or MS. If the secondary management connection does not exist, the SNMP messages, or other management protocol messages, may go through another interface in the customer premise or on a transport connection over the air interface..

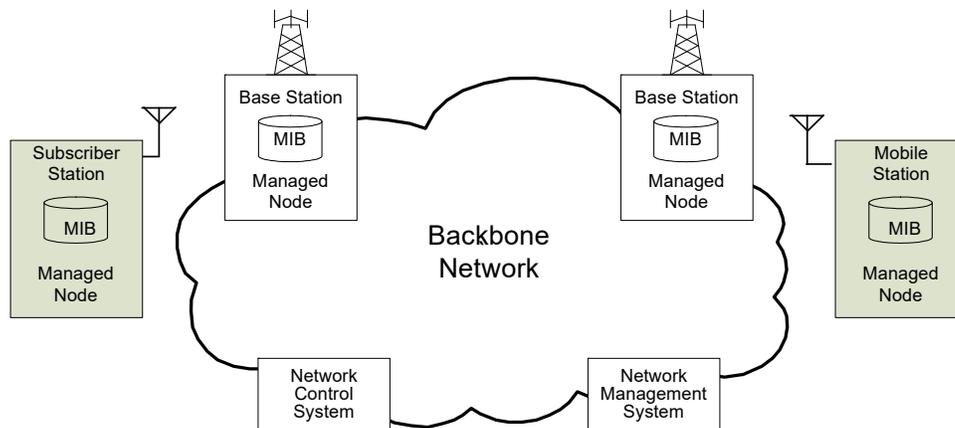


Figure 1-2—BWA WirelessMAN network management reference model

1.4.2 Handover (HO) process

The HO process in which an MS migrates from the air-interface provided by one BS to the air-interface provided by another BS is defined in 6.3.20.2.

1.4.3 IEEE 802.16 entity

An IEEE 802.16 entity is defined as the logical entity in an SS/MS or BS that comprises the PHY and MAC layers of the Data Plane and the Management/Control Plane.

1.6 Multihop relay

Multihop relay (MR) is an optional deployment that may be used to provide additional coverage or performance advantage in an access network. In MR networks, the BS may be replaced by a multihop relay BS (MR-BS) and one or more relay stations (RS).

Traffic and signaling between the SS and MR-BS are relayed by the RS thereby extending the coverage and performance of the system in areas where RSs are deployed. Each RS is under the supervision of an MR-BS. In a more than two hop system, traffic and signaling between an access RS and MR-BS may also be relayed through intermediate RSs. The RS may be fixed in location (i.e., attached to a building) or, in the case of an access RS, it may be mobile (i.e., traveling with a transportation vehicle). The SS may also communicate directly with the MR-BS.

The various MR features defined throughout this standard permit a multihop relay system to be configured in several modes.

The protocols (including the mobility features) on the access link remain unchanged. New functionality has been specified on the relay link to support the MR features.

Two different modes (centralized and distributed scheduling) are specified for controlling the allocation of bandwidths for an SS or an RS. In centralized scheduling mode, the bandwidth allocation for an RS's subordinate stations is determined at the MR-BS; conversely in distributed scheduling mode, the bandwidth allocation of an RS's subordinate stations is determined by the RS, in cooperation with the MR-BS.

Two different types of RS are defined, namely transparent and non-transparent. A non-transparent RS can operate in both centralized and distributed scheduling mode, while a transparent RS can only operate in centralized scheduling mode.

A transparent RS communicates with the superordinate station and subordinate station(s) using the same carrier frequency. A non-transparent RS may communicate with the superordinate station and subordinate station(s) using the same or different carrier frequencies.

The MAC layer includes extensions to signaling to support functions such as network entry (of an RS, and of an SS through an RS), bandwidth request, forwarding of PDUs, connection management, and handover.

Two different security modes are defined (see Clause 7). The first one, referred to as the centralized security mode, is based on key management between an MR-BS and an SS. The second security mode, referred to as the distributed security mode, incorporates authentication and key management between an MR-BS and a non-transparent access RS and between the access-RS and an SS.

An RS may be configured to operate either in normal CID allocation mode, where primary management, secondary, and basic CIDs are allocated by the MR-BS or in local CID allocation mode where the primary management and basic CID are allocated by the RS. The network management of RS shall use secondary management connection and shall follow the management reference model as defined in 1.4.1.

The PHY includes extensions to the OFDMA-PHY layer (see 8.4) for transmission of PHY PDUs across the relay link between the MR-BS and the RS.

1.7 Support for machine-to-machine (M2M) communications

The M2M communication is referred to as the information exchange between devices through a base station, or between a device and a server in the core network through a base station that may be carried out without any human interaction.

M2M communications is a very distinct capability that enables the implementation of the “Internet of things.”

Some of the typical use cases that the M2M communication enables are secured access and surveillance, tracking and tracing, public safety, payment, healthcare, remote maintenance and control, metering, consumer devices, and retailing.

In order to enable a range of machine-to-machine applications in which the device communications require wide area wireless coverage in licensed bands, and are automated rather than human-initiated or human-controlled for purposes such as observation and control, some MAC protocols and PHY specifications have been changed for enhancement. MAC enhancements and minimal PHY modifications include support of lower power consumption at the device, support by the base station of significantly larger numbers of devices, efficient support of small burst transmission, and improved device authentication.

1.8 Support for high reliability networks

A high reliability (HR) network implements features that enable increased robustness and alternate radio path establishment in a degraded network, in the case of failure of one or more infrastructure nodes or network connectivity.

In order to support high reliability in WirelessMAN-OFDMA, multi-mode operation of base station as a relay and mobile station as a relay, direct communication between MSs, forwarding of MS traffic to the network and another MS by other MS, standalone network, local forwarding bypassing backhaul links, path management against single point of failures by providing alternative radio and backhaul paths, and enhanced multicast-based service among a group of mobile stations are supported.

Those distinct functionalities in HR Networks support the mission critical application, including Public Safety, Avionics, Airport Surface, and Smart Grid.

1.9 Support for multi-tier networks

Multi-tier networks utilize base stations of a variety of power level tiers, each of which represents a different range of operating power levels, in order to improve network capacity and efficiently manage radio resources, in comparison to networks using only base stations of a uniform power level tier. In such multi-tier networks, coordination techniques among base stations across multiple tiers and among base stations in the same tier are important to achieve system capacity enhancements. Interference mitigation techniques across tiers is also critical to achieving user throughput enhancements.

Multi-tier network operation is specified in this standard to support efficient cooperation among base stations in multi-tier networks in order to enhance interference mitigation, mobility management, and base station power management. Associated management protocol among base stations and between base stations and mobile stations enables efficient cooperation and coordination. Multi-tier network operation is supported by a specific set of MAC management messages, without physical layer customization of mobile stations. This standard addresses two tiers of network, with higher-power base stations (BSs) that are capable of signaling to lower-power stations, known as small base stations (SBSs).

2. Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ATM Forum Specification af-uni-0010.002, ATM User-Network Interface Specification, Version 3.1, Sept. 1994.¹

ATM Forum Specification af-sig-0061.000, ATM User-Network Interface (UNI) Signalling Specification, Version 4.0, July 1996.

ETSI EN 301 213-3, Fixed Radio Systems; Point-to-multipoint equipment; Point-to-multipoint digital radio systems in frequency bands in the range 24,25 GHz to 29,5 GHz using different access methods; Part 3: Time Division Multiple Access (TDMA) methods, Version 1.3.1, Sept. 2001.²

FIPS 46-3, Data Encryption Standard (DES), Oct. 1999.³ This reference is withdrawn.

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FIPS 186-2, Digital Signature Standard (DSS), Jan. 2000. This reference is withdrawn.

FIPS 197, Advanced Encryption Standard (AES).

IEEE Std 802[®], IEEE Standards for Local and Metropolitan Area Networks: Overview and Architecture.^{4, 5}

IEEE Std 802.1D™, IEEE Standard for Local and metropolitan Area Networks: Media Access Control (MAC) Bridges.⁶

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IEEE Std 802.3™, IEEE Standard for Ethernet.

IEEE Std 802.16.1™-2012, IEEE Standard for WirelessMAN-Advanced Air Interface for Broadband Wireless Access Systems.

IEEE Std 802.16.2™, IEEE Recommended Practice for Local and metropolitan area networks—Coexistence of Fixed Broadband Wireless Access Systems.

¹ATM Forum publications are available from the ATM Forum (<http://www.atmforum.com/>).

²ETSI publications are available from the European Telecommunications Standards Institute (<http://www.etsi.org/>).

³FIPS publications are available from the National Technical Information Service (NTIS) (<http://www.ntis.gov/>).

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3. Definitions

Insert the following definitions in alphabetical order:

AAI-only ABS: A base station that supports the WirelessMAN-Advanced Air Interface specified by IEEE Std 802.16.1-2012, but does not support the OFDMA air interface specified in IEEE Std 802.16.

acceptable interference: An interference caused by an interference signal that does not degrade the current selection of modulation and coding at a receiver.

acceptable interference threshold: A value (in dBm) of a signal level, below which an interference signal causes acceptable interference.

access link: A radio link between an MR-BS or RS and an MS, or between an MR-BS or RS and a subordinate RS during network entry.

access RS: A relay station that serves as an access station.

access station: A station that provides a point of access into the network for an MS or RS. An access station can be a base station (BS), relay station (RS), or multihop relay BS (MR-BS).

active base station: A BS that is informed of the mobile station (MS) capabilities, security parameters, service flows, and full medium access control layer (MAC) context information.

adaptive antenna system (AAS): An array of antennas and associated signal processing that together is able to change its antenna radiation pattern dynamically to adjust to noise environment, interference and multipath.

adaptive modulation: A system's ability to communicate with another system using multiple burst profiles and a system's ability to subsequently communicate with multiple systems using different burst profiles.

adjacent subcarrier allocation: A variation of PUSC permutation wherein the subcarriers are located adjacent to each other.

adjacent subcarrier permutation: A permutation scheme in which symbol data within a subchannel is assigned to adjacent subcarriers and wherein the pilot and data subcarriers are assigned fixed positions in the frequency domain within an OFDMA symbol.

affected HR-BS: An HR-BS that is experiencing a failure of its backhaul connection to the backbone network. *See also:* **high reliability base station (HR-BS).**

alternative channel (ALTCH): A physical (frequency) channel determined by the base station as being a suitable alternative physical channel for use if its current physical channel becomes unavailable.

alternative subframe (ALTSF): A subframe that can be used by the base station of a system because it is unoccupied.

anchor base station: A base station, used with macro diversity handover or fast base station switching, supporting mobile station registration, synchronization, ranging, and downlink monitoring.

Authenticator: Entity in the network control and management system (NCMS) incorporating AAA client functionality and facilitating authentication of a supplicant.

automatic repeat request (ARQ) block: A distinct unit of data that is carried on an ARQ-enabled connection.

backbone network: A communication mechanism by which two or more base stations (BSs) communicate to each other. It may also include communication with other networks. The method of communication for backbone networks is outside the scope of IEEE Std 802.16.

band AMC: A permutation scheme in which the entire channel is split into groups of contiguous subcarriers.

bandwidth stealing: The use, by a subscriber station (SS), of a portion of the bandwidth allocated in response to a bandwidth request (BR) for a connection to send a BR or data for any of its connections.

NOTE—See also 6.3.6.¹²

base station (BS): A generalized equipment set providing connectivity, management, and control of the subscriber station (SS). *See also:* **active base station (BS)**, **anchor base station (BS)**, **neighbor base station (BS)**, **serving base station (BS)**, **target base station (BS)**.

base station (BS) receive/transmit transition gap (RTG): A gap between the last sample of the uplink (UL) burst and the first sample of the subsequent downlink (DL) burst at the antenna port of the BS in a time division duplex (TDD) transceiver. This gap allows time for the BS to switch from receive (Rx) to transmit (Tx) mode. During this gap, the BS is not transmitting modulated data but simply allowing the BS transmitter carrier to ramp up and the Tx/Rx antenna switch to actuate. Not applicable for frequency division duplex (FDD) systems.

base station (BS) transmit/receive transition gap (TTG): A gap between the last sample of the downlink (DL) burst and the first sample of the subsequent uplink (UL) burst at the antenna port of the BS in a time division duplex (TDD) transceiver. This gap allows time for the BS to switch from transmit (Tx) to receive (Rx) mode. During this gap, the BS is not transmitting modulated data but simply allowing the BS transmitter carrier to ramp down, the Tx/Rx antenna switch to actuate, and the BS receiver section to activate. Not applicable for frequency division duplex (FDD) systems.

basic connection: Connection that is established during subscriber station (SS) initial ranging and used to transport delay-intolerant medium access control layer (MAC) management messages.

broadband: Having instantaneous bandwidths greater than around 1 MHz and supporting data rates greater than about 1.5 Mb/s.

broadband wireless access (BWA): Wireless access in which the connection(s) capabilities are broadband.

broadcast connection: The management connection used by the base station (BS) to send medium access control layer (MAC) management messages on a downlink (DL) to all subscriber stations (SSs). The broadcast connection is identified by a well-known connection identifier (CID). A fragmentable broadcast connection is a connection that allows fragmentation of broadcast MAC management messages.

NOTE—See Table 10-5.

BS power controller: BS power controller is a network element that performs BS power management services in the network control and management system (NCMS).

¹²Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement this standard.

burst profile: Set of parameters that describe the uplink (UL) or downlink (DL) transmission properties associated with an interval usage code. Each profile contains parameters such as modulation type, forward error correction (FEC) type, preamble length, guard times, etc. *See also:* **interval usage code**.

bursty system: A system that comprises non-SSU units and transmits data in short uneven intervals.

candidate channel: A frequency channel within the frequency band that may be used by a system.

centralized scheduling: A mode of operation applicable to multihop relay where a multihop relay BS (MR-BS) determines the bandwidth allocations and generates the corresponding MAPs [or dictates the information used by relay stations (RSs) to generate their MAPs] for all access and relay links in the MR-cell.

channel identifier (ChID): An identifier used to distinguish between multiple uplink (UL) channels, all of which are associated with the same downlink (DL) channel.

coexistence: A state of acceptable co-channel and/or adjacent channel operation of two or more radio systems (possibly using different wireless access technologies) within the same geographical area.

coexistence community: A coexistence community is composed of those systems that have resolved their interference and coexist within it.

Coexistence Control Channel (CXCC): A logical channel composed of a periodic sequence of time slots, which may be used for sensing, synchronization, cumulated interference measurement and broadcast of the coordinated coexistence related information. CXCC is used for WirelessMAN-CX and may be used for WirelessMAN-UCP.

Coexistence frame (CX-Frame): A pre-defined sequence of IEEE 802.16 DL and UL subframes that, in conjunction with associated operational rules, is used for facilitating coexistence between systems.

Coexistence Messaging Interval (CMI): A unique repetitive sequence of intervals defined in CXCC and claimed by a system. It is used for broadcasting system's main radio parameters to other systems in its Coexistence Community using always the same predefined PHY parameters.

coexistence messaging mechanism: The messaging mechanism defined in WirelessMAN-CX to exchange information specifically between wireless systems with the same PHY profiles.

Coexistence Protocol (CXP): An intersystem protocol for improving coexistence through the exchange of information, using communication over-the-air or back-haul. Messages for intersystem communication over-the-air and primitives for communication over the backhaul are provided.

coexistence signaling: The signaling mechanism defined in WirelessMAN-CX to exchange information between wireless systems with or without the same PHY profiles.

Coexistence Signaling Interval (CSI): A predefined time slot not associated with the CXCC, used for coexistence signaling purposes between systems that may have different PHYs. This technique uses power keyed energy symbols and RSSI detection, by a BS to contact its coexistence neighbor BS through one or more coexistence neighbor SSs in the common coverage area.

Coexistence Signaling Interval Number (CSIN): The allocation of CSI according to the time order within CX-Frame. The range of CSIN is from 0 to 3 while 0-3 is referring to OCSI1/OCSI2/OCSI3/ICSI, respectively.

cognitive radio (CR): A system that is aware of its operational environment and internal state, and has the capability to make decisions about its radio operating behavior. An active cognitive radio can share information regarding its spectral/temporal/spatial characteristics with other similar systems and/or dynamically and autonomously adjust its radio operating parameters depending on the results of its actions and environmental usage patterns. This definition reflects the CR functionality in IEEE Std 802.16.

Common subframe: That part at the beginning of the MAC Frame within the CX-Frame where all the systems of a coexistence neighborhood may operate in parallel. The operation of non-Master systems during these subframes may require limitations on the transmit power.

community: A group of systems that coordinate to resolve their interference.

concatenation: The act of combining multiple medium access control layer (MAC) protocol data units (PDUs) into a single physical layer (PHY) service data unit (SDU).

connection: A unidirectional mapping between base station (BS) and subscriber station (SS) medium access control layer (MAC) peers. Connections are identified by a connection identifier (CID). The MAC defines two kinds of connections: management connections and transport connections. *See also:* **connection identifier (CID)**.

connection identifier (CID): A 16-bit value that identifies a transport connection or an uplink (UL)/downlink (DL) pair of associated management connections [i.e., belonging to the same subscriber station (SS)] to equivalent peers in the medium access control layer (MAC) of the base station (BS) and SS. The CID address space is common (i.e., shared) between UL and DL and partitioned among the different types of connections. Security associations (SAs) also exist between keying material and CIDs. *See also:* **connection**.

NOTE—Table 10-5 specifies how the CID address space is partitioned among the different types of connections.

Coordinated Coexistence Mechanism: A coexistence mechanism relying on rules of behavior based on a common Coexistence Frame (CX-Frame) and a Coexistence Control Channel (CXCC).

Credit Token-Based Coexistence Protocol (CT-CXP): Over-the-air or backhaul-based mechanisms enabling dynamic subframe sharing between systems.

DC subcarrier: In an orthogonal frequency division multiplexing (OFDM) or orthogonal frequency division multiple access (OFDMA) signal, the subcarrier whose frequency would be equal to the radio frequency (RF) center frequency of the station.

destination base station (BS): The BS that responds to an intersystem communication request.

destructive interference: Interference that disables a particular PHY receiver from receiving using any combination of its modulation and coding methods.

detection threshold: A value (in dBm) of a signal level, used for the purpose of initiating an action.

distributed scheduling: A mode of operation applicable to multihop relay where the MR-BS and each RS in the MR-cell (with or without information from the MR-BS) determine the bandwidth allocations and generate the corresponding MAPs for the access link to/from their subordinate SSs and/or relay links to/from their subordinate RSs.

diversity set: A list of active base stations (BSs) to the mobile station (MS). The diversity set is managed by the MS and BSs and is applicable to macro diversity handover (MDHO) and fast BS switching (FBSS).

DL access zone: A portion of the DL subframe in the MR-BS/RS frame used for MR-BS/RS to MS or RS (except TTR RS in TDD mode) transmission. The DL access zone may consist of the entire downlink subframe, depending on the method used to separate the transmissions on the access and relay links.

DL relay zone: A portion of the DL subframe in the MR-BS/RS frame used for MR-BS/RS to RS transmission. A frame may have no DL relay zone, depending on the method used to separate the transmissions on the access and relay links.

downlink (DL): The direction from the base station (BS) to the subscriber station (SS).

downlink burst transition gap (DLBTG): The gap included on the trailing edge of each allocated downlink (DL) burst so that ramp-down can occur and delay-spread can clear receivers.

downlink channel descriptor (DCD): A medium access control layer (MAC) message that describes the physical layer (PHY) characteristics of a downlink (DL) channel.

downlink interval usage code (DIUC): An interval usage code specific to a downlink (DL). *See also:* interval usage code.

downlink map (DL-MAP): A medium access control layer (MAC) message that defines burst start times for both time division multiplex and time division multiple access (TDMA) by a subscriber station (SS) on the downlink (DL).

Dynamic Channel Selection (DCS): The ability of a system to switch to a different physical (frequency) operating channel based on channel measurements avoiding interference in license-exempt bands of operation. DCS is distinct from DFS (Dynamic Frequency Selection) because DCS is not used for interference avoidance to regulatory protected devices, such as radar systems, but to other non-SSUs in the band.

dynamic frequency selection (DFS): The ability of a system to switch to different physical radio frequency (RF) channels based on channel measurement criteria to conform to particular regulatory requirements.

dynamic service: The set of messages and protocols that allow the base station (BS) and subscriber station (SS) to add, modify, or delete the characteristics of a service flow.

fast base station switching (FBSS): Base station (BS) switching that utilizes a fast switching mechanism to improve link quality. The mobile station (MS) is only transmitting/receiving data to/from one of the active BS (anchor BS) at any given frame. The anchor BS can change from frame to frame depending on the BS selection scheme.

fixed wireless access: Wireless access application in which the locations of the base station (BS) and subscriber station (SS) are fixed in location during operation.

frame: A structured data sequence of fixed duration used by some physical layer (PHY) specifications. A frame may contain both an uplink (UL) subframe and a downlink (DL) subframe.

frequency assignment (FA): A logical assignment of downlink (DL) center frequency and channel bandwidth programmed to the base station (BS).

frequency assignment (FA) index: A network-specific logical FA index assignment. FA index assignment is used in combination with operator-specific configuration information provided to the mobile station (MS) in a method outside the scope of IEEE Std 802.16.

frequency division duplex (FDD): A duplex scheme in which uplink (UL) and downlink (DL) transmissions use different frequencies but are typically simultaneous.

frequency offset index: An index number identifying a particular subcarrier in an orthogonal frequency division multiplexing (OFDM) or orthogonal frequency division multiple access (OFDMA) signal, which is related to its subcarrier index. Frequency offset indices may be positive or negative.

group key encryption key (GKEK): A random number generated by the base station (BS) or a network entity [e.g., an authentication and service authorization (ASA) server] used to encrypt the group traffic encryption keys (GTEKs) sent in broadcast messages by the BS to mobile stations (MSs) in the same multicast group.

handover (HO): The process in which a mobile station (MS) migrates from the air-interface provided by one base station (BS) to the air-interface provided by another BS. A break-before-make HO is where service with the target BS starts after a disconnection of service with the previous serving BS. A make-before-break HO is where service with the target BS starts before disconnection of the service with the previous serving BS.

harmful interference: An interference caused by an interference signal that seriously degrades, obstructs, or repeatedly interrupts the radio communication.

high reliability base station (HR-BS): A base station that is a subset of base station (BS) features and functions and additionally supports the WirelessMAN-High Reliability Air Interface. *See also:* **base station (BS)**.

high reliability mobile station (HR-MS): A subscriber station capable of performing the WirelessMAN-OFDMA subset of mobile station (MS) features and functions and additionally implementing the WirelessMAN-High Reliability Air Interface. *See also:* **mobile station (MS)**.

high reliability network (HR-Network): A network compliant with High Reliability Air Interface System.

high reliability relay station (HR-RS): A relay station that is a subset of relay station (RS) features and functions and additionally supports the WirelessMAN-High Reliability Air Interface.

high reliability station (HR-station): An HR-MS, HR-BS, or HR-RS.

infrastructure station: An MR-BS, RS, HR-BS, or HR-RS. *See also:* **multihop relay base station (MR-BS)**, **relay station (RS)**, **high reliability base station (HR-BS)**, **high reliability relay station (HR-RS)**.

Initialization Coexistence Signaling Interval (ICSI): The periodically appointed CSI specially used by an Initializing Base Station (IBS) to contact its neighbor OBS. When the IBS gets the OCSI allocation and starts the operating stage, it will cease from using the ICSI.

NOTE—See Table 10-5.

initial ranging connection: A management connection used by the subscriber station (SS) and the base station (BS) during the initial ranging process. The initial ranging connection is identified by a well-known connection identifier (CID). This CID is defined as a constant value within the protocol since an SS has no addressing information available until the initial ranging process is complete.

Interference Evaluation Burst (IEB): A short regular data transmission during an interference-free slot. This transmission is scheduled using CXP messages. The time position of this interval is associated with an IEB identifier.

intermediate RS: A relay station that is located on a path between an MR-BS and an access RS.

interval usage code: A code identifying a particular burst profile that can be used by a downlink (DL) or uplink (UL) transmission interval.

licensing regime: Specific service rules defined by a regulatory body for a given band and possibly region of operation.

Location Based Services (LBS): Services that are based on location data of the MS and/or BS in a network of IEEE 802.16 devices. Examples in location sensitized applications, emergency call origination tracking, equipment tracking, etc.

machine-to-machine (M2M) communication: Information exchange between user devices through a Base Station, or between a device and a server in the core network through a Base Station, that may be carried out without any human interaction.

M2M feature: A unique characteristic of an M2M application.

macro diversity handover (MDHO): The process in which an mobile station (MS) migrates from the air-interface provided by one or more base stations (BSs) to the air-interface provided by one or more other BSs. This process is accomplished in the downlink (DL) by having two or more BSs transmitting the same medium access control layer (MAC) or physical layer (PHY) protocol data unit (PDU) to the MS so that diversity combining can be performed by the MS. In the uplink (UL), it is accomplished by having two or more BSs receiving (demodulating, decoding) the same PDU from the MS so that diversity combining of the received PDU can be performed among the BSs.

management connection: A connection used for transporting medium access control layer (MAC) management messages or standards-based messages required by the MAC. *For MAC management messages, see also: basic connection, primary management connection, broadcast connection, initial ranging connection. For standards-based messages required by the MAC, see also: secondary management connection.*

NOTE—Table 6-56 specifies which MAC management message is transmitted on which of the management connections.

management tunnel CID (MT-CID): An identifier taken from the connection identifier (CID) space managed by an MR-BS that uniquely identifies a management tunnel connection between the MR-BS and an access RS.

Master subframe: The part of the MAC frame that is used by a specific system (Master system) of a coexistence community to operate with reduced interference from its neighboring systems.

Master system: A specific system that operates during the Master subframe. Systems of a coexistence community equally share the role of Master system on a rotating basis.

minislot: A unit of uplink (UL) bandwidth allocation equivalent to n physical slots (PSs), where $n = 2^m$ and m is an integer ranging from 0 through 7.

mobile station (MS): A station in the mobile service intended to be used while in motion or during halts at unspecified points. An MS is always a subscriber station (SS) unless specifically excepted otherwise in IEEE Std 802.16.

MR-BS frame: Frame structure for DL transmission/UL reception by MR-BS.

M2M ASN: An Access Service Network that supports M2M service.

M2M device: An MS that is capable of providing M2M communication.

M2M device group: A group of M2M devices that share one or more downlink multicast service flows.

M2M feature: A unique characteristic of an M2M application.

multicast polling group: A group of zero or more subscriber stations (SSs) that are assigned a multicast address for the purposes of polling.

multihop relay base station (MR-BS): A generalized equipment set providing connectivity, management, and control of relay stations and subscriber stations. *See also:* **base station (BS)**, **relay station (RS)**.

multiple input multiple output (MIMO): A system employing at least two transmit (Tx) antennas and at least two receive (Rx) antennas to improve the system capacity, coverage, or throughput.

neighbor base station (BS): For any mobile station (MS), a BS (other than the serving BS) whose downlink (DL) transmission can be received by the MS.

non-transparent RS: A relay station that transmits DL frame-start preamble, FCH, MAP message(s) and channel descriptor (DCD/UCD) messages.

Operation Coexistence Signaling Interval (OCSI): All the CSIs other than ICSI, periodically reallocated to OBSs.

Operator ID: Operator ID is an identifier of the network provider. The Operator ID is contained in the Base Station ID.

orderly power-down procedure: The procedure that the mobile station (MS) performs when powering down, for example, as directed by user input or as prompted by a automatic power-down mechanism.

packing: The act of combining multiple service data units (SDUs) from a higher layer into a single medium access control layer (MAC) protocol data unit (PDU).

Paging Controller: A unit that belongs to the idle mode services in the network control and management system (NCMS). The paging controller retains the MS state and operational parameters and/or administers paging activity for the MS while in idle mode.

payload header suppression (PHS): The process of suppressing the repetitive portion of payload headers at the sender and restoring the headers at the receiver.

Payload Header Suppression field (PHSF): A string of bytes representing the header portion of a protocol data unit (PDU) in which one or more bytes are to be suppressed (i.e., a snapshot of the uncompressed PDU header inclusive of suppressed and unsuppressed bytes).

payload header suppression index (PHSI): An 8-bit value that references the payload header suppression (PHS) rule.

payload header suppression mask (PHSM): A bit mask indicating which bytes in the Payload Header Suppression field (PHSF) to suppress and which bytes to not suppress.

payload header suppression size (PHSS): The length of the suppressed field in bytes. This value is equivalent to the number of bytes in the Payload Header Suppression field (PHSF) and also the number of valid bits in the payload header suppression mask (PHSM).

payload header suppression valid (PHSV): A flag that tells the sending entity to verify all bytes that are to be suppressed.

physical slot (PS): A unit of time, dependent on the physical layer (PHY) specification, for allocating bandwidth.

point-to-point (PtP): A mode of operation whereby a link exists between two network entities.

primary management connection: A connection that is established during initial subscriber station (SS) ranging and used to transport delay-tolerant medium access control layer (MAC) management messages.

Primary service: See ITU Radio Regulations, sections 5.2 to 5.31.

Primary (Spectrum) users: Users of radio services that have a regulatory PRIMARY status in a band. In a given frequency allocation there may be SSU, non-SSU, or both SSU and non-SSU, assigned as primary users.

Privacy Key Management (PKM) Protocol: A client/server model between the base station (BS) and subscriber station (SS) that is used to secure distribution of keying material.

protocol data unit (PDU): The data unit exchanged between peer entities of the same protocol layer. On the downward direction, it is the data unit generated for the next lower layer. On the upward direction, it is the data unit received from the previous lower layer (see Figure 3-1).

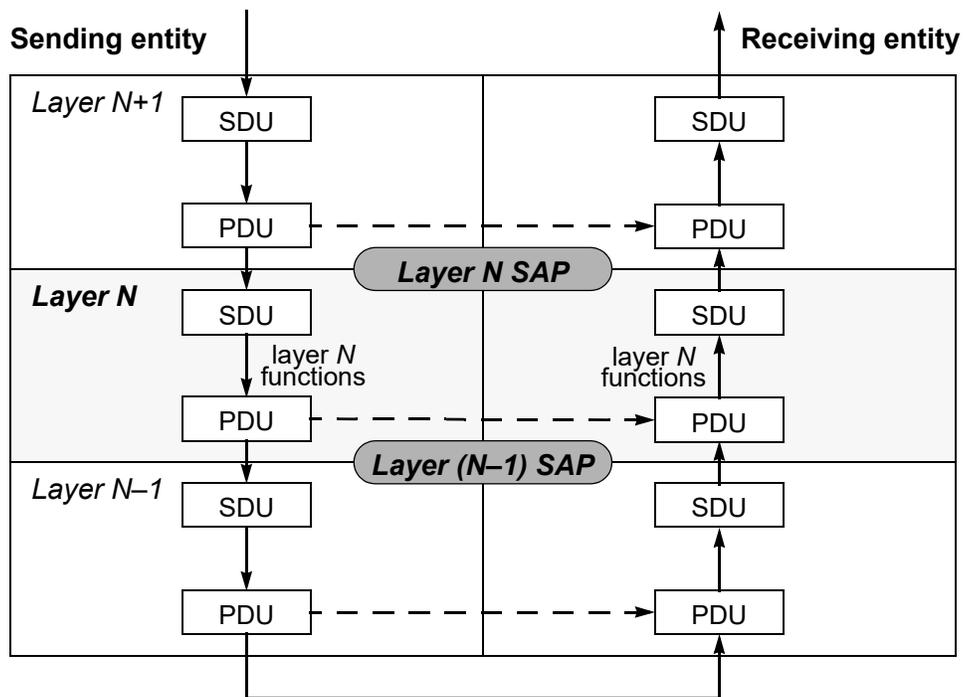


Figure 3-1—PDU and SDU in a protocol stack

quality of service (QoS) parameter set: A parameter set associated with a service flow identifier (SFID). The contained traffic parameters define scheduling behavior of uplink (UL) or downlink (DL) flows associated with transport connections.

NOTE—See 6.3.14.1.

radio frequency (RF) center frequency: The center of the frequency band in which a base station (BS) or subscriber station (SS) is intended to transmit.

radio path redundancy: The ability to provide alternative paths between base stations, relay stations, and subscriber stations.

random temporary key (RTK): The temporary key sent over-the-air, to be cross-checked with the key contained in the request primitive (15.6.5.2) received by the BS that originally sent it over-the-air. RTK is used to obstruct the coexistence requests from unauthenticated terminals.

regulatory threshold: A value (in dBm) of a signal level, as defined by the regulatory rules, above which the receiver has to initiate an action.

relay link (R-link): A radio link between an MR-BS and an RS or between a pair of RSs. This can be a relay uplink or downlink.

relay station (RS): A generalized equipment set, dependent on a multihop relay base station (MR-BS) providing connectivity, to other RSs or subscriber stations (SS). An RS may also provide management and control of subordinate RSs or SSs. The air interface between an RS and an SS is identical to the air interface between a BS and an SS. *See also:* multihop relay base station (MR-BS), base station (BS), subscriber station (SS).

relay zone: A portion of a frame used for the relay link.

round-trip delay (RTD): The round-trip delay time between communicating stations (i.e., such as between an RS and its superordinate station).

RS frame: Frame structure for DL/UL transmission/reception by RS.

RS receive/transmit transition gap (RSRTG): The minimum receive-to-transmit turnaround gap required at an RS. RSRTG is measured from the time of the last sample of the received burst to the first sample of the transmitted burst at the antenna port of the RS.

RS transmit/receive transition gap (RSTTG): The minimum transmit-to-receive turnaround gap required at an RS. RSTTG is measured from the time of the last sample of the transmitted burst to the first sample of the received burst at the antenna port of the RS.

scanning interval: A time period intended for the mobile station (MS) to monitor neighbor base stations (BSs) to determine the suitability of the BSs as targets for handover (HO).

scheduling RS: A relay station that serves as a scheduling station; i.e., a non-transparent RS with unique BSID and operating in distributed scheduling mode.

scheduling station: In centralized scheduling mode, the scheduling station is always the MR-BS. In distributed scheduling mode, the scheduling station of a given MS/RS is the first station along the route to the MR-BS that transmits MAPs; i.e., either a non-transparent RS or the MR-BS itself.

secondary management connection: A connection that may be established during subscriber station (SS) registration that is used to transport standards-based [e.g, Simple Network Management Protocol (SNMP), Dynamic Host Configuration Protocol (DHCP)] messages.

security association (SA): The set of security information that a base station (BS) and one or more of its client subscriber stations (SSs) share in order to support secure communications. This shared information includes traffic encryption keys (TEKs) and cipher block chaining (CBC) initialization vectors (IVs).

security association identifier (SAID): An identifier shared between the base station (BS) and subscriber station (SS) that uniquely identifies a security association (SA). The SAID is unique within MS. The uniqueness of this identifier shall be guaranteed by {MS MAC Address, SAID} pair.

security zone (SZ): A group consisting of one or more RSs and the MR-BS that share key material for the protection of MAC management messages produced and processed by members of the group.

security zone key (SZK): A group key shared by the MR-BS and a group of RSs within the same security zone. The SZK is a head of key hierarchy used to satisfy the security requirements such as integrity protection for MAC management messages within a defined security zone.

service access point (SAP): The point in a protocol stack where the services of a lower layer are available to its next higher layer.

service data unit (SDU): The data unit exchanged between two adjacent protocol layers. On the downward direction, it is the data unit received from the previous higher layer. On the upward direction, it is the data unit sent to the next higher layer.

NOTE—See Figure 3-1.

service flow (SF): A unidirectional flow of medium access control layer (MAC) service data units (SDUs) on a connection that is provided a particular quality of service (QoS).

service flow identifier (SFID): A 32-bit quantity that uniquely identifies a service flow to the subscriber station (SS).

serving base station (BS): For any mobile station (MS), the BS with which the MS has most recently completed registration at initial network-entry or during a handover (HO).

Shared subframe: The MAC Frame where all the systems of a coexistence community may operate in parallel. The operation during this frame may require limitations on the transmit power.

Slave subframe: That part of the MAC frame coinciding with the Master subframe in which all systems (other than the Master) of the coexistence community have restricted operation.

Slave system: A specific system that operates during the Slave subframe. This system shall not create interference to the Master systems that operate during its Master subframe.

small BS (SBS): A BS operating in a multi-tier network, typically at a lower-power tier than a BS that is not an SBS, with additional functionality related to Idle Mode, BS power management, and/or CSG support.

source base station (BS): The BS that initiates an intersystem communication procedure.

specific spectrum user (SSU): A service specifically identified in regulation as requiring protection from harmful interference. These systems are given a priority from a regulatory point of view within a given frequency band.

STC layer: OFDMA Space Time Coding information-flow fed to the STC encoder as an input. The number of STC layers in a system with vertical encoding is one, while in horizontal encoding, it depends on the number of encoding/modulation paths. This term may be used interchangeably with the word *layer* when used in the context of OFDMA STC.

STC stream: OFDMA Space Time Coding information path encoded by the STC encoder that is passed to subcarrier mapping and sent through one antenna, or passed on to the beamformer. The number of STC

streams in both vertical and horizontal encoding systems is the same as the number of output paths of the STC encoder. This term may be used interchangeably with the word *stream* when used in the context of OFDMA STC.

STR RS: A non-transparent relay station capable of performing STR relaying.

subcarrier index: An index number identifying a particular used subcarrier in an orthogonal frequency division multiplexing (OFDM) or orthogonal frequency division multiple access (OFDMA) signal. Subcarrier indices are greater than or equal to zero.

subscriber station (SS): A generalized equipment set providing connectivity between subscriber equipment and a base station (BS).

subscriber station receive/transmit gap (SSRTG): The minimum receive-to-transmit turnaround gap. SSRTG is measured from the time of the last sample of the received burst to the first sample of the transmitted burst at the antenna port of the SS.

subscriber station transmit/receive gap (SSTTG): The minimum transmit-to-receive turnaround gap. SSTTG is measured from the time of the last sample of the transmitted burst to the first sample of the received burst at the antenna port of the SS.

system: A base station (BS) and its subscriber stations (SSs).

target base station (BS): The BS with which a mobile station (MS) intends to be registered at the end of a handover (HO).

time division duplex (TDD): A duplex scheme where uplink (UL) and downlink (DL) transmissions occur at different times but may share the same frequency.

time division multiple access (TDMA) burst: A contiguous portion of the uplink (UL) or downlink (DL) using physical layer (PHY) parameters, determined by the downlink interval usage code (DIUC) or uplink interval usage code (UIUC), that remain constant for the duration of the burst. TDMA bursts are separated by preambles and are separated by gaps in transmission if subsequent bursts are from different transmitters.

time division multiplexing (TDM) burst: A contiguous portion of a TDM data stream using physical layer (PHY) parameters, determined by the downlink interval usage code (DIUC), that remain constant for the duration of the burst. TDM bursts are not separated by gaps or preambles.

transparent RS: A relay station that does not transmit DL frame-start preamble, FCH, MAP message(s) or channel descriptor (DCD/UCD) messages.

transparent zone: A portion of the DL subframe in the MR-BS/RS frame for an RS operating in the transparent mode used for MR-BS/RS to MS transmission. A DL subframe may, or may not, have a transparent zone.

transport connection: A connection used to transport user data. It does not include any traffic over the basic, primary, or secondary management connections. A fragmentable transport connection is a connection that allows fragmentation of service data units (SDUs).

transport connection identifier (CID): A unique identifier taken from the CID address space that uniquely identifies the transport connection. All user data traffic is carried on transport connections, even for service flows that implement connectionless protocols, such as Internet Protocol (IP). An active or admitted service flow [identified by a service flow identifier (SFID)] maps to a Transport CID assigned by the base station (BS).

TTR RS: A non-transparent relay station that performs TTR relaying.

tunnel CID (T-CID): An identifier taken from the connection identifier (CID) space that uniquely identifies a transport tunnel connection.

turbo decoding: Iterative decoding, using soft inputs and soft outputs.

type/length/value (TLV): A formatting scheme that adds a tag to each transmitted parameter containing the parameter type (and implicitly its encoding rules) and the length of the encoded parameter.

U Interface: The management and control interface that exists between the SS and the BS over the air interface.

UL access zone: A portion of the UL subframe in the MR-BS/RS frame used for MS or RS (except TTR RS in TDD mode) to MR-BS/RS transmission. A frame may have no UL access zone, or the UL access zone may consist of the entire uplink subframe, depending on the method used to separate the transmissions on the access and relay links.

UL relay zone: A portion of the UL subframe in the MR-BS/RS frame used for RS to MR-BS/RS transmission. A frame may have no UL relay zone, or the UL relay zone may consist of the entire uplink subframe, depending on the method used to separate the transmissions on the access and relay links.

Uncoordinated Coexistence Mechanism: A mechanism by which a radio system attempts to achieve coexistence without coordination with other spectrum users.

uplink (UL): The direction from a subscriber station (SS) to the base station (BS).

uplink channel descriptor (UCD): A medium access control layer (MAC) message that describes the physical layer (PHY) characteristics of an uplink (UL).

uplink interval usage code (UIUC): An interval usage code specific to an uplink (UL).

uplink map (UL-MAP): A set of information that defines the entire access for a scheduling interval.

user data: Protocol data units (PDUs) of any protocol above a service-specific convergence sublayer (CS) received over the CS service access point (SAP).

wireless access: End-user radio connection(s) to core networks.

WirelessMAN-CX: The designation used to describe the realization that adds coordinated coexistence mechanisms to systems operating below 11 GHz in license-exempt bands.

WirelessMAN-UCP: The designation used to describe the realization that adds uncoordinated coexistence mechanisms to systems operating below 11 GHz in license-exempt bands.

4. Abbreviations and acronyms

3-DES	triple data encryption standard
AAS	adaptive antenna system
AC	authentication control
ACLR	Adjacent Channel Leakage Ratio
ACM	account management
ACS	Adaptive Channel Selection
ADPD	Advertisement Discovery Policy Descriptor
AES	advanced encryption standard
AGC	automatic gain control
AK	authorization key
AKID	authorization key identifier
ALTCH	alternative channel
AMC	adaptive modulation and coding
AMS	advanced mobile station (specified in IEEE Std 802.16.1-2012)
ARQ	automatic repeat request
ASA	authentication and service authorization
ASR	anchor switch reporting
ATDD	adaptive time division duplexing
ATM	asynchronous transfer mode
BCC	block convolutional code
BE	best effort
BER	bit error ratio
BPSK	binary phase shift keying
BR	bandwidth request
BS	base station
BSD	base station descriptor
BSIS	Base Station Identification Server
BSN	block sequence number
BTC	block turbo code
BW	bandwidth (abbreviation used only in equations, tables, and figures)
BWA	broadband wireless access
BWAA	bandwidth allocation/access
C/I	carrier-to-interference ratio
C/N	carrier-to-noise ratio
CA	certification authority
CBC	cipher block chaining
CBC-MAC	cipher block chaining message authentication code
CC	confirmation code
CCA	Clear Channel Assessment
CCD	Candidate Channel Determination
CCH	control subchannel
CCI	co-channel interference
CCM	CTR mode with CBC-MAC
CCMFA	Candidate Channel and Master Frame Assessment

CCS	common channel signaling
CCV	clock comparison value
CDMA	code division multiple access
ChCtrFr	channel center frequency
ChID	channel identifier
CID	connection identifier
CINR	carrier-to-interference-and-noise ratio
CIR	channel impulse response
CLP	cell loss priority
CMAC	cipher-based message authentication code
CMI	Coexistence Messaging Interval
CoNBR	coexistence neighbor
CP	cyclic prefix
CPS	common part sublayer
CQI	channel quality information
CQICH	channel quality information channel
CR	cognitive radio
CRC	cyclic redundancy check
CS	convergence sublayer
CSCF	centralized scheduling configuration
CSCH	centralized scheduling
CSG	closed subscriber group
CSI	Coexistence Signaling Interval
CSIN	Coexistence Signaling Interval Number
CSIT	channel state information at the transmitter
CT	cooperative transmission
CTC	convolutional turbo code
CT-CX	credit token-based coexistence
CTG	CSI Transmission GAP
CTR	counter mode encryption
CW	contention window
CX	Coexistence
CX_CMI_D	Coexistence Message Interval Downlink
CX_CMI_U	Coexistence Message Interval Uplink
CXCBI	Coordinated Coexistence Contention-Based Interval
CX-CBP	Coordinated Coexistence Contention-Based Protocol
CXCC	Coexistence Control Channel
CXCW	coexistence contention window
CXP	Coexistence Protocol
CXSBI	Coordinated Scheduled-Based Interval
DCS	Dynamic Channel Selection
DAMA	demand assigned multiple access
DARS	digital audio radio satellite
dB _i	decibels of gain relative to the 0 dB gain of a free-space isotropic radiator
dB _m	decibels relative to 1 mW
DCD	downlink channel descriptor

DES	data encryption standard. This reference is withdrawn.
DFS	dynamic frequency selection
DHCP	Dynamic Host Configuration Protocol
DID	deregistration identifier (specified in IEEE Std 802.16.1-2012)
DIUC	downlink interval usage code
DL	downlink
DLFP	downlink frame prefix
DSA	dynamic service addition
DSC	dynamic service change
DSCH	distributed scheduling
DSCP	differentiated services codepoint
DSD	dynamic service deletion
DSx	dynamic service addition, change, or deletion
D-TDOA	Downlink Time Difference Of Arrival
EAP	extensible authentication protocol
EC	encryption control
ECB	electronic code book
ECRTP	a IP-header-compression CS PDU format (IETF RFC 3545)
EDE	encrypt-decrypt-encrypt
EESS	earth exploratory satellite system
EIK	EAP Integrity Key
EIRP	effective isotropic radiated power
EKS	encryption key sequence
EOF	End of Frame (of the CSI message)
EQP	extended quiet period
EVM	error vector magnitude
FA	frequency assignment
FBIS	forwarding between infrastructure stations
FBSS	fast base station switching
FC	fragmentation control
FCZ	forwarding control zone
FCAPS	Fault Management, Configuration Management, Account Management, Performance Management, Security Management
FCC	Federal Communications Commission
FCH	frame control header
FDD	frequency division duplex or duplexing
FEC	forward error correction
FFSH	fast-feedback allocation subheader
FFT	fast Fourier transform
FHDC	frequency hopping diversity coding
FPC	fast power control
FRS	fixed relay station
FSH	fragmentation subheader
FSN	fragment sequence number
FSS	fixed satellite service
FUSC	full usage of subchannels

GPCS	Generic Packet Convergence Sublayer
GF	galois field
GKEK	group key encryption key
GMSH	grant management subheader
GPS	global positioning system
GS	guard symbol
GTEK	group traffic encryption key
HARQ	hybrid ARQ
HCS	header check sequence
HEC	header error check
H-FDD	half-duplex frequency division duplex
HMAC	hashed message authentication code
HO	handover
HR	handover ranging
HR	high reliability
HT	header type
HUMAN	high-speed unlicensed metropolitan area network
I	inphase
IANA	Internet Assigned Numbers Authority
IBS	initializing base station
ICSI	Initialization Coexistence Signaling Interval
IE	information elemen
IEB	Interference Evaluation Burst
IEBBS _n	Nth Interference Evaluation Burst of a BS
IEBSS _n	Nth Interference Evaluation Burst over all the SS associated with a BS
IFFT	inverse fast Fourier transform
IM	interference management
IMM	idle mode management
INR	interference-to-noise ratio
IP	Internet Protocol
IR	initial ranging
IS	infrastructure station
IV	initialization vector
IWF	interworking function
KEK	key encryption key
LAN	local area network
LBS	location based services
LBT	listen-before-talk
LBT-TXOP	Transmission Opportunity depending on LBT result
LDPC	low-density parity check
LE	license-exempt
LFSR	linear feedback shift register
LLC	logical link control
LOS	line-of-sight
LSB	least significant bit
M2M	machine-to-machine

M2MCID	M2M multicast connection identifier
MAC	medium access control layer
MAK	MBS authorization key
MAN	metropolitan area network
MBS	multicast and broadcast service
MCID	multicast CID (see Table 8-285)
MCS	modulation coding scheme
MDHO	macro diversity handover
MDS	multipoint distribution service
MGTEK	MBS group traffic encryption key
MIB	management information base
MIC	message integrity check
MIH	media independent handover
MIHF	MIH Function
MIMO	multiple input multiple output
MMDS	multichannel multipoint distribution service
MPEG	moving pictures experts group
MR-BS	multihop relay base station
MRS	mobile relay station
MS	mobile station
MSB	most significant bit
MSK	master session key
NCFG	network configuration
NCMS	network control and management system
NCMS(BS)	network control and management system at the BS side (network side)
NCMS(SS/MS)	network control and management system at the SS/MS side
NEM	network entry management
NENT	network entry
NLOS	non-line-of-sight
NNI	network-to-network interface (or network node interface)
NRM	network reference model
nrtPS	non-real-time polling service
NSP	network service provider
NTI	Network Time Intervals
NTI_S	Network Time Interval Slots
NTP	Network Time Protocol
NURBC	Neighborhood Update Request BroadCast
OBS	operating base station
OCSI	Operation Coexistence Signaling Interval
OFDM	orthogonal frequency division multiplexing
OFDMA	orthogonal frequency division multiple access
OID	object identifier
PAK	primary authorization key
PAPR	peak to average power ratio
PBR	piggyback request
PDU	protocol data unit

PER	packet error ratio
PHS	payload header suppression
PHSF	Payload Header Suppression field
PHSI	payload header suppression index
PHSM	payload header suppression mask
PHSS	payload header suppression size
PHSV	payload header suppression valid
PHY	physical layer
PKM	privacy key management
PLD	PayLoaD (of the CSI message)
PM	poll-me bit
PMD	physical medium dependent
PMK	pairwise master key
PMP	point-to-multipoint
PN	packet number
PPDR	public protection and disaster relief
PPP	Point-to-Point Protocol
PRBS	pseudo-random binary sequence
PS	physical slot
PSC	power saving class
PTI	payload type indicator
PtP	point to point
PUSC	partial usage of subchannels
PUSC-ASCA	partial usage of subchannels – adjacent subcarrier allocation
PVC	permanent virtual circuit
Q	quadrature
QAM	quadrature amplitude modulation
QoS	quality of service
QP	quiet period
QPSK	quadrature phase-shift keying
R-ACK	relay ACK
RAIS	Radio Application Identification Server
RCG	Receive CSI GAP
R-DL	relay downlink
REQ	request
R-FCH	relay zone frame control header
RLAN	Radio Local Area Network
R-MAP	relay zone MAP
RNG	ranging
ROHC	an IP-header-compression CS PDU format [IETF RFC 3095 (updated by RFC 4815 [B44])]
RRA	radio resource agent
RRC	radio resource controller
RRM	radio resource management
R-RTI	relay receive/transmit transition interval
RRU	renting resource unit

RS	Reed-Solomon
RS	relay station
RSP	response
RSS	receive signal strength
RSSI	receive signal strength indicator
RTD	round-trip delay
RTG	receive/transmit transition gap
RTK	random temporary key
rtPS	real-time polling service
R-TTI	relay transmit/receive transition interval
R-UL	relay uplink
Rx	receive (abbreviation not used as verb)
RxDs	receiver delay spread clearing interval
R-Zone	relay zone
SA	security association
SAID	security association identifier
SAP	Service Access Point
SAR	synthetic aperture radar
SC	single carrier
SDMA	spatial division multiple access
SDU	service data unit
SF	service flow
SFID	service flow identifier
SFM	service flow management
SHA	secure hash algorithm
SI	slip indicator
SIQ	service information query
SM	spatial multiplexing
SN	sequence number
SNMP	Simple Network Management Protocol
SNR	signal-to-noise ratio
SOF	Start of Frame (of CSI message)
SPOF	single point of failure
SS	subscriber station
SSID	subscriber station identification (MAC address)
SSM	subscriber station management
SSTG	subscriber station transition gap
SSU	specific spectrum user
SSURF	Subscriber Station Uplink Radio Frequency
STC	space time coding
STID	Station Identifier (specified in IEEE Std 802.16.1-2012)
STR	simultaneous transmit and receive relaying
STTD	space time transmit diversity
SVC	switched virtual circuit
TCM	trellis coded modulation
TCP	Transmission Control Protocol

TCS	transmission convergence sublayer
TDD	time division duplex or duplexing
TDM	time division multiplexing
TDMA	time division multiple access
TDOA	time difference of arrival
TDU	tunnel data unit
TEK	traffic encryption key
TFTP	Trivial File Transfer Protocol
TLV	type/length/value
TPC	Transmit Power Control
TTG	transmit/receive transition gap
TTR	time-division transmit and receive relaying
TUSC	tile usage of subchannels
Tx	transmit (abbreviation not used as verb)
UCD	uplink channel descriptor
UCP	Uncoordinated Coexistence Protocol
UDP	User Datagram Protocol
UEP	unequal error protection
UGS	unsolicited grant service
UIUC	uplink interval usage code
UL	uplink
UNI	user-to-network interface (or user-network interface)
U-NII	unlicensed national information infrastructure
UTC	coordinated universal time
U-TDOA	uplink time difference of arrival
UW	unique word
VC	virtual channel
VCI	virtual channel identifier
VLAN	virtual local area network
VP	virtual path
VPI	virtual path identifier
WirelessHUMAN	Wireless High-speed Unlicensed Metropolitan Area Networks
WirelessMAN	Wireless Metropolitan Area Networks
WirelessMAN-CX	Wireless Metropolitan Access Network Coexistence
WirelessMAN-UCP	Wireless Metropolitan Access Network Uncoordinated Coexistence Protocol
WLAN	wireless local area network
XOR	exclusive-or

1 5. MAC common part sublayer

2 5.1 Data/Control plane

3 5.1.1 Addressing and connections

4 5.1.1.1 Point-to-multipoint (PMP)

5 Each air interface in an SS shall have a 48-bit universal MAC address, as defined in IEEE Std 802®. This
6 address uniquely defines the air interface of the SS. It is used during the initial ranging process to establish
7 the appropriate connections for an SS. It is also used as part of the authentication process by which the BS
8 and SS each verify the identity of the other. The definition and usage of the MAC address defined above for
9 the SS and the BS shall be applicable for the RS and the MR-BS, respectively.

10 Connections are identified by a 16-bit CID. At SS initialization, two pairs of management connections, basic
11 connections (UL and DL) and primary management connections (UL and DL), shall be established between
12 the SS and the BS, and a third pair of management connections (secondary management, DL and UL) may
13 be optionally generated. The three pairs of management connections reflect the fact that there are inherently
14 three different levels of QoS for management traffic between an SS and the BS. The basic connection is used
15 by the BS MAC and SS MAC to exchange short, time-urgent MAC management messages. The primary
16 management connection is used by the BS MAC and SS MAC to exchange longer, more delay-tolerant
17 MAC management messages. Table 6-55 specifies which MAC management messages are transferred on
18 which of these two connections. In addition, it also specifies which MAC management messages are
19 transported on the broadcast connection. Finally, the secondary management connection is used by the BS
20 and SS to transfer delay-tolerant, standards-based [Dynamic Host Configuration Protocol (DHCP), Trivial
21 File Transfer Protocol (TFTP), SNMP, etc.] messages. Messages carried on the secondary management
22 connection may be packed and/or fragmented. For the OFDM, and OFDMA PHYs, management messages
23 shall have CRC. Use of the secondary management connection is required only for managed SS. The
24 identification, establishment, and usage of the connection defined above for the SS and the BS shall be
25 applicable for the RS and the MR-BS, respectively. In addition, the multicast management connection is
26 used by the MR-BS to transfer MAC management messages to a group of RSs.

27 The CIDs for these connections shall be assigned in the RNG-RSP, REG-RSP, RS_Config-CMD (RS only),
28 or MOB_BSHO-REQ/RSP for pre-allocation in handover. When CID pre-allocation is used during HO, a
29 primary management CID may be derived based on Basic CID without assignment in the messages (see
30 6.3.20.2.11). The message dialogs provide three CID values. The same CID value is assigned to both
31 members (UL and DL) of each connection pair.

32 For bearer services, the BS and the SS may initiate the set-up of service flows based upon the provisioning
33 information. The registration of an SS, or the modification of the services contracted at an SS, stimulates the
34 higher layers of the BS and/or the SS to initiate the setup of the service flows. When admitted or active,
35 service flows are uniquely associated with transport connections. MAC management messages shall never
36 be transferred over transport connections. Bearer or data services shall never be transferred on the basic,
37 primary, or secondary management connections.

38 Bearer connection CID reassignments during handover or network reentry shall be sent using the REG-RSP
39 encodings TLV in the RNG-RSP message, the REG-RSP message, or reassigned autonomously without
40 explicit assignment in any message (see 6.3.20.2.11).

41 Requests for transmission are based on these CIDs, since the allowable bandwidth may differ for different
42 connections, even within the same service type. For example, an SS unit serving multiple tenants in an office
43 building would make requests on behalf of all of them, though the contractual service limits and other
44 connection parameters may be different for each of them.

45 Many higher layer sessions may operate over the same wireless CID. For example, many users within a
46 company may be communicating with Transmission Control Protocol (TCP)/IP to different destinations, but
47 since they all operate within the same overall service parameters, all of their traffic is pooled for request/
48 grant purposes. Since the original local area network (LAN) source and destination addresses are
49 encapsulated in the payload portion of the transmission, there is no problem in identifying different user
50 sessions.

51 The type of service and other current parameters of a service are implicit in the CID; they may be accessed
52 by a lookup indexed by the CID.

53 **5.1.1.2 Multihop relay**

54 Addressing and connections as perceived by an SS served by an RS or MR-BS are defined in the same
55 manner as in 5.1.1.1. This subclause specifies the additional addressing and connection definitions that
56 apply to multihop relay systems. A non-transparent RS shall be assigned a Base Station ID. The format of
57 the Base Station ID is defined in 6.3.2.3.2.

58 Connections may span multiple hops and may pass through one or more intermediate RSs. These
59 connections shall be identified by the connection ID (CID) as specified in 5.1.1.1 and the CIDs shall be
60 unique within an MR cell. All the CID connection types specified in PMP mode shall be supported between
61 the MR-BS and MS.

62 An additional type of connection called a tunnel connection may be established between the MR-BS and an
63 access RS, or between the MR-BS and a superordinate station of an RS group (see 5.1.7). Tunnel
64 connections shall be used for transporting relay MAC PDUs from one or more connections between the MR-
65 BS and an access RS and may pass through one or more intermediate RSs. It is not required that all
66 connections shall pass through a tunnel connection. MAC PDUs from connections that do not pass through a
67 tunnel are forwarded based on the CID of the connection. There shall be two types of tunnel connections.
68 Management tunnel connections, identified using the MT-CID, shall be used exclusively for transporting
69 MAC PDUs from management (basic, primary, or secondary) connections. Transport tunnel connections,
70 identified using the T-CID, shall be used exclusively for transporting MAC PDUs from transport
71 connections. The MR-BS shall allocate the T-CID and MT-CID using the DSA messages. MT-CID is
72 bidirectional and T-CID is unidirectional.

73 **5.1.1.2.1 Addressing scheme for relaying**

74 In the procedure of network entry and initialization for a new RS, the MR-BS may pre-allocate a range of
75 management CIDs to an RS. The operation for pre-allocation of these CIDs is described in 6.3.9.18.2. One or
76 more BS in an area of the network may be grouped into an M2M zone and identified by an M2M GROUP
77 ZONE ID. A BS may belong to at most one M2M group zone. The BS may broadcast the M2M GROUP
78 ZONE ID of the zone to which it belongs in the DCD message.

79 The M2M multicast connection ID (M2MCID) uniquely identifies a downlink multicast service flow shared
80 by a group of M2M devices within an M2M zone. Implicitly, it is also used to identify the group of M2M
81 devices that share the downlink multicast service flow. An M2M device may share more than one downlink
82 multicast service flow each identified by an M2MCID. All M2MCIDs that are assigned to an M2M device
83 belong to the same M2M group zone.

84 The M2MCID is assigned to a service flow of an M2M device during the DSA procedure and released
85 during the DSD procedure or an explicit network exit (e.g., power down location update). The assigned
86 M2MCID shall be retained by an M2M device even in idle mode unless the M2M device exits from the net-
87 work or the network explicitly deletes the service flow associated with the M2MCID. The M2MCID may be
88 reassigned during normal operation mode and idle mode. During normal operation, the M2MCID may be
89 changed and deleted by DSC and DSD procedures respectively.

90 During idle mode, the M2MCID may be changed by a location update procedure or during network reentry
91 through the RNG-RSP message. The BS may trigger the group location update via paging message. In
92 normal operation, the BS may update the M2MCID for a M2M device group using the MAC Group Man-
93 agement Control (MGMC) message.

94 When the M2M device performs the timer-based location update, if the BS needs to update the M2MCID of
95 M2M device, the BS may send a RNG-RSP message with an M2MCID Update TLV, which contains a new
96 M2MCID value in response to the RNG-REQ message.

97 A BS may use the MOB_PAG-ADV message to indicate the update of the M2MCID and its new value to all
98 the M2M devices in a group. When an idle mode M2M device that belongs to the M2M device group
99 (identified by its M2MCID) receives a paging message containing an M2MCID TLV identifying one of its
100 service flows and an Action Code TLV with value set to 0b11, this M2M device shall update the M2MCID
101 based on the value indicated by M2MCID reassignment TLV (see 11.17.5).

102 After receiving the updated M2MCID value, the M2M device shall send an acknowledgment (ACK) to the
103 BS.

104 If the BS does not receive an acknowledgment from some of the M2M devices, it may trigger location
105 update in the next paging cycle of those M2M devices by sending MOB_PAG-ADV message containing
106 MS MAC Address hash and it may send a RNG-RSP message with an M2MCID Update TLV containing
107 the new M2MCID to each of them during the location update procedure.

108 The BS may use the M2M Group MAC Control (MGMC) message with the M2MCIDs to send the
109 information to multiple M2M devices. The M2M device shall respond to acknowledge this message with
110 M2M ACK MAC Control (MAMC) message.

111 The information of the neighboring M2M Group Zones may be advertised by BSs of a given M2M Group
112 Zone in MOB_NBR-ADV message. Neighboring M2M Group Zones implies the M2M Group Zones to
113 which the neighboring BSs belong are different from the M2M Group Zone to which the serving BS
114 belongs.

115 The MOB_NBR-ADV message contains M2M_GROUP_ZONE_ID of the neighboring M2M Group Zones
116 along with the mappings of M2MCID from the M2M Group Zone of the serving BS to one or more neigh-
117 boring M2M Group Zones. When an M2M device changes its preferred or serving BS to a BS that belongs
118 to a different M2M Group Zone than the current serving BS, it may have the M2MCID mapping information
119 for the M2M Group Zone of that BS, if it has already received the MOB_NBR-ADV.

120 The MOB_NBR-ADV message including M2M Group Zone information should be transmitted by the BSs
121 that are situated at the M2M Group Zone boundaries.

122 **5.1.1.3 MAC header formats**

123 The MAC header formats are defined in Table 5-1 except for the MAC header formats for DL-MAP and UL-
124 MAP MAC messages for channel bandwidth less than 1.25 MHz in which case the MAC header formats are
125 defined in subclause 5.1.1.3.1.1.

126 There is one defined DL MAC header, which is the Generic MAC header, which begins each DL MAC PDU
127 containing either MAC management messages or CS data. There are two defined UL MAC header formats.
128 The first is the Generic MAC header that begins each MAC PDU containing either MAC management
129 messages or CS data, where the header type (HT) is set to 0 as shown in Table 5-2. The second is the MAC
130 header format without payload where HT is set to 1 as shown in Table 5-2. For the latter format, the header
131 is not followed by any MAC PDU payload and CRC.

Table 5-1—MAC header formats

Syntax	Size (bit)	Notes
MAC Header() {	—	—
HT	1	See below for context-dependent definitions.
EC	1	If HT = 1, EC = 0
if (HT == 0) {	—	—
Type	6	—
ESF	1	—
CI	1	—
EKS	2	—
<i>Reserved</i>	1	Shall be set to zero
LEN	11	—
}	—	—
else {	—	—
Type	3	—
BR	19	—
}	—	—
CID	16	—
HCS	8	—
}	—	—

Table 5-2—MAC header HT and EC fields encoding

HT	EC ^a	MAC PDU type	Reference figure	Reference table
0	0	Generic MAC header for DL and UL. MAC PDU with data payload, no encryption, with a 6-bit type field, see Table 5-4 for its type field encodings.	Figure 5-1	Table 5-3
0	1	Generic MAC header for DL and UL. MAC PDU with data payload, with encryption with a 6-bit type field, see Table 5-4 for its type field encodings.	Figure 5-1	Table 5-3
1	0	DL: DL M2M MAC signaling header type I. MAC PDU without data payload, with a 3-bit type field, see Table 6-30 for type encoding definitions.	Figure 5-5, Figure 6-8, Figure 6-9– Figure 6-14	Table 5-6, Table 6-7, Table 6-8– Table 6-13 Table 6-30, Table 6-31

Table 5-2—MAC header HT and EC fields encoding (continued)

HT	EC ^a	MAC PDU type	Reference figure	Reference table
1	1	DL: Compressed/Reduced Private DL-MAP ^b UL: MAC signaling header type II. MAC PDU without data payload, with 1-bit type field, see Table 5-7 for type encoding definitions.	Figure 5-6– Figure 6-17	Table 5-7, Table 6-15

^aHeaders with HT = 1 shall not be encrypted. Thus the EC field is used to distinguish between feedback MAC header (UL)/Compress MAP (DL), and all other type headers.

^bCompressed DL-MAP and Reduced Private MAP do not use MAC headers as defined in 5.1.1.3; however, the first two bits of these maps replace the HT/EC fields and are always set to 0b11 to identify them as such (see 8.3.6.6, 8.3.6.7, 8.4.5.6, and 8.4.5.8). If the most significant bit of the Type field is set to 0, it indicates the presence of a compressed/reduced private DL-MAP. If the most significant bit of the Type field is set to 1, it indicates the presence of a SUB-DL-UL-MAP.

132 **5.1.1.3.1 Generic MAC header**

133 The Generic MAC header is illustrated in Figure 5-1.

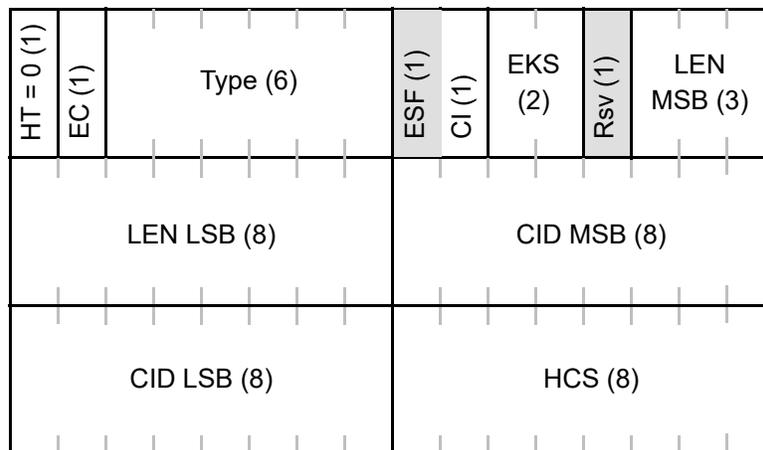


Figure 5-1—Generic MAC header format

134 The fields of the Generic MAC header are defined in Table 5-3. Every header is encoded, starting with the
 135 HT and encryption control (EC) fields. The coding of these fields is such that the first byte of a MAC header
 136 shall never have the value of 0xFF, where “X” means “do not care.” This prevents false detection on the
 137 stuff byte used in the transmission convergence sublayer (TCS).

138 The ESF bit in the Generic MAC header indicates that the extended subheader is present. Using this field, a
 139 number of additional subheaders can be used within a PDU. The extended subheader shall always appear
 140 immediately after the Generic MAC header and before all other subheaders. Contrary to the other
 141 subheaders, extended subheaders are not considered part of the MAC PDU payload and, hence are not
 142 encrypted. When an entity transmits a MAC PDU without a payload, it shall set the EC bit in the Generic
 143 MAC header to 0, even if the connection on which it transmits the MAC PDU is associated with data
 144 encryption. When an entity receives a MAC PDU that does not contain a payload, it shall process this MAC
 145 PDU if the EC bit is set to 0, and should discard this MAC PDU if the EC bit is set to 1.

Table 5-3—Generic MAC header fields

Name	Length (bit)	Description
HT	1	Header type. Shall be set to zero.
EC	1	Encryption control. 0 = Payload is not encrypted or payload is not included. 1 = Payload is encrypted.
Type	6	This field indicates the subheaders and special payload types present in the message payload.
ESF	1	Extended Subheader field. If ESF = 0, the extended subheader is absent. If ESF = 1, the extended subheader is present and shall follow the Generic MAC header immediately. (See 6.3.2.2.7.) The ESF is applicable both in the DL and in the UL.
CI	1	CRC indicator. 1 = CRC is included in the PDU by appending it to the PDU payload after encryption, if any. 0 = No CRC is included.
EKS	2	Encryption key sequence. The index of the traffic encryption key (TEK) and initialization vector (IV) used to encrypt the payload. This field is only meaningful if the EC field is set to 1.
RSV	1	<i>Reserved</i>
LEN	11	Length. The length in bytes of the MAC PDU including the MAC header and the CRC if present.
CID	16	Connection identifier.
HCS	8	Header check sequence. An 8-bit field used to detect errors in the header. The transmitter shall calculate the HCS value for the first five bytes of the cell header, and insert the result into the HCS field (the last byte of the MAC header). It shall be the remainder of the division (Modulo 2) by the generator polynomial $g(D = D^8 + D^2 + D + 1)$ of the polynomial D^8 multiplied by the content of the header excluding the HCS field. (Example: [HT EC Type] = 0x80, BR = 0xAAAA, CID = 0x0F0F; HCS would then be set to 0xD5).

¹⁴⁶ The definition of the Type field is indicated in Table 5-4.

Table 5-4—Type encodings

Type bit	Value
#5 most significant bit (MSB)	<i>Reserved</i>
#4	ARQ feedback payload 1 = present, 0 = absent
#3	Extended type Indicates whether the present packing subheader (PSH) or fragmentation subheader (FSH) is extended for non-ARQ-enabled connections 1 = Extended 0 = Not extended For ARQ-enabled connections, this bit shall be set to 1.
#2	Fragmentation subheader (FSH) 1 = present, 0 = absent

Table 5-4—Type encodings (continued)

Type bit	Value
#1	Packing subheader (PSH) 1 = present, 0 = absent
#0 least significant bit (LSB)	DL: Fast-feedback allocation subheader (FFSH) UL: Grant management subheader (GMSH) 1 = present, 0 = absent

147 If the ARQ Feedback Payload bit in the MAC Type field (see Table 5-4) is set, the ARQ Feedback Payload
 148 shall be transported. If packing is used, it shall be transported as the first packed payload. See 6.3.3.4.3. Note
 149 that this bit does not address the ARQ Feedback payload contained inside an ARQ Feedback message.

150 MAC PDUs sent on a relay link through a tunnel shall be constructed into a relay MAC PDU of the form
 151 illustrated in Figure 6-2. Each relay MAC PDU shall begin with a fixed length relay MAC header (see
 152 5.1.1.3.2). The relay MAC header shall be followed by zero or more extended subheaders and the payload.
 153 The payload shall consist of zero or more subheaders and zero or more MAC PDUs as defined in Figure 6-1.
 154 In the case of management tunnel, the payload may consist of zero or more subheaders and one
 155 MT_Transfer MAC message. A relay MAC PDU may contain a CRC as described in 6.3.3.5.2.
 156 Implementation of CRC capability is mandatory for MR systems and the presence of a CRC is indicated in
 157 the relay MAC header. When a relay MAC PDU contains a CRC, the CRCs of individual MAC PDUs
 158 within the payload shall be omitted but the CI bit setting and LEN values are retained. If omitted, the egress
 159 station of the tunnel shall calculate the CRCs and attach them to the individual MAC PDUs if the CI bit of
 160 the MAC PDU header within the relay MAC PDU is set.

161 **5.1.1.3.1.1 Generic MAC header format for DL-MAP and UL-MAP MAC messages when the**
 162 **channel bandwidth is less than 1.25 MHz**

163 The header of the DL-MAP MAC message shall be of the format defined in Figure 5-2. The DL-MAP is
 164 always the first burst in the DLSF so it can be identified as DL-MAP by its position in the burst. Therefore
 165 only LEN and HCS fields are transmitted. The modified GMAC header consists of 1 byte length field and
 166 1 byte for HCS field.



Figure 5-2—Modified DL-MAP header for channel bandwidths less than 1.25 MHz

167 The header of the UL-MAP MAC message shall be of the format defined in Figure 5-3. The UL-MAP, if
 168 present, is the first data burst in the DLSF after DL-MAP, but it may not always be present in a frame in
 169 which case, the first burst may carry data traffic. Conflict will be avoided by setting HT = 1 to identify the
 170 burst as UL-MAP.



Figure 5-3—Modified UL-MAP header for channel bandwidths less than 1.25 MHz

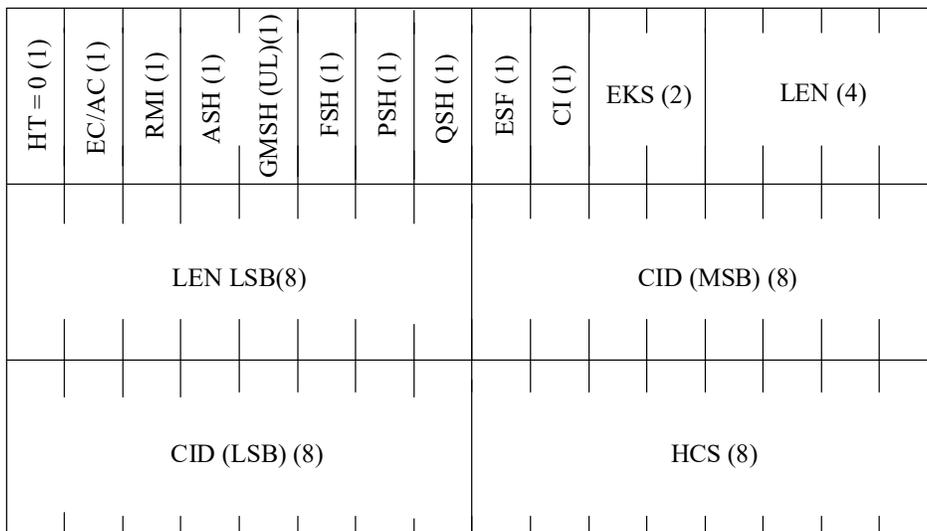
171 **5.1.1.3.2 Relay MAC header format**

172 The header of the relay MAC PDU shall be of the format defined in Table 5-5 and further illustrated in
 173 Figure 5-4.

Table 5-5—Description of relay MAC header fields

Name	Length (bits)	Description
HT	1	Shall be set to zero.
EC/AC	1	Encryption control if CID in the relay MAC header is T-CID. 0 = Payload is not encrypted 1 = Payload, except subheaders inserted on the relay link, is encrypted. Authentication control if CID in the relay MAC header is MT-CID. 0 = Payload starting with MAC header defined in Table 5-1. 1 = Payload starting with MT_Transfer message defined in Table 6-222.
RMI	1	Relay Mode Indicator Shall be set to 1.
ASH	1	Allocation subheader 1=present; 0=absent
GMSH	1	UL: grant management subheader (GMSH) 1 = present, 0 = absent DL: <i>Reserved</i> ; shall be set to 0.
FSH	1	Fragmentation subheader (FSH) 1=present; 0=absent
PSH	1	Packing subheader (PSH) 1=present; 0=absent
QSH	1	QoS subheader (QSH) 1=present; 0=absent
ESF	1	Extended subheader field If ESF=0, the extended subheader is absent. If ESF=1, the extended subheader is present and immediately follows the relay MAC header. The ESF is applicable in both the DL and UL.
CI	1	CRC indicator. 1 = CRC is included in the relay MAC PDU by appending it to the relay MAC PDU payload after encryption, if any. 0 = No CRC is included.
EKS	2	Encryption key sequence. The index of the traffic encryption key (TEK) of the access RS operating in distributed security mode and initialization vector (IV) used to encrypt the payload. This field is only meaningful if the EC/AC field is set to 1; otherwise, it shall be set to zero.
LEN	12	Length. The length in bytes of the relay MAC PDU including the relay MAC header and the CRC if present.
CID	16	T-CID or MT-CID.
HCS	8	Header Check Sequence.

174



175

Figure 5-4—Header format of relay MAC PDU with payload

176 **5.1.1.3.3 MAC header without payload**

177 This MAC header format is applicable to UL only. The MAC header is not followed by any MAC PDU
178 payload and CRC.

179 **5.1.1.3.3.1 MAC signaling header type I**

180 For this MAC header format, there is no payload following the MAC header. The MAC signaling header
181 type I is illustrated in Figure 5-5. Table 5-6 describes the encoding of the 3-bit Type field following the
182 EC field.

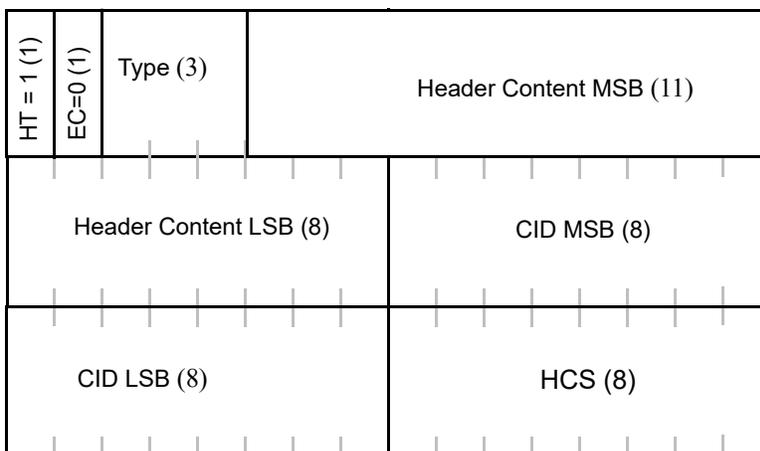


Figure 5-5—MAC signaling header type I format

Table 5-6—Type field encodings for MAC signaling header type I

Type field (3 bits)	MAC header type (with HT/EC = 0b10)	Reference figure	Reference table
000	BR incremental	Figure 6-8	Table 6-7
001	BR aggregate	Figure 6-8	Table 6-7
010	PHY channel report	Figure 6-12	Table 6-11
011	BR with UL Tx power report	Figure 6-9	Table 6-8
100	BR and CINR report	Figure 6-10	Table 6-9
101	BR with UL sleep control	Figure 6-13	Table 6-12
110	SN Report	Figure 6-14	Table 6-13
111	CQICH allocation request	Figure 6-11	Table 6-10

183 **5.1.1.3.3.2 MAC signaling header type II**

184 This type of MAC header is UL-specific. There is no payload following the MAC header. The MAC
185 signaling header type II is illustrated in Figure 5-6. Table 5-7 describes the encoding of the 1-bit type field
186 following the EC field. The description of DL MAC header format with HT/EC = 0b11, defined as the
187 Compressed DL-MAP, is not part of this subclause. The detailed description can be found in 8.4.5.6.1.

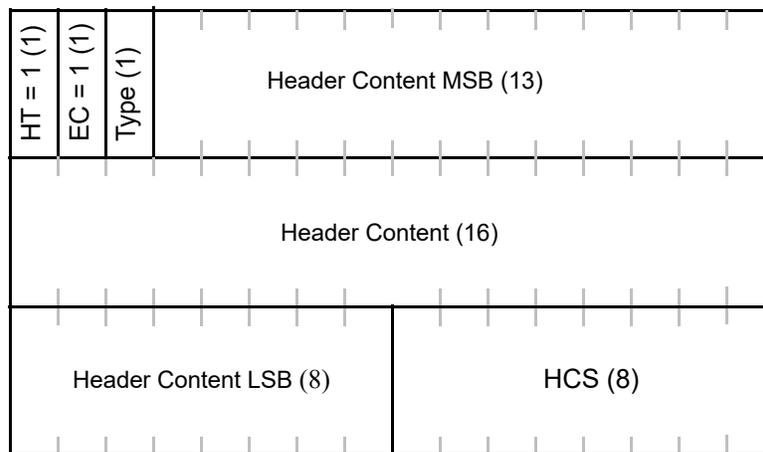


Figure 5-6—MAC signaling header type II format

188 **5.1.1.3.4 DL MAC header without payload**

189 This MAC header format is applicable to DL only. The MAC header is not followed by any MAC PDU
190 payload and CRC.

191 **5.1.1.4 MAC subheaders and special payloads**

192 Five types of subheaders may be present in a MAC PDU with Generic MAC header; four per-PDU
193 subheader types and one per-SDU subheader type. The per-PDU subheaders (i.e., extended subheaders,

Table 5-7—Type field encodings for MAC signaling header type II

Type field	MAC header type (with HT/EC = 0b11)	Reference figure	Reference table
0	Feedback header, with another 4-bit type field; see Table 6-16 for its type encodings.	Figure 6-16, Figure 6-17	Table 6-15
1	Extended relay MAC Signaling Header Type II Extended M2M device MAC Signaling Header Type II (M2M)	Figure 6-20	Table 6-18 Table 6-28

194 FSH, FFSH, and GMSH) may be inserted in the MAC PDUs immediately following the Generic MAC
 195 header. If both the FSH and GMSH are indicated, the GMSH shall come first. In the DL, the FFSH shall
 196 always appear as the last per-PDU subheader. The ESF bit in the Generic MAC header indicates that one or
 197 more extended subheaders are present in the PDU. The extended subheaders shall always appear
 198 immediately after the Generic MAC header and before all other subheaders. All extended subheaders are not
 199 encrypted. (See 6.3.2.2.7.)

200 The only per-SDU subheader is the PSH. It may be inserted before each MAC SDU if so indicated by the
 201 Type field. The PSH and FSH are mutually exclusive and shall not both be present within the same MAC
 202 PDU.

203 When present, per-PDU subheaders shall always precede the first per-SDU subheader.

204 **5.1.1.4.1 Downlink operation**

205 **5.1.1.4.1.1 BS operation**

206 To change the location of a HARQ region associated with a particular Persistent Region ID, the BS transmits
 207 the Persistent HARQ DL MAP IE with a new HARQ Region definition (OFDMA Symbol offset,
 208 Subchannel offset, Number of OFDMA symbols, Number of subchannels) and sets the Persistent Region ID
 209 field of the Persistent HARQ DL MAP IE to the associated Persistent Region ID. The BS should set the
 210 allocation period to the same value for all persistent allocations associated with a particular Persistent
 211 Region ID.

212 **5.1.1.4.1.2 MS operation**

213 If the MS receives a persistent HARQ DL MAP IE, which includes its RCID and has the Persistent Flag set
 214 to 1, the MS shall store the Persistent Region ID field and the HARQ region definition. The MS shall
 215 determine its resource allocation using the slot offset field and the HARQ region definition. Upon receiving
 216 a subsequent Persistent HARQ DL MAP IE in a frame corresponding to the period of the persistent
 217 allocation, which has the Persistent Region ID field set to the stored Persistent Region ID, the MS shall store
 218 the new HARQ region definition and determine its resource allocation using the slot offset field and the new
 219 HARQ region definition. If the MS successfully decodes the DL-MAP and there is no Persistent HARQ DL
 220 MAP IE containing its assigned Persistent Region ID, then the MS shall use the stored location for the
 221 Persistent Region ID for its persistent allocation.

222 **5.1.1.4.2 Uplink operation**

223 **5.1.1.4.2.1 BS operation**

224 To change the location of a HARQ region associated with a particular Persistent Region ID, the BS transmits
 225 the Persistent HARQ UL MAP IE with a new HARQ Region definition. For uplink operation, the HARQ
 226 region is identified by the start of the UL subframe or allocation start indication information (if included).

227 Additionally, the BS sets the Persistent Region ID field of the Persistent HARQ UL MAP IE to the
228 associated Persistent Region ID. The BS should set the allocation period to the same value for all persistent
229 allocations associated with a particular Persistent Region ID.

230 **5.1.1.4.2.2 MS operation**

231 If the MS receives a persistent HARQ UL MAP IE, which includes its RCID and has the Persistent Flag set
232 to 1, the MS shall store the Persistent Region ID and the HARQ region definition. The MS shall determine
233 its resource allocation using the slot offset field and the HARQ region definition. Upon receiving a
234 subsequent Persistent HARQ UL MAP IE in a distance in time which is multiple of the period of the
235 persistent allocation, which has same Persistent Region ID value, the MS shall store the new HARQ region
236 definition and determine its resource allocation using the slot offset field and the new HARQ region
237 definition. If the MS successfully decodes the UL-MAP and there is no Persistent HARQ UL MAP IE
238 containing its assigned Persistent Region ID, then the MS shall use the stored location for the Persistent
239 Region ID for its persistent allocation.

240 **5.1.1.5 Explicit path management for relay**

241 After MR-BS discovers the topology between a newly attached MS or RS and itself, or detects a topology
242 update due to events such as mobility, MR-BS may remove an old path, establish a new path and inform the
243 new path information to all the RSs on the path.

244 When connections are established or removed, MR-BS may distribute the mapping information between the
245 connection and the path to all the RSs on the path. The connection could be a regular connection established
246 for an MS or a connection established for an RS (e.g., basic/primary management CID and tunnel
247 connection). The path management procedures are specified below.

248 **5.1.1.5.1 Path establishment, removal and update**

249 After RS is operational, the MR-BS shall send a DSA-REQ message to distribute the path information to all
250 the RSs on the path. The explicit path information and a uniquely assigned path ID shall be included. The
251 CIDs to be routed on this path and their associated service flow parameters may also be included for path/
252 CID binding operation.

253 If the MR-BS decides to remove an existing path (e.g., after an MRS handover), it shall send a DSD-REQ
254 message with the path ID. The RSs receiving the DSD-REQ message shall remove all the information
255 related to the path.

256 Upon receiving the DSA/DSD-REQ, the RS performs the operation as requested in the message, and then
257 sends the request to its subordinate RS using the primary management CID of the subordinate RS that is
258 obtained from the explicit path information included in the DSA/DSD-REQ message, or derived from the
259 path information obtained from previous operation. Such process is repeated until the last RS on the path
260 (i.e., the access RS) is reached. If an intermediate RS fails to process the request, it sends a DSA/DSD-RSP
261 directly to MR-BS with the associated confirmation code. After receiving the DSA/DSD-REQ, the access
262 RS then sends a DSA/DSD-RSP directly back to MR-BS.

263 The MR-BS may aggregate multiple path management commands into one DSA/DSD-REQ message to
264 save bandwidth. When the paths of different path management commands in the same message divaricates
265 in an RS, the RS separates the path establishment or removal commands into different messages and
266 transmits them to the appropriate next-hop RSs.

267 **5.1.1.5.2 CID to path binding**

268 A routing table that contains the mapping between a CID and one given path needs to be updated when a
269 new tunnel (identified by a Tunnel CID) is generated between the MR-BS and an access RS, or when a new
270 connection (identified by an individual CID) is established for an RS or MS and the new connection is not
271 put into a tunnel. The MR-BS selects a path to carry the traffic for the new connection, and informs all the
272 RSs on the path of the binding between the path ID and the supported CIDs by sending a DSA-REQ
273 message to all the RSs on the specified path. Such DSA-REQ message contains the CIDs of the connections
274 that will be routed through the specified path, the path ID and optionally the service flow parameters for the
275 connection. If the connection is a tunnel connection, the service flow parameters are the aggregate service
276 flow parameters for all the connections put into the tunnel.

277 For multicast there may be more than one path bound to a single multicast CID.

278 When an RS on the path receives such a DSA-REQ message, it retrieves the CIDs and path ID information
279 and builds up the routing table that will be used to route the traffic in the future for the specified CIDs. If the
280 SFID and the QoS requirement are also present for certain connection, the RS saves them for scheduling the
281 traffic for the specified CID. This process is repeated until the last RS along the path is reached. The last
282 access RS then replies with the DSA-RSP.

283 If the MR-BS decides to cancel an existing binding between a path and one or more CID (e.g., after MS or
284 MRS handover to another RS, or MS deregistration, or service flow deletion), it sends a DSD-REQ message
285 with the path ID and the affected CIDs to the associated RSs. The RSs receiving such DSD-REQ shall
286 remove the record of the correspondent mapping.

287 The processing of DSA/DSD-REQ by the RSs on the path is the same as that defined in 5.1.1.5.1.

288 The MR-BS may aggregate multiple CID to path binding commands in one DSA/DSD-REQ message to
289 save bandwidth. In addition, when a path is established for one or more connections, the CID to path
290 binding/unbinding procedure can be conducted together with the path establishment procedure by sending a
291 single DSA-REQ or DSD-REQ to save bandwidth.

292 **5.1.1.5.3 Temporary path establishment and CID to path binding during initial network entry**

293 When an access RS does not use tunneling, a new path is determined by the MR-BS during MS/RS network
294 entry, relay path management for forwarding the management messages of other MS/RS network entry
295 procedures can be conducted as defined below.

- 296 — When an SS/RS performs initial ranging, it shall follow the steps indicated by the type of system in
297 6.3.10.3.1.1.
- 298 — When an RS receives RNG-RSP message with RS basic CID with path information, it shall bind
299 basic CID and primary CID contained in the message with the path ID and start a timer T65
300 associated with the path ID. The RNG-RSP and the SBC-RSP messages shall be forwarded to the
301 access RS by following the same mechanism defined for the DSA message in 5.1.1.5.2. If the RS is
302 the endpoint of the path, replace RS basic CID with ranging CID, and forward to the MS or RS
303 originating RNG-REQ.
- 304 — If T65 expires before the RS receiving DSA-REQ, the RS shall remove the association between the
305 path ID and basic CID and primary CID. Otherwise, the RS shall stop T65 when receiving DSA-
306 REQ with the same path ID.

307 **5.1.1.6 Relaying support for combined ranging and initial topology discovery**

308 A combined initial ranging and initial topology discovery procedure can be conducted as defined below:

- 309 — When an SS/RS performs initial ranging, it shall follow the steps indicated by the type of system in
310 6.3.10.3.1.1.
- 311 — When an MR-BS receives an initial RNG-REQ from an SS/RS, it determines that the SS/RS sending
312 the RNG-REQ directly attaches to MR-BS and is just one hop away.
- 313 — When an MR-BS receives a RNG-REQ message with the CID set to the basic CID of an RS, it shall
314 verify its validity after replacing the basic CID with the ranging CID. Since the MR-BS is already
315 aware of the topology between the selected access RS and itself, by using the same mechanism as
316 defined in this section, it establishes the topology between the SS/RS and itself.

317 **5.1.1.7 R-link monitoring and reporting procedure for relay path management**

318 Computation at the MR-BS of the end-to-end route quality metric for the multihop path between the MR-BS
319 and an RS in its cell may, optionally, be enabled. Optionally, the stability of link quality may be considered
320 as a metric for multihop path selection. A route quality metric may be derived at the MR-BS based on link
321 measurements obtained from a CQI fast-feedback channel (CQICH) and/or from a REP-RSP message
322 carrying an R-link TLV.

323 In the case of RSs operating in centralized scheduling mode, MR-BS may allocate CQICH to an RS in its
324 cell for reporting CQI on DL transmissions originating at RS's superordinate RS or MR-BS. Allocation of
325 CQICH for RSs is performed in the relay zone.

326 In the case of scheduling RS, MR-BS and each RS in an MR cell may allocate CQICH to a subordinate RS.
327 Allocation of CQICH for an RS is performed in the relay zone.

328 To report R-UL, R-DL and R-Link neighbor measurements, REP-RSP messages with R-Link TLV may
329 optionally be used. An MR-BS may send a REP-REQ message to an RS in its cell requesting RSSI mean
330 and standard deviation or CINR mean and standard deviation measurements. The RS may respond with a
331 REP-RSP message containing R-Link TLV and requested measurements. MR-BS may use the reported
332 measurements for route quality calculations, and optionally for computing the stability of a route.

333 **5.1.1.7.1 Access-link monitoring and reporting procedure for MS path management**

334 Computation at the MR-BS of the overall quality metric for the multihop path between the MR-BS and an
335 MS in its cell may, optionally, be enabled. To enable routing metric computation at the MR-BS, R-link
336 metrics shall be reported to the MR-BS in the REP-RSP message containing R-Link TLV, and access link
337 metrics may optionally be reported to the MR-BS in the REP-RSP message containing Access-Link TLV.
338 The REP-RSP message may be sent to the MR-BS in response to the REP-REQ message or by sending an
339 unsolicited REP-RSP message. Access-link measurements at an MS may optionally be triggered by sending
340 a MOB_SCN-RSP message (6.3.2.3.44) to the MS.

341 To enable DL CQI reporting, MR-BS may allocate CQICH to MSs in its cell. CQICH is allocated in the
342 access zone on the access link hop, and may optionally be allocated in the relay zone on subsequent hops.
343 Therefore, an RS may send to MR-BS CQI received from an MS in the access zone through a corresponding
344 CQICH in the relay zone. A fast feedback region for reporting MS CQI values in the relay zone to the
345 MR-BS may be allocated by sending, in a unicast manner, a FAST-FEEDBACK allocation IE (8.4.5.4.39) to
346 an RS. Fast feedback slot assignments in this region shall be the same as those in the CQI fast feedback
347 region in the RS access zone.

348 **5.1.1.8 Path management for multicast services**

349 The MR-BS may initiate a multicast distribution tree for the MBS. Alternatively, an MS may initiate a MBS,
350 by sending a DSA-REQ message with the MBS service request to the MR-BS. The procedures for
351 establishing a multicast distribution tree are as follows.

352 When an MR-BS initiates a MBS or receives a DSA-REQ message with the MBS request from an MS, it
353 checks whether the requested MBS has been created. If not, the MR-BS creates a multicast distribution tree
354 for this MBS and allocates a multicast CID (MCID) to it. The MR-BS also determines the path(s) to carry
355 this multicast service flow. The MR-BS creates the mapping between the determined path and the MCID.
356 The MR-BS informs all the RSs on the path of the binding between the path ID and MCID by sending a
357 DSA-REQ message along path as specified in 5.1.1.5. Each RS along the path stores the path ID and MCID
358 binding information for forwarding multicast data with the MCID. The MR-BS adds this path to the
359 multicast distribution tree and records the number and identification information of the MSs using the path
360 for multicast communications. A multicast distribution tree may consist of multiple paths.

361 If the multicast distribution tree has been created and an MCID has been allocated to this MBS, the MR-BS
362 determines the path to carry this multicast service flow. If the path is not in the multicast distribution tree, the
363 MR-BS creates the binding between the determined path and the MCID. The MR-BS distributes the path
364 and MCID binding information to all the RSs along the path. The MR-BS adds this path to the multicast
365 distribution tree and records the number and identification information of the MSs using the path for
366 multicast communications. If the path is already in the multicast distribution tree, the MR-BS simply
367 updates the number and identification information of the MSs using the path for the MBS in the multicast
368 tree.

369 A path may be removed from a multicast distribution tree by the MR-BS. When an MS needs to leave the
370 multicast service, the MS sends a DSD-REQ to the MR-BS to request removing it from the multicast service
371 flow. The MR-BS first updates the number and identification information of the MSs that are receiving the
372 MBS along the path to this requesting MS. The MR-BS determines whether the path can be removed from
373 the tree MCID. If no more MSs use this path for the MBS, the path may be removed from the multicast
374 distribution tree. Otherwise, the path shall not be removed from the multicast distribution tree. If the path is
375 removed from the tree-MCID then the MR-BS removes the binding between the path and the MCID by
376 sending a DSD-REQ along path as specified in 5.1.1.5.

377 When the parameters for a multicast service flow change, an MR-BS or MS may also send a DSC-REQ
378 message to update these changes. All the RSs in the multicast distribution tree of the MBS are informed of
379 these changes. This is achieved by MR-BS sending a DSC-REQ message to all of the RSs along all the paths
380 in the multicast distribution tree as specified in 5.1.1.5.

381 **5.1.1.9 Neighbor path metric for relay**

382 An end-to-end metric of the path between an RS and its MR-BS may be reported in the MR_NBR-INFO
383 message. The end-to-end metric is carried in the form of a TLV described in 11.4.

384 **5.1.2 Relay station neighborhood discovery**

385 In order to perform RS neighborhood discovery, the RS may obtain its neighbor information using
386 MR_NBR-INFO message (6.3.2.3.61). Then, it shall scan the preamble or, if present, the R-amble
387 transmitted by the existing MR-BS(s) or RS(s), and send the measurement report to the MR-BS using the RS
388 _NBR-MEAS-REP message (6.3.2.3.64).

389 As not every RS will transmit its own preamble and the existing RSs in an MR network need to perform
390 measurement over the preamble, the MR-BS may instruct the RSs to perform complete neighborhood
391 discovery/measurement, as described further in this subclause.

392 The neighborhood discovery/measurement can be used in different stages of operation, during initial
393 network entry, during periodic intervals or whenever an MR-BS requires this information. There are two
394 methods to carry out neighborhood measurements:

- 395 a) Repeatable R-amble transmission and monitoring scheme

396 b) Preplanned R-amble transmission and monitoring scheme

397 **5.1.2.1 Repeatable R-amble transmission and monitoring scheme**

398 The transmission and monitoring frames for the R-amble are specified by the MR-BS in the RS_Config-
399 CMD message (6.3.2.3.63). Each RS finds the R-amble sequences from the parameters provided in the
400 RS_Config-CMD message. More details are provided in 8.4.6.1.1.4. The measurement results shall be sent
401 to the MR-BS by using the RS_NBR_MEAS-REP message (6.3.2.3.64) or using any other appropriate
402 measurement report messages, periodically or as requested by the MR-BS.

403 **5.1.2.2 Preplanned R-amble transmission and monitoring scheme**

404 In this scheme, the MR-BS first sends the RS_Config-CMD message to the RSs that will be involved in the
405 neighborhood measurement mechanism, and the message is either broadcast, multicast or unicast to these
406 RSs. The 8 LSB bits of frame number shall be set to synchronize the starting time to the RSs. If the RSs
407 involved in this mechanism are in a different MR-cell, each of the Start Frame Numbers sent by each MR-
408 BSs shall be synchronized to the same frame time. The Prefix shall be set to “00” and attach the transmit/
409 receive pattern for each iteration. The pattern is indicated by Amble Index, which are the indexes instructed
410 in the RS_Config-CMD message.

411 Second, the stations follow the instruction to transmit/receive the R-amble at the designated frames in each
412 iteration.

413 Third, the RSs report their RSSI or CINR measurement results with corresponding amble index by
414 RS_NBR_MEAS-REP to MR-BS.

415 The preplanned R-amble transmission opportunities are identified by Monitoring Duration and Interleaving
416 Interval for each iteration. An example is given in Figure 5-7, where the Duration = 2, Interleaving Interval
417 = 3 and the Iteration = 2. When the Iteration is more than one, the pattern for each iteration shall be carried
418 in this message. After the last iteration, the RSs shall report the measurement results by RS_NBR_MEAS-
419 REP message defined in 6.3.2.3.64.

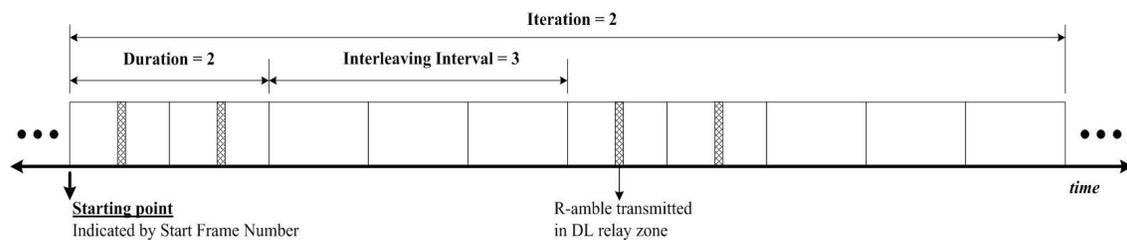


Figure 5-7—R-amble transmission pattern as per the preplanned scheme instructed by MR-BS

420 **5.1.3 Interference measurement in MR systems**

421 This subclause describes a measurement and reporting procedure with supported messaging mechanism to
422 estimate the interference level in MR network.

423 5.1.3.1 Interference prediction by RS neighborhood measurement

424 In order to predict the interference or SINR of the radio links for different MR network topology and radio
425 resource reuse pattern, the following prediction method may be considered based on the RSSI reported by
426 RS_NBR_MEAS-REP message (see 6.3.2.3.64):

- 427 a) Prediction of the interference plus noise power received by station #i: The interference plus noise
428 may be the summation of (1) the thermal noise plus background interference power received by
429 station #i and (2) the signal power not intended to be received by station #i but transmitted by the
430 same radio resource.
- 431 b) Prediction of the received SINR of station #i: The SINR may be the following ratio:
 - 432 1) The total signal power destined to station # i to
 - 433 2) The interference plus noise power obtained in step a)

434 5.1.3.2 Optional interference detection and measurement by RS sounding

435 As an option, the path loss and interference between multiple RSs and the MR-BS can be estimated using
436 the UL sounding mechanism (8.4.6.2.7). In order to predict the interferences between different RS cells, the
437 MR-BS needs to collect the interference measurements from the related RSs and possibly from their
438 associated MSs. The interference can be estimated by having one or multiple RSs or MSs transmit UL
439 sounding signals at specific sounding zones and having the other related RSs and BSs measure the related
440 CINR or RSSI of the received sounding signals. An MR-BS may construct a multicast group within its MR-
441 cell that uses a multicast CID to represent the group of the RSs that participate in the interference
442 measurement. Alternatively multiple unicast messages can be sent. This group is called
443 RS_interference_measurement group and shall be setup before any measurement of UL sounding signals by
444 the group. The interference measurement procedure is controlled by the MR-BS for intra-MR-cell
445 interference measurement. For interference measurement performed across clusters of MR-cells, a network
446 control entity is required to coordinate the measurement activities across the MR-cells.

447 The interference measurement operation within an MR cell is as follows: the MR-BS sends an REP-REQ
448 message to its RS_interference_measurement group. The REP-REQ carries the reporting period, start frame
449 number and the type of measurement reports (either CINR or RSSI). MR-BS sends
450 UL_Sounding_Command_IE to RS_interference_measurement_group as a multicast burst. The MR-BS
451 shall also transmit PAPR_Safety_and_Sounding_Zone_Allocation_IE. When an RS receives such an REP-
452 REQ, it expects to hear the PAPR_Safety_and_Sounding_Zone_Allocation_IE (8.4.5.4.2) starting from the
453 start frame number until the time indicated in the TLV of report period in the REP-REQ message. If an RS
454 specified by the multicast CID in PAPR_Safety_and_Sounding_Zone_Allocation_IE, and indicated by CID
455 in the UL_Sounding_Command_IE, the RS shall transmit the sounding signal at the specified symbol and
456 subcarriers as instructed by the MR-BS. Otherwise, the RSs belonging to the
457 RS_interference_measurement_group shall measure the sounding signals if they are not scheduled to
458 transmit sounding signals in the same symbol. The scheduling of RS
459 PAPR_Safety_and_Sounding_Zone_Allocation_IEs by MR-BS is implementation specific.

460 The sounding signal sent from different RSs and different MSs can be multiplexed in the same sounding
461 zone. This can be done when the MR-BS or RS serving the MS sends to the MS a separate
462 UL_Sounding_Command_IE with instruction of the sounding signal that may be sent by the MS. The
463 measurement and reporting procedure of the MS UL sounding signal by the RSs in the
464 RS_interference_measurement_group remains the same as the RS sounding procedure. The average
465 measurement results are reported. After an MR-BS receives the REP-RSP from all the RSs in its
466 RS_interference_measurement_group, it shall forward it to the network control entity.

467 When interference across different MR-cells needs to be estimated, the above UL sounding procedure shall
468 be conducted with the coordination of a network control entity that controls multiple BSs. In this case the

469 network control entity shall coordinate the multiple BSs to send
470 PAPR_Safety_and_Sounding_Zone_Allocation_IE and UL_Sounding_Command_IE to their respective
471 RS_interference_measurement_groups and MSs for conducting UL sounding measurement across MR-
472 cells. When the RS sounding signal is to be sent by an RS in one of the MR-cells, the same
473 PAPR_Safety_and_Sounding_Zone_Allocation_IE and UL_Sounding_Command_IE shall be duplicated
474 and sent in the other MR cells, so the RSs in these other cells shall conduct measurement on the UL
475 sounding signal.

476 5.1.4 RS broadcast message relaying

477 For a non-transparent RS operating in centralized scheduling mode, the MR-BS shall generate and send
478 RS_Access-MAP message to the RS over the basic connection of the RS. When the RS receives the
479 RS_Access-MAP message, RS shall compose FCH and possibly the associated MAPs such as DL/UL-MAP
480 message, Compressed DL/UL-MAP, SUB-DL-UL-MAPs message and HARQ MAP message, etc., based on
481 the RS_Access-MAP message. In case of more than two hops, the MR-BS shall generate and send
482 RS-Relay-MAP message to RS over the basic connection of the RS. When RS receives RS-Relay-MAP
483 message, RS shall compose R-FCH and R-MAP based on the RS_Relay-MAP message.

484 Upon receiving the DCD/UCD message with RS primary CID, as shown in Figure 5-8, or RS multicast
485 management CID, the RS shall acknowledge the reception of DCD or UCD messages over primary
486 management connection by sending an acknowledgment header (see 6.3.2.1.3.2.2.3) or MR Generic-ACK
487 message (see 6.3.2.3.79). The Transaction ID of the MR Acknowledgment header or 8 LSB of the
488 transaction ID of the MR_Generic-ACK message shall be set to the Configuration Change Count of the
489 DCD or UCD message. There shall be one MR Acknowledgment header or MR_Generic-ACK message per
490 DCD/UCD message. The MR-BS may retransmit the DCD/UCD message if an acknowledgment header or
491 message is not received at the expiration of T61 timer.

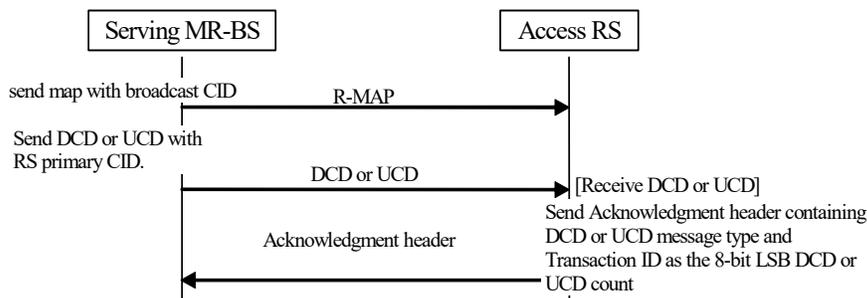


Figure 5-8—Relaying DCD/UCD procedure

492 For a centralized scheduling mode RS, as shown in Figure 5-9, after receiving an acknowledgment header
493 from the RS corresponding to reception of the DCD/UCD, the MR-BS shall periodically allocate unsolicited
494 bandwidth to the RS to enable it to broadcast the DCD/UCD message over the access link by using an
495 RS_BW-Alloc_IE in the RS-Access-MAP message. To enable the RS to send the DCD/UCD message with
496 fragmentable broadcast CID, if the RS_BW-Alloc_IE is lost, the RS shall request bandwidth by using an RS
497 BR header after the timer T69 expires. For a scheduling RS, the RS shall autonomously broadcast DCD/
498 UCD with fragmentable broadcast CID.

499 When the DCD and UCD messages are generated by the MR-BS, the MR-BS shall send DCD and UCD
500 messages to either one RS with its primary management CID or multiple RSs with RS multicast
501 management CID. In RS grouping, the superordinate station of the group shall use the multicast CID of the
502 RS group to send RS RS_Access-MAP message.

503 In MR networks, each RS would be assigned to different DCD/UCD messages with the same configuration
504 change count. In this case, each DCD/UCD message may be separated into the common part and the specific

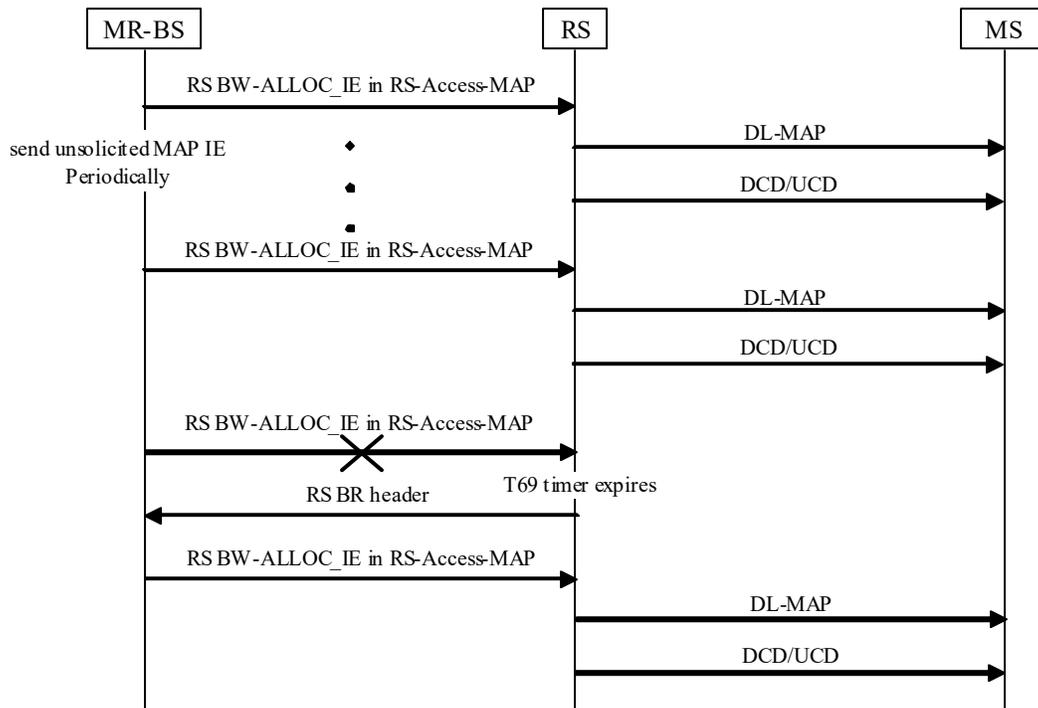


Figure 5-9—DCD/UCD broadcasting procedure with an RS operating in centralized scheduling mode

505 part before fragmentation. The common part shall be packed with multicast management CID, and the
 506 receiving RS shall buffer the common part until receiving the specific part that shall be packed as a new
 507 DCD/UCD message with the RS primary management CID. In the specific part, the message type field,
 508 reserved field and configuration change count field shall be the same as the associated common part. The
 509 receiving RS shall restructure the common part and the associated specific part to a complete DCD/UCD
 510 message, and then broadcast the message with Fragmentable Broadcast CID.

511 5.1.5 RS de-registration

512 In MR networks, an RS may end its service and be removed from the networks. During the RS de-
 513 registration process, all subordinate MSs of the RS shall be transferred to another RS or MR-BS prior to RS
 514 deregistration. An RS may transmit DREG-REQ to an MR-BS so that it initiates the de-registration
 515 procedure and requests handover of all its subordinate MSs. Upon receiving DREG-REQ, the MR-BS
 516 decides whether it allows the RS de-registration. If the request is accepted, the MR-BS may transmit DREG-
 517 CMD to inform the acceptance and start BS-initiated handover process for the requested MSs. After
 518 handover procedures between the MR-BS and the RS's subordinate MSs are completed, the MR-BS informs
 519 the RS that handover is completed by transmitting DREG-CMD. Upon receiving DREG-CMD, the RS starts
 520 deregistration process. The MR-BS may initiate the de-registration process by transmitting an unsolicited
 521 DREG-CMD message.

522 If the MR-BS rejects the request (Action Code = 0x06), the MR-BS informs the RS rejection of the request
 523 by transmitting DREG-CMD. Upon receiving DREG-CMD with rejection information, the RS continues
 524 normal operation. After REQ-duration expires, the RS retransmits DREG-REQ to the MR-BS.

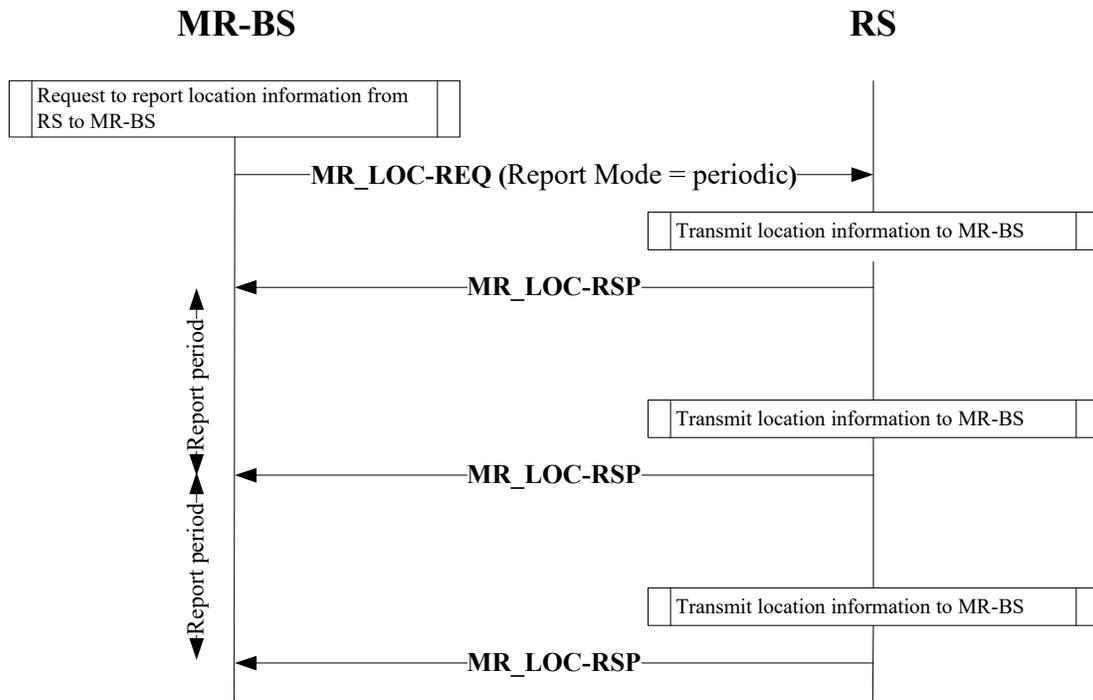
525 **5.1.6 MR location information**

526 In order to assist RS neighborhood discovery, MR-BS may send an MR_LOC-REQ message to the RS.
 527 Upon receiving the MR_LOC-REQ message, the RS shall report its location information by sending an
 528 MR_LOC-RSP message to the MR-BS. If the MR_LOC-REQ message containing the report type field
 529 0b01, RS shall periodically send an MR_LOC-RSP message to the serving MR-BS every time interval
 530 defined by “Report period.”

531 In order to obtain the location information of neighbor stations, an RS may send an MR_LOC-REQ message
 532 to the MR-BS. Upon receiving the MR_LOC-REQ message, MR-BS shall report the location information of
 533 neighboring stations by sending an MR_LOC-RSP message to the RS.

534 The message sequence charts (Figure 5-10, Figure 5-11, and Figure 5-12) describe the RS location request
 535 and report that shall be followed by compliant RSs and MR-BSs.

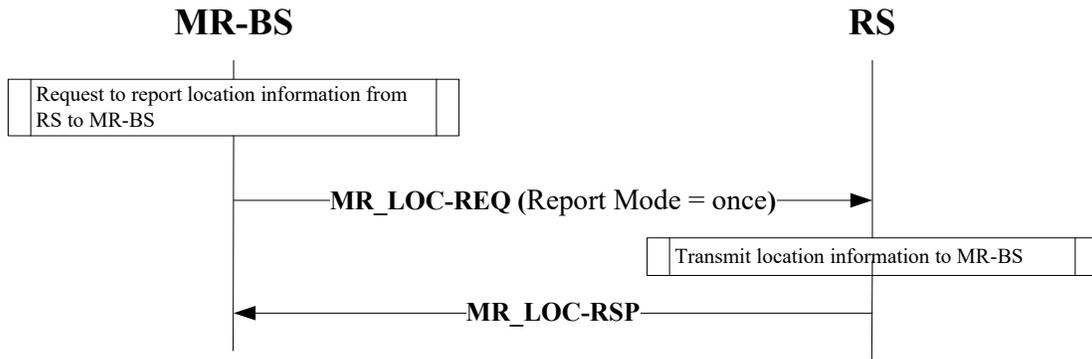
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Figure 5-10—Relay location report (part 1)

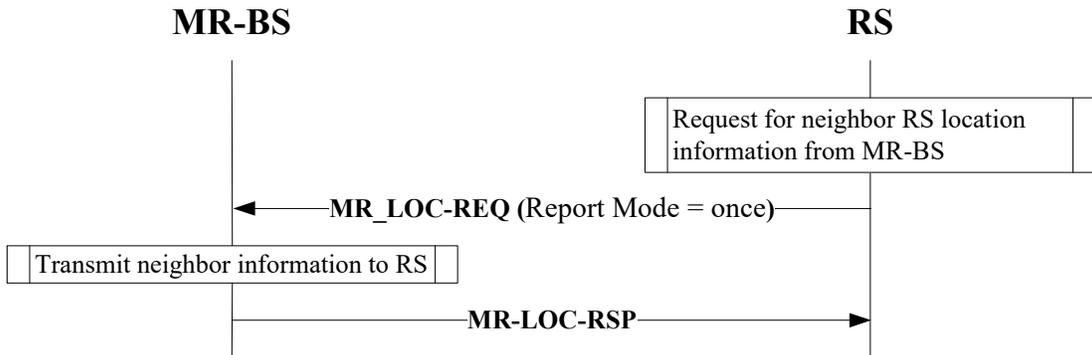
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Figure 5-11—Relay location report (part 2)

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541

Figure 5-12—Relay location report (part 3)

542 **5.1.7 RS grouping**

543 The RS grouping method may be used to enable the following operation scenarios:

- 544 — The operation of an RS in a location where no segment allocation is possible due to interference
- 545 from all other segments
- 546 — The operation of MSs in a region served by multiple short-range RS without incurring high
- 547 handover signaling disadvantages
- 548 — The operation of mobile RSs with dynamic adjustments of coordinated transmission and reception
- 549 — Macro-diversity within an MR cell applied to individual SSs and individual connections

550 The grouping of RS and the coordinated operation of RS in a group is determined and controlled by its
 551 superordinated station or MR-BS.

- 552 — The members of the group are assigned a multicast CID as the RS group ID. The multicast CID is
- 553 the same for all members in the group. Thus, an RS can be managed individually or as a group using
- 554 the basic CID and this multicast CID. These IDs are unique within the associated MR-BS. The
- 555 association of an RS to an RS group is configured using RS_Config-CMD message (see 6.3.2.3.63).

- 556 The multicast CID of the RS group is used for messages that are addressed to all the members of the
557 RS group, and the basic CID is used for the individual members of the RS group. When the MS
558 performs network entry into an RS group, the MS network entry procedure outlined in 6.3.10.3.1.1
559 shall be followed. When the MS moves within the RS group, the MS movement procedure outlined
560 in 5.1.7.1 shall be followed. For a transparent (or non-transparent) RS group all the other procedures
561 follow the procedures for the transparent (or non-transparent) RS. For example, if the RS group is
562 non-transparent, the MAPs for the individual RSs shall be received by the RSs according to the
563 associated procedure defined for a non-transparent RS using the multicast CID of the RS group (see
564 5.1.4).
- 565 — The RS group has a superordinate station (non-transparent RS or MR-BS) that is the superordinate
566 station of all RSs in the group. All the RSs in the RS group shall either transmit the same preamble,
567 FCH and MAPs or they all do not transmit any preamble, FCH or MAPs. The MR-BS or the
568 superordinate station carries out resource control and scheduling for the RS group. The non-
569 transparent RS group transmitting with a preamble different from superordinate station's preamble
570 may be assigned a BSID parameter value. The RS group shall serve only MSs. The radio resources
571 may be shared by the RSs members of the RS group for data burst transmission. The RSs members
572 of the non-transparent RS group shall transmit with the same EIRP parameter value, decided by the
573 MR-BS.
 - 574 — Removal of an RS from the group: During normal operation of the RS group, each RS continues to
575 monitor the radio environment (e.g., the interference). One example is that for an RS that is located
576 at the edge of the group coverage area, it could detect strong segment interference from other nearby
577 RS(s) or RS groups. When this happens, the MR-BS can reconfigure the RS(s) operate in a different
578 RS operational mode using the TLV described in 11.25.1. For RS grouping, DL/UL reciprocity
579 relied on by SS in the open loop power control may not hold. In this case, the SS power control
580 correction term in Equation (8-148) may be used to set SS UL TX power to an appropriate level.
581 Computation of the correction term is implementation specific.
 - 582 — Addition of an RS to an existing group or forming a new group: An RS, at network entry, can a)
583 operate on its own, i.e., it is assigned a dedicated preamble index (implying the segment), b) form a
584 new group or c) join an existing group. The RS may perform measurements such as radio signals
585 from the neighbor stations (the RSs or the MR-BS), and then report to the MR-BS the preferred
586 preamble index selected by the RS (implying the segment). The MR-BS replies by either confirming
587 the preamble sequence index selected by the RS or assigning a different one, indicating whether it
588 should transmit the preamble, and at the same time, providing the corresponding RS group ID. The
589 MR-BS may assign one of the members as the designated RS based on the measured signal qualities
590 at the members. The designated RS may be responsible for certain procedures such as measurement
591 reporting as specified elsewhere in this standard.
 - 592 — For communication with RS groups, tunnel-based or CID based forwarding can be applied. If the
593 MS/SS is served by an RS group, the tunnel connections shall be established between the MR-BS
594 and the superordinate station of the RS group i.e., the superordinate station is considered as the
595 access station for the tunnel connection that is the end-of-tunnel in DL and beginning-of-tunnel in
596 UL.
 - 597 — Data forwarding within RS group: For DL, the members of an RS group may be configured to
598 forward traffic data for only specific subordinate terminal stations. This may be done on a per-
599 connection basis. In this way, by specifying scheduling times, two RSs belonging to the same RS
600 group may transmit to two different MSs/SSs at the same time. In addition, transmissions may be
601 scheduled such that multiple RSs in the RS group may transmit to the same MS to exploit macro-
602 diversity. This scheduling may be achieved for RSs operating in centralized scheduling mode by
603 keeping CID list associated with each RS. Each RS would look for the data bound to its
604 subordinated stations or data coming from the subordinate stations in the uplink and forward in the
605 assigned times indicated in the MAP. The list may be updated by the RS_Member_List_Update
606 message defined in 6.3.2.3.77 or DL_Transmit_Reference_IE defined in 6.3.2.3.80. If the MR-BS
607 does not receive MR_Generic-ACK message from all RS group members designated in the
608 RS_Member_List_Update message after the Frame Action Number, DL_Transmit_Reference IE
609 should be used to encode the forwarding rules for the RS group members. The RS group members

610 shall follow the forwarding rules encoded in DL_Transmit_Reference IE, if present, instead of its
611 original forwarding rules to forward the data to the MS. If the RS_Member_List_Update message is
612 not provided by the superordinate station to the RSs members of the RS group, then all RSs
613 members of the group shall transmit according to the MAPs received, without using the per CID
614 transmission. Data forwarding may also follow the procedure defined in 6.3.15.7 for DL HARQ for
615 RS groups.

616 — For the UL, the UL signaling can be designed such that several member RSs may receive data from
617 multiple MS at the same time. Data forwarding may also follow the procedure defined in 6.3.15.7
618 for UL HARQ for RS groups. This scheduling may be achieved for RSs operating in centralized
619 scheduling mode by keeping an MS list or CID list associated with each RS and forwarding those
620 messages in a specified resource unit (time and frequency). When the MS is same and the resources
621 are the same, it is equivalent to macro-diversity. When the resources are same but the MSs are
622 different, it is equivalent to parallel transmission occurring at different locations.

623 — Each time a handover occurs or a new terminal joins an RS group, the list of CIDs for the RSs in the
624 group may be updated.

625 **5.1.7.1 MS movement among access stations that share the same BSID**

626 The stations that share the same BSID (i.e., the non-transparent RSs that transmit the same preamble, FCH
627 or MAPs or transparent RSs that have the same BSID), shall perform measurement of MS signal quality to
628 assist MS movement among stations.

629 The stations shall measure the signal quality (RSSI, CINR), Timing Adjustment (TA), power and Frequency
630 Adjustment (FA) for each active MS served by these stations to support MS mobility among these stations.
631 All RSs shall use an MR_RNG-REP message to provide MR-BS/superordinate RS with the selected report
632 metrics (RSSI and/or CINR, TA, FA and power adjustment) for each active MS when needed.

633 Two modes of operation are described in 5.1.7.1.1 and 5.1.7.1.2. The mode of operation and related
634 reporting parameters are configured in RS_Config-CMD in 6.3.2.3.63.

635 An MR-BS/superordinate RS may select a new designated RS based on the measurement results and use
636 RNG-RSP to adjust the timing and the power level of the MS, in order to fulfill the handover procedure. An
637 MR-BS/superordinate RS may use the RS_Member_List_Update management message to notify the RSs of
638 the changes regarding data forwarding status for the specified MSs.

639 **5.1.7.1.1 Mode 1**

640 For this mode of operation, only those RSs that are marked as designated RSs shall automatically report the
641 measurement results to MR-BS/superordinate RS in an event-triggered or periodic way, for the basic CID of
642 MSs provided in the RS_Member_List_Update.

643 For event-triggered reporting, the designated RS shall send an MR_RNG-REP message to report its
644 measurement results if the selected triggering condition is met. The trigger condition could be RSSI, CINR,
645 or TA and is specified in RS_Config-CMD message. For periodic reporting, the designated RS shall send an
646 MR_RNG-REP message every REP_INT that is specified in RS_Config-CMD message and the MR-BS/
647 superordinate RS shall periodically allocate uplink resource for the designated RS to report the latest
648 measurement result for each active MS.

649 In Mode 1, non-designated RSs shall report their measurement results only if the RS_MOB_MEAS-REQ
650 message is received. The MR-BS/superordinate RS shall send RS_MOB_MEAS-REQ message to request
651 all or part of RSs in the same RS group to report their measurement results for a specific MS. The MR-BS/
652 superordinate RS shall allocate uplink resource for the selected non-designated RSs to send their MR_RNG-
653 REP messages at the frame specified in RS_MOB_MEAS-REQ.

654 **5.1.7.1.2 Mode 2**

655 For this mode of operation, an RS may report the measurement results to an MR-BS/superordinate RS using
656 an MR_RNG-REP message in an event-triggered way as indicated below.

657 If the MR-BS/superordinate RS provides the thresholds values for triggering, the RS shall send the
658 measurement report to MR-BS/superordinate RS in the following instances:

- 659 — When the measured RSSI/CINR crosses above RSSI/CINR_T_ADD[i] (i=0,...,NRSSI-1/NCINR-1).
- 660 — When the measured RSSI/CINR crosses below the RSSI/CINR_T_DEL[i] (i=0,...,NRSSI-1/
661 NCINR-1).
- 662 — When the current measured TA exceeds TA_DIFF and the RS has the CID of the MS included in the
663 RS_Member_List_Update message.

664 If the MR-BS/superordinate RS does not provide the threshold values for adding/removing an MS, the RS
665 uses its own threshold values to decide when to report the measurement to MR-BS/superordinate RS.

666 **5.1.8 Support of multicast operation for M2M applications**

667 A BS may provide a multicast service for group of M2M devices that share a downlink multicast service
668 flow. The BS shall initiate the establishment of a service flow using the DSA procedures. During the
669 establishment of the service flow, the service flow is assigned an M2MCID, which uniquely identifies the
670 service flow. The M2M device shall retain these identifiers in idle mode (see 6.3.1). The BS shall provide
671 the mapping between the service flow and the M2MCID during the DSA signaling and may modify this
672 mapping using the DSC procedures or by using M2MCID Update TLV during network reentry.

673 **5.1.8.1 M2M multicast operation in idle mode**

674 A BS may provide a multicast service for M2M devices in idle mode with or without requiring network
675 reentry of the M2M devices. Before a BS sends DL multicast data, the BS shall transmit the paging message
676 including the multicast traffic indication to the M2M devices during the paging listening intervals of the
677 M2M devices. If an M2M device receives the paging message indicating multicast traffic reception without
678 network reentry during its paging listening interval and the paging message does not include the Multicast
679 transmission start time TLV, the M2M device shall start receiving the DL multicast data without the idle
680 mode termination.

681 The Multicast transmission start time TLV may be included in the paging message in order to indicate when
682 the DL multicast data is sent by the BS. The value of Multicast transmission start time TLV shall be less than
683 the start time of the next paging listening interval of the M2M devices receiving the MOB_PAG-ADV
684 message. The M2M device may power down until the frame indicated by the Multicast transmission start
685 time TLV in the MOB_PAG-ADV message.

686 When the multicast data transmission ends, the BS shall notify the end of multicast data transmission to the
687 group of M2M devices by sending the MOB_MTE-IND message. Upon receiving the MOB_MTE-IND
688 message, the M2M devices may enter the paging unavailable interval as specified in 6.3.22.4.

689 In order to receive the M2M multicast data during idle mode M2M devices in idle mode shall use M2M
690 Multicast Traffic Reception timer. If Multicast transmission start time TLV is included in the MOB_PAG-
691 ADV message indicating the multicast traffic reception (Action code = 0b10), M2M devices receiving the
692 MOB_PAG-ADV message shall start the Multicast Traffic Reception timer at the frame indicated by the
693 Multicast transmission start time TLV. Otherwise, the M2M device shall start the Multicast Traffic
694 Reception timer when the M2M device receives the MOB_PAG-ADV. The M2M device shall reset this
695 timer whenever the multicast data is received and stop the timer when it receives the MOB_MTE-IND

696 message. If the M2M Multicast Traffic Reception timer expires, the M2M device shall enter the paging
697 unavailable interval as specified in 6.3.22.4.

698 **5.1.9 Abnormal power down**

699 When an abnormal or involuntary power down has occurred, an M2M device may attempt to report the
700 abnormal power down event.

701 **5.1.9.1 Abnormal power down reporting in normal operation**

702 If the M2M device is in normal operation with uplink bandwidth already allocated and available, then it may
703 use the available bandwidth to send an M2M Abnormal Power Down Report header (as defined in
704 6.3.2.1.3.2.3.1).

705 If the M2M device does not have available UL bandwidth, then it may use the procedure defined in 6.3.6 to
706 request bandwidth. Upon receiving bandwidth allocation it may send the M2M Abnormal Power Down
707 Report header.

708 The M2M device may start its Abnormal Power Down Confirmation timer at the transmission of the M2M
709 Abnormal Power Down Report header in order to wait for Abnormal Power Down Confirmation signaling
710 header. If the M2M device has not received the M2M Abnormal Power Down Confirmation header until the
711 Abnormal Power Down Confirmation timer expires, it may restart the abnormal power down reporting
712 procedure.

713 **5.1.9.2 Abnormal power down reporting in idle mode**

714 When an abnormal power down occurs, an M2M device in idle mode that has been configured to report
715 abnormal power down events and that has a valid security association with the preferred BS shall select a
716 ranging opportunity within a backoff window starting at the next frame. The M2M device shall set the back-
717 off window size as large as possible, yet such that it is guaranteed to complete the abnormal power down
718 reporting procedure before its power is depleted. The M2M shall select the ranging opportunity, t , where
719 $t = 1, \dots, b$, within the backoff window according to the following cumulative distribution function:

$$720 \quad F(t) = \frac{N^{t/b} - 1}{N - 1}$$

721 where b is the backoff window size and N is the value of the configurable system parameter Abnormal
722 Power Down Ranging Opportunity Selection parameter (see Table 10-1). At the selected ranging
723 opportunity, the M2M device shall transmit the Abnormal Power Down Ranging Code, which is also a
724 configurable system parameter (see Table 10-1).

725 The BS, upon receiving the ranging code, may include a CDMA Allocation IE in the next frame identifying
726 the M2M device and provide an allocation sufficiently large to allow the M2M device to transmit a RNG-
727 REQ message including a Ranging Purpose Indication TLV and the CMAC/HMAC Tuple. Upon receiving
728 this allocation, the M2M device shall transmit a RNG-REQ message including a Ranging Purpose
729 Indication TLV with bits 5–7 set to 001 (power outage) and a valid HMAC/CMAC Tuple. The M2M device
730 shall not repeat sending of a ranging code if it does not receive an allocation from the BS.

731 If the target BS evaluates the HMAC/CMAC Tuple as valid and can supply a corresponding authenticating
732 HMAC/CMAC Tuple, then the target BS may reply with a RNG-RSP message including the Location
733 Update Response TLV and HMAC/CMAC Tuple completing the abnormal power down reporting process.

734 5.1.10 M2M Short Data Burst transmission

735 If an M2M device receives a bandwidth allocation that is sufficient for piggybacking M2M Short Data Burst
736 contents in a RNG-REQ message during network reentry, it may send the RNG-REQ message with a
737 piggybacked M2M Short Data Burst with SFID for Short Data Burst.

738 If the data is received successfully, the BS shall send a RNG-RSP message with an M2M Short Data Burst
739 Confirmation TLV. This concludes the Short Data Burst transaction.

740 If an M2M device receives a bandwidth allocation that is not sufficient for piggybacking M2M Short Data
741 Burst contents, it may include an M2M Bandwidth Request combined with the related SFID in a RNG-REQ
742 message during network reentry. If the allocation allows for it, it may additionally include the Bandwidth
743 Request Size in the RNG-REQ message. If the BS receives the RNG-REQ message with an M2M
744 Bandwidth Request, the BS shall include M2M Bandwidth Request ACK in the RNG-RSP message. If the
745 BS accepts the bandwidth request, the BS shall allocate UL bandwidth to the M2M device after network
746 reentry completion.

747 To transmit short data DL bursts, the BS may include an M2M Short Data Burst TLV in a RNG-RSP
748 message when the action code of MOB_PAG-ADV indicates location update.

749 For DL short data burst transmission, the BS should send a Basic CID and a Temp CID Timer in a RNG-
750 RSP message. When the M2M device successfully receives a RNG-RSP message with an M2M Short Data
751 Burst, a Basic CID, and the Temp CID Timer, it shall set T3 timer (see Table 10-1) and wait for bandwidth
752 allocation on the Basic CID. If UL bandwidth is allocated before expiration of T3 timer, the M2M device
753 transmits a RNG-REQ message containing an M2M Short Data Burst Confirmation TLV. If T3 timer
754 expires, the M2M device shall perform bandwidth request procedure to transmit a RNG-REQ message
755 containing an M2M Short Data Burst Confirmation TLV.

756 5.2 Procedures for uncoordinated coexistence

757 This subclause describes enhancements in support of operation in license-exempt bands. First, general
758 concepts are described, after which details of support for uncoordinated coexistence mechanisms are
759 presented. The mechanisms detailed are as follows:

- 760 — Coexistence with *specific spectrum users* (SSUs) (5.2.1.2), often termed Dynamic Frequency
761 Selection (DFS) (ITU-R F.1499 [B51], ETSI EN 301 893 [B17]).
- 762 — Coexistence with *non-specific spectrum users (non-SSUs)* (5.2.1.3). Dynamic Channel Selection
763 (DCS) (5.2.1.3.2) is a realization.
- 764 — Uncoordinated Coexistence Protocol (UCP) (5.2.1.3).

765 Mechanisms are related to bands containing SSUs and those containing non-SSUs. It shall be left to
766 regulation to mandate such mechanisms for a particular band.

767 5.2.1 Uncoordinated coexistence mechanisms

768 5.2.1.1 Overview

769 This subclause details a number of uncoordinated coexistence mechanisms. Whether these features are
770 mandatory or optional is governed by adherence to profiles described in 12.8.1.

771 The mechanism overviewed in 5.2.1.2 is intended to protect *specific spectrum users* (SSUs) where
772 regulation mandates. Subclause 5.2.1.3 provides a general uncoordinated coexistence mechanism suitable,
773 for example, in bands where no mandatory coexistence behavior is required.

774 In bands containing both SSUs and non-SSUs, it can be expected that a combination of schemes presented in
775 5.2.1 will be required to provide mandatory protection for the SSUs and as well as a means of coexistence
776 with non-SSUs.

777 Subclause 5.2.1.3 provides a UCP to provide a further mechanism to allow operation in license-exempt
778 bands for non-SSUs.

779 Upon system startup, the BS shall choose a suitable channel in which to operate. Channel selection shall
780 depend upon the requirements for operation in a given band. If the band contains SSUs, the BS shall use a
781 protocol termed in this subclause “DFS” to attempt to find a channel free of SSUs; this protocol is described
782 in 5.2.1.2. If the band contains only non-SSUs (IEEE 802.16 or non-IEEE 802.16), the BS uses the DCS
783 protocol to find the best channel for operation; this protocol is described in 5.2.1.3. In certain regulatory
784 regimes where SSUs are not present, it may be sufficient for the choice of channel to be able to be performed
785 manually with coordination between operators as needed. If the band contains both SSUs and non-SSUs
786 (IEEE 802.16 or non-IEEE 802.16) then both DFS and DCS protocols are used together. The DFS protocol
787 is used to avoid interference to SSUs by vacating the channels on which SSUs are detected, and additionally
788 DCS is used to select the best channel of the set of channels in the band that are cleared for operation by
789 DFS.

790 The BS shall continue to perform DFS and DCS operation, as required, selecting the most appropriate
791 channels based on the prevailing conditions and reacting to reported measurements from the SSs. For the
792 case where SSUs are detected on a channel then the DFS protocol shall attempt to select an alternative
793 channel. For the non-SSU (IEEE 802.16 or non-IEEE 802.16) detection of the BS shall use the DCS
794 protocol in order to select an alternative channel, previously checked to be clear of SSUs. For improved
795 coexistence with other uncoordinated IEEE 802.16 systems, the BS shall claim a Master frame (15.4.1.2)
796 sequence as described in 5.2.1.3.3 and shall use the described mechanism to share the channel with up to two
797 other IEEE 802.16 systems on a minimally interfering basis.

798 This clause describes the use of a UCP. The UCP is designed to use passive cognitive radio techniques to
799 allow co-channel coexistence between multiple IEEE 802.16 systems.

800 **5.2.1.2 Uncoordinated coexistence with specific spectrum users (SSUs)**

801 **5.2.1.2.1 Overview**

802 Procedures are defined in this subclause that may be used when the IEEE 802.16 system is sharing a
803 frequency band with another system or service to reduce interference to and from other systems, to facilitate
804 coexistence of systems, or to address other reasons. These procedures generally involve mechanisms to
805 facilitate the detection of other users and to avoid and prevent harmful interference into other users. Within
806 these procedures for certain sharing scenarios, regulatory requirements specify that DFS (as defined by
807 ITU-R M.1652 [B52]) shall be used to facilitate sharing with SSUs identified by regulation. A specific
808 spectrum user is a user from a service specifically identified by regulation as requiring protection from
809 harmful interference. When DFS is mandated by regulatory requirements, it shall be implemented according
810 to this specification.

811 Further, the use of a channel selection algorithm may be required, which results in uniform channel
812 spreading across a minimum number of channels. This specification is intended to be compliant with
813 regulatory requirements such as ECC/DEC/(04)08 [B11]. The timing and threshold parameters used for DFS
814 are specified by each regulatory administration.

815 The procedures specified in this subclause provide for the following:

- 816 — Testing channels for other users including SSUs (5.2.1.2.2)
- 817 — Discontinuing operations after detecting other users including SSUs (5.2.1.2.3)

- 818 — Detecting other users including SSUs (5.2.1.2.4)
- 819 — Scheduling for channel testing (5.2.1.2.5)
- 820 — Requesting and reporting of measurements (5.2.1.2.6)
- 821 — Selecting and advertising a new channel (5.2.1.2.7)

822 5.2.1.2.2 Testing channels for other users (including specific spectrum users)

823 A BS or SS implementing these procedures shall not use a channel that it knows contains other users or has
824 not been tested recently for the presence of other users. A BS shall test for the presence of other users based
825 on timing parameters and values that may be set locally or, in the case of DFS and the detection of specific
826 spectrum users, may be defined in regulation. Timing parameters include the following:

- 827 — **Startup Test Period** before operating in a new channel if the channel has not been tested for other
828 users for at least **Startup Test Period** during the last **Startup Test Valid**.
- 829 — **Startup Test Period** before operating in a new channel if a channel was previously determined to
830 contain other users during the last **Startup Test Valid**.
- 831 — **Operating Test Period** (where the period is only accumulated during testing) of each **Operating**
832 **Test Cycle** while operating in a channel. Testing may occur in quiet periods or during normal
833 operation.

834 An SS may start operating in a new channel without following the above start-up testing procedures if

- 835 — The SS moves to the channel as a result of the receipt of a Channel Switch Announcement from the
836 BS.
- 837 — The SS is initializing with a BS that is not currently advertising, using the Channel Switch
838 Announcement, that it is about to move to a new channel.

839 A BS may start operating in a new channel without following the above start-up testing procedures if it has
840 learned from another device by means outside the scope of this standard that it is usable.

841 5.2.1.2.3 Discontinuing operations after detecting specific spectrum users

842 If a BS or an SS is operating in a channel and detects SSUs, it shall discontinue any transmission of the
843 following:

- 844 — MAC PDUs carrying data within **Max Data Operations Period**.
- 845 — MAC PDUs carrying MAC management messages within **Management Operations Period**.

846 The values of the above parameters may be set locally or, in the case of DFS, may be defined in regulation.

847 The detection of a *specific spectrum user* shall mean the channel is unusable for a **Channel Exclusion**
848 **Period**. The channel is marked as an Excluded Channel for a period defined by regulation.

849 5.2.1.2.4 Detecting specific spectrum users

850 Each BS and SS shall use a method to detect SSUs operating in a channel that satisfies the regulatory
851 requirements, where applicable. The particular method used to perform detection is outside the scope of this
852 standard.

853 5.2.1.2.5 Scheduling for channel testing

854 A BS may measure one or more channels itself and may request any SS to measure one or more channels on
855 its behalf, either in a quiet period or during normal operation.

856 To request the SSs to measure one channel, the BS shall include in the DL-MAP a Channel Measurement IE
857 as specified in 8.3.6.2.3. The BS that requests the SSs to perform a measurement shall not transmit MAC
858 PDUs to any SS during the measurement interval. If the channel measured is the operational channel, the BS
859 shall not schedule any UL transmissions from SSs to take place during the measurement period.

860 Upon receiving a DL-MAP with the Channel Measurement IE, an SS shall start to measure the indicated
861 channel no later than **Max. Channel Switch Time** after the start of the measurement period. An SS may
862 stop the measurement no sooner than **Max. Channel Switch Time** before the expected start of the next
863 frame or the next scheduled UL transmission (of any SS). If the channel to be measured is the operating
864 channel, Max. Channel Switch Time shall be equal to the value of the receive/transmit transition gap (RTG),
865 as specified in Table 8-304, or, in the case of DFS Max. Channel Switch Time, may be defined in regulation.

866 **5.2.1.2.6 Requesting and reporting of measurements**

867 The SS shall, for each measured channel, keep track of the following information:

- 868 — Frame Number of the frame during which the first measurement was made
- 869 — Accumulated time measured
- 870 — Existence of a specific spectrum user on the channel
- 871 — Whether a IEEE 802.16 system using the same PHY system was detected on the measured channel
- 872 — Whether unknown transmissions [such as radio local area network (RLAN) transmissions] were
873 detected on the channel

874 The BS may request a measurement report by sending a REP-REQ message. This is typically done after the
875 aggregated measurement time for one or more channels exceeds the regulatory required measurement time.
876 Upon receiving a REP-REQ the SS shall reply with a REP-RSP message and reset its measurement counters
877 for each channel on which it reported.

878 If the SS detects a SSU on the channel where it is operating during a measurement interval or during normal
879 operation, it shall immediately cease to send any user data if so mandated by regulatory requirements and
880 send at the earliest possible opportunity an unsolicited REP-RSP. The BS shall provide transmission
881 opportunities for sending an unsolicited REP-RSP frequently enough to meet regulatory requirements,
882 where applicable. The SS may also send, in an unsolicited fashion, a REP-RSP when other user interference
883 is detected above a threshold value.

884 **5.2.1.2.7 Selecting and advertising a new channel**

885 A BS may decide to stop operating in a channel at any time. The algorithm used to decide to stop operating
886 in a channel is outside the scope of this standard, but shall satisfy any regulatory requirements.

887 A BS may use a variety of information, including information learned during SS initialization and
888 information gathered from measurements undertaken by the BS and the SSs, to assist in the selection of the
889 new channel. The algorithm to choose a new channel is not standardized but, in the case of DFS, shall satisfy
890 any regulatory requirements, including uniform spreading rules and channel testing rules. If a BS would like
891 to move to a new channel, a channel supported by all SSs in the sector should be selected.

892 A BS shall inform its associated SSs of the new channel using the Channel Nr in the DCD message. The new
893 channel shall be used starting from the frame with the number given by the Channel Switch Frame Number
894 in the DCD message. The BS shall not schedule any transmissions during the last Max. Channel Switch
895 Time before the channel change is to take place.

896 The Uplink Burst Profiles used on the old channel defined shall be considered valid also for the new
897 channel, i.e., the BS need not define new Uplink Burst Profiles when changing channels. When operating in
898 license-exempt bands, the BS shall not send the Frequency (Type = 3) parameter as a part of UCD message.

899 5.2.1.3 Uncoordinated coexistence with non-specific spectrum users (non-SSUs)

900 5.2.1.3.1 Overview

901 This subclause considers uncoordinated coexistence mechanisms for use in bands where non-SSUs are
902 present. The important distinction for coexistence with non-SSUs, when compared with SSUs (5.2.1.2), is
903 that there are less stringent, if any, regulatory demands placed on the coexistence solution. Aspects where
904 requirements may be relaxed include monitoring resource requirements and accompanying detection times,
905 probability of detection requirements, or time to vacate the operating channel. When a non-SSU is detected
906 it is not mandated that the operating channel be vacated, it may be possible to use a more robust modulation
907 scheme, or use an AAS beamforming approach to focus energy and reduce interference; however, to meet
908 with some guidelines on coexistence in license-exempt bands then channel changing to a less interfered
909 channel may be a preferred option. One realization of uncoordinated coexistence with non-SSUs is termed
910 *Dynamic Channel Selection* (DCS).

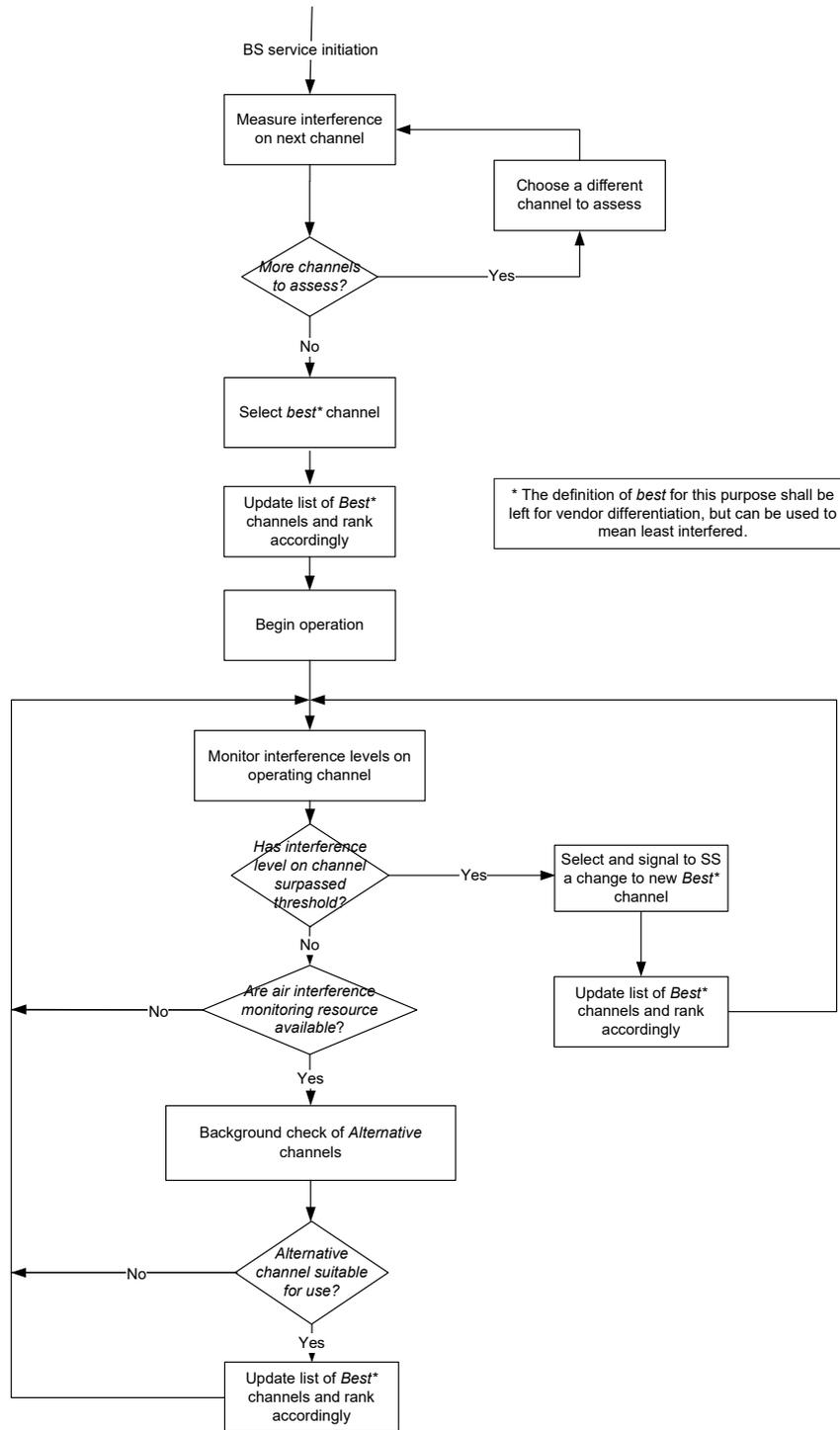
911 5.2.1.3.2 Dynamic Channel Selection (DCS)

912 Dynamic Channel Selection (DCS) is an uncoordinated coexistence mechanism that provides the ability for
913 a system to switch to a different physical frequency channel, based on channel conditions, and thereby avoid
914 interference in license-exempt bands. DCS can be used as a means of finding a least interfered channel at
915 system startup or can be used during normal system operation to provide constant interference monitoring
916 capabilities and, with the ability to monitor other channels, provide a list of *alternative channels* for
917 informed switchover to a different, less interfered, channel. An illustrative example is given in Figure 5-13
918 for possible behavior at the BS, while Figure 5-14 illustrates the behavior at the SS. DCS may be used when
919 the interference is caused by other IEEE 802.16 systems or by non-IEEE 802.16 systems (e.g., IEEE 802.11
920 systems).

921 Quiet periods for measurement are scheduled by the BS via the DL-MAP and the UL-MAP for the BS and
922 SS respectively, with measurements provided, for example, by an OFDM Periodic Channel Measurement IE
923 (see 8.3.6.2.10) and OFDMA Periodic Channel Measurement IE (see 8.4.5.3.34). These mechanisms are
924 supported with the REP-REQ/REP-RSP (6.3.2.3.33) MAC messages to provide reports of incident
925 interference. Once a channel is deemed unusable due to prevailing interference that has surpassed the
926 *acceptable threshold* or degraded the BER sufficiently, the BS may choose to move to a new channel. This
927 new channel may be unmeasured or a member of an *alternative* list of available channels previously
928 measured by the BS or SSs. The number of *alternative channels* that can be monitored depends on the spare
929 channel capacity available. Also the “freshness” of a channel (in terms of when the channel was last
930 measured and how accurate the measurement is likely to be) may also depend on available resources to
931 accomplish this task. The previously interfered channel that was vacated may be monitored for usability
932 after some defined period. Figure 5-13 and Figure 5-14 provide an example of how DCS can be used to
933 provide resource management and alternative operating channels.

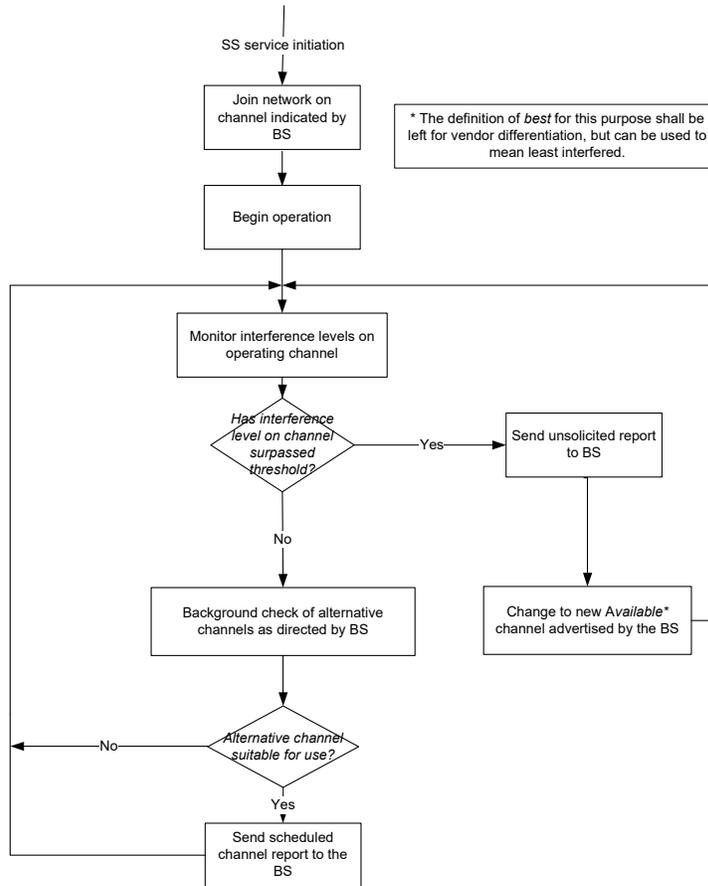
934 An example of a DCS solution is provided in Figure 5-15 in which interference detection results in a channel
935 change. Figure 5-15 indicates the events that occur following interference detection at the BS. The DCS
936 algorithm has a choice to either vacate the channel or overcome the interference by using a more robust
937 modulation scheme. The Channel Measurement IE, containing a reference to the ChCtrFr, is used to make
938 the channel change. A similar procedure is followed for interference detection at the SS, illustrated in
939 Figure 5-16; however, in this case, the REP-RSP message, sent by the SS in an unsolicited manner,
940 initializes the response by the BS.

941 The mechanism given in 5.2.1.2 may be used to maintain a list of available *alternative channels* for use in
942 the event interference is detected on a channel that needs vacating due to high levels of interference.



943

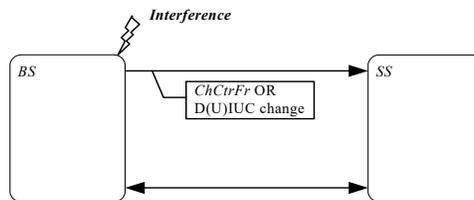
944 **Figure 5-13—Flowchart showing generic operation at the BS in bands with non-SSUs only**



945

946 **Figure 5-14—Flowchart showing generic operation at the SS in bands with non-SSUs only**

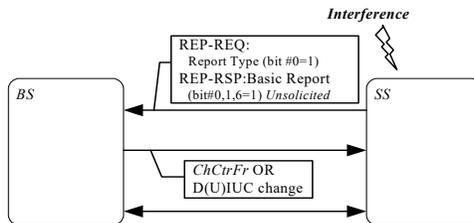
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Figure 5-15—Interference reporting and remedial action at the BS

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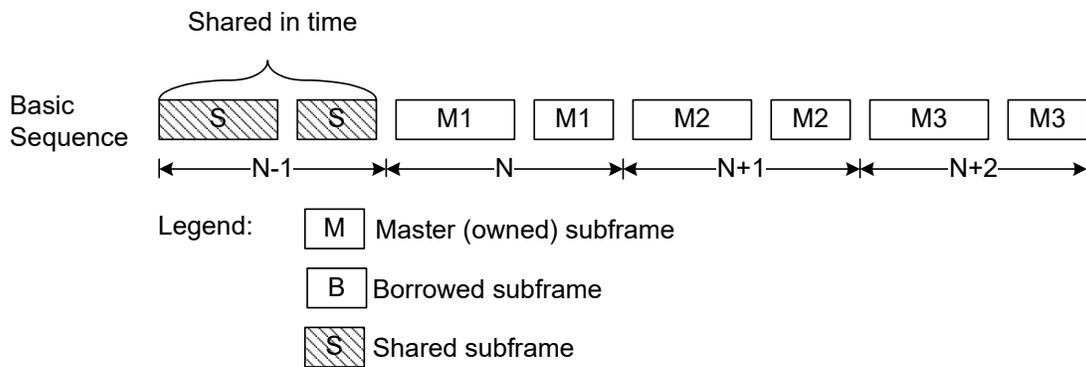
Figure 5-16—Interference reporting and remedial action at the SS

951 **5.2.1.3.3 Frame structure and frame allocation**

952 Co-channel coexistence between multiple IEEE 802.16 systems is achievable by the sharing of frames,
 953 whereby advantage is derived from the synchronous behavior of IEEE 802.16. This sharing is reliant upon a
 954 known frame allocation and network synchronization. The mechanism for co-channel coexistence at the
 955 frame level is related to the band of operation, but all BS shall follow the procedures in 15.2. Situations exist
 956 where frames may be assigned to IEEE 802.16 systems by administrative means within the context of a 4-
 957 frame structure. This administrative provisioning eliminates the need to support a discovery protocol, and an
 958 a priori knowledge of frame allocation patterns. Such situations occur, for example, in bands where a
 959 regulatory requirement demands device registration together with information on device location. It is
 960 therefore possible to make use of this location information and make informed decisions on which systems
 961 should be assigned to which frames. Administrative provisioning shall therefore be used if sufficient
 962 information is available, otherwise a discovery protocol or standardized frame structure shall be used.

963 The frame structure based on the CX-Frame is described in 15.4. The systems compliant with UCP shall not
 964 use Slave subframes.

965 When all systems attempting to coexist on the same channel are IEEE 802.16 systems, the end result after all
 966 three systems have entered the channel is a four frame sequence of frame usage as shown in Figure 5-17.
 967 This is a simplified version of Figure 15-19.

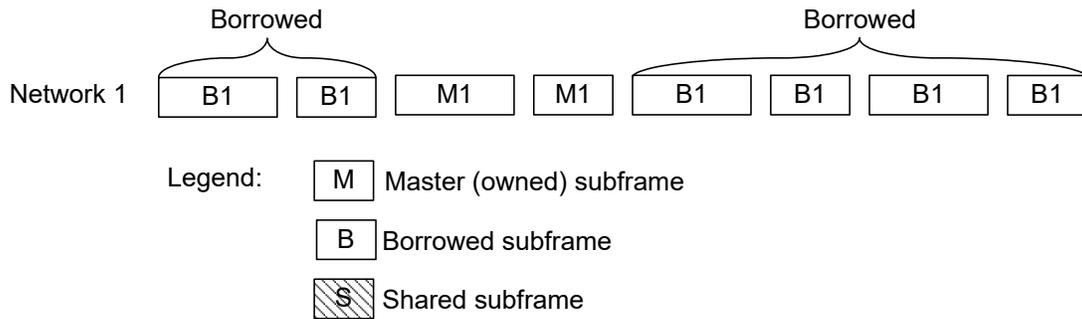


968

Figure 5-17—Basic four frame repetitive sequence

969 Initially when the channel has no occupants, the first system to operate on the channel shall claim a slot
 970 within the repetitive sequence as Master. While a system may be administratively allowed to borrow unused
 971 slots a system shall claim no more than a single slot as Master. It does not matter which slot the first system
 972 claims although it is highly recommended that all BSs on the given channel belonging to the same network
 973 operator claim the same slot as this will reduce the need for operator coordination. Operator coordination is
 974 necessary when there are conflicts that are not resolved automatically. If there are two operators on the same
 975 channel, operating in the same geographic location, and the equipment of the first has randomly chosen a
 976 different Master allocation in each cell, then it becomes much more difficult for the equipment of the second
 977 operator to automatically select non-interfering allocations. Any unresolved cases of interference should be
 978 resolved through operator coordination.

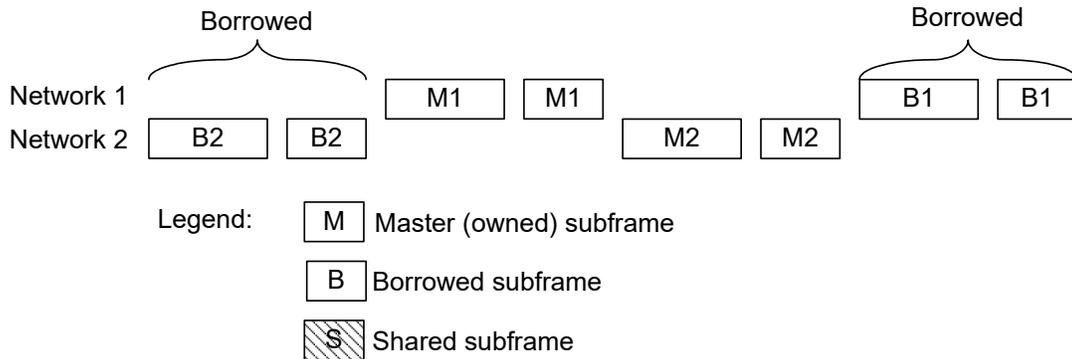
979 The result of the first system claiming slot 1 of the repetitive sequence is shown in Figure 5-18.



980

Figure 5-18—First IEEE 802.16 system claiming slot 1

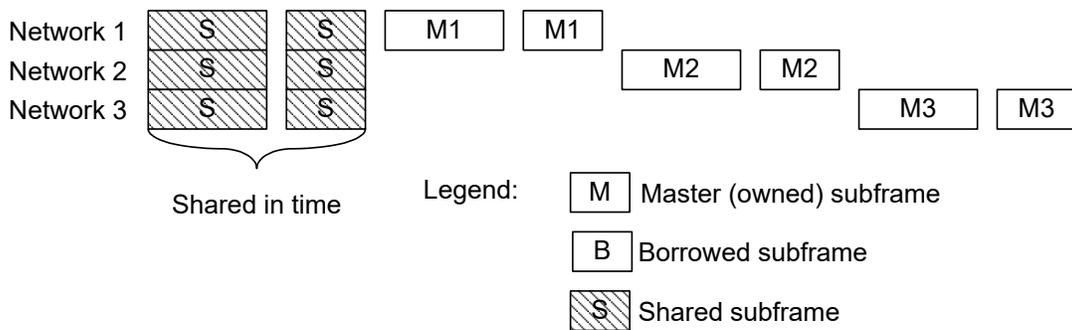
981 The result after a second system has claimed slot 2 is shown in Figure 5-19.



982

Figure 5-19—Second IEEE 802.16 system claiming slot 2

983 The result after a third system has claimed slot 3 is shown in Figure 5-20. This creates the basic 4-frame
 984 sequence originally described.



985

986

Figure 5-20—Third IEEE 802.16 system claiming slot 3

6. TLV encodings

6.1 Common encodings

Common TLV fields and their associated type codes are presented in Table 6-1.

Table 6-1—Type values for common TLV encodings

Type	Name
115	CSGID
116	HR multicast service flow update mapping info
117	ABS information for direct HO
118	Network address for intersystem communication
119	UCD encodings
120	DCD encodings
121	SA-SZK-Update
122	Path Info
123	Path CID Binding Update
124	Path Addition
125	Path ID
126	Bi-directional service flow
127	MCID Continuity and Transmission Info
128	MCID Pre-allocation and Transmission info
129	Query ID
130	MIHF frame type
131	MIHF frame
132	Verbose NSP Name List
133	NSP List
134	Paging Information
135	Paging Controller ID
136	MAC Hash Skip Threshold
137	Next Periodic Ranging
138	SLPID_Update
139	Enabled-Action-Triggered
140	Short-HMAC tuple
141	CMAC tuple
142	SA-TEK-Update

Table 6-1—Type values for common TLV encodings (continued)

Type	Name
143	Vendor-Specific Information
144	Vendor ID Encoding
145	Uplink Service Flow
146	Downlink Service Flow
147	Current Transmit Power
148	MAC Version Encoding
149	HMAC Tuple

7. Management interfaces and procedures

17. Support for Multi-tier Networks

17.1