Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Draft IEEE 802.16m Requirements**
Date	**2007-03-15**
Source(s)	802.16m Requirements Editor: mark.cudak@motorola.com Mark Cudak Motorola
Re:	Call for Comments on Project 802.16m Requirements (IEEE 802.16m-07/008r2)
Abstract	This document was edited in the TGm meeting during Session #48. The following sections have been reviewed during Session #48: sub-sections 5.2, 5.5, 5.6, 5.7, 5.9 of section 5, sub-sections 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.12 of section 6, all of section 7, and sub-section 8.3 of section 8. All the text in the reviewed sections is no longer color-code or bracketed. All remaining sections have not completed task group review and therefore continue to carry the color-coding and brackets.
Purpose	Edited version of the 802.16m requirements as reviewed by TGm in Session #48
Notice	
Release	
Patent Policy and Procedures	

Contents

Editor's notes:

This document has been both color-coded and encoded using bracketed text. The color-coding is used to identify input from the various contributions. At the top of each major section you will find a table assigning a color to particular contribution. Colors have been reused from one major section to another. We have attempted to give like authors the same color throughout the document; however, this was not possible in all cases. All colored-coded text is sourced from the contributions with only minor edits. Black text represents editor's proposed text. In addition to the color coding, the drafting group has marked some text with brackets and left other text unbracketed. Square brackets [ ] identify text that requires further harmonization. This may include situations where the specified text is proposed for removal by one or more contributors or there are contradictory contributions related to that text.

UPDATE 3/15/2007: This document was edited in the TGm meeting during Session #48. The following sections have been reviewed during the Session #48: sub-section 5.2, 5.5, 5.6, 5.7, 5.9 of section 5, sub-sections 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.12 of section 6, all of section 7, and sub-section 8.3 of section 8. All the text in the reviewed sections is no longer color-code or bracketed. All remaining sections have not completed task group review and they continue to carry the color-coding and brackets

1.0Overview

Color	Section 1-4 Source Document Authors	Section 1-4 Source Document Reference
Blue	San Youb Kim, et. al.	IEEE C802.16m-07/030
Brown	Sassan Ahmadi, et. Al.	IEEE C802.16m-07/041
Green	Kiseon Ryu, et. Al.	IEEE C802.16m-07/037
Pink	Roger Marks	IEEE C802.16m-07/079

The IEEE 802.16m amendment provides an advanced air interface which includes enhancements and extensions to IEEE STD 802.16-2004 and 802.16e-2005 in order to meet the requirements of next generation mobile networks.

[IEEE 802.16m is based on the WirelessMAN-OFDMA specification and provides continuing support for legacy WirelessMAN-OFDMA equipment, including base stations and subscriber stations.]

[IEEE 802.16m is based on the WirelessMAN-OFDMA specification and defines a backward compatible evolution of the standard providing interoperability with legacy subscriber stations and base stations.]

The purpose of this standard is to update the WirelessMAN-OFDMA air interface in accordance with the requirements defined for the internationally agreed radio interface standards for next generation mobile networks such as IMT-Advanced.

This standard is intended to be a candidate for consideration in the IMT-Advanced standard evaluation process being conducted by the International Telecommunications Union – Radio Communications Sector (ITU-R).

This document captures the high-level system requirements for the proposed IEEE 802.16m amendment as envisioned by the working group.

The system requirements for the IEEE 802.16m are defined to ensure competitiveness of the evolved air-interface with respect to other mobile broadband radio access technologies, and to ensure support and satisfactory performance for the emerging services and applications. The IEEE 802.16m system requirements also call for significant gains and improvements relative to the IEEE 802.16e reference system to justify the creation of a new standard revision/amendment.

[IEEE 802.16m is further required to maintain backward compatibility with the existing deployment of IEEE 802.16e standard. A reference system is defined that includes all mandatory features and a subset of optional features of IEEE 802.16e standard as specified by the Mobile System Profile [1] and is used as the reference for backward compatibility.]

This document further describes possible deployment scenarios for IEEE 802.16m standard. These scenarios include topologies consisting of new and legacy mobile and base stations as well as combinations of fixed and mobile relays.

[While IEEE 802.16m is expected to further facilitate the use of mobile multi-hop relays, the baseline architecture of the IEEE 802.16m does not include relays and the system requirements shall be met without inclusion of the relay stations.]

Some of the requirements in this document are separated for the mobile and the base station. Such requirements shall be construed as minimum performance requirements for the mobile and base stations. It must be noted that the system requirements described in this document shall be met with a system comprising of all new IEEE 802.16m compliant mobile and base stations.

[To accelerate the completion and evaluation of the standard, and in order to improve the clarity and reduce complexity of the standard specification, and to further facilitate the deployment of the IEEE 802.16m systems, the number of optional features shall be limited to a minimum.]

[The P802.16m draft shall be developed in accordance with the P802.16 project authorization request (PAR), as approved on 6 December 2007 <http://standards.ieee.org/board/nes/projects/802-16m.pdf>, and with the Five Criteria Statement in IEEE 802.16-06/055r3 <http://ieee802.org/16/docs/06/80216-06_055r3.pdf>.

According to the PAR, the standard shall be developed as an amendment to IEEE Std 802.16. The scope of the resulting standard shall fit within the following scope:

This standard amends the IEEE 802.16 WirelessMAN-OFDMA specification to provide an advanced air interface for operation in licensed bands. It meets the cellular layer requirements of IMT-Advanced next generation mobile networks. This amendment provides continuing support for legacy WirelessMAN-OFDMA equipment.

And the standard will address the following purpose:

The purpose of this standard is to provide performance improvements necessary to support future advanced services and applications, such as those described by the ITU in Report ITU-R M.2072.

The standard is intended to be a candidate for consideration in the IMT-Advanced evaluation process being conducted by the International Telecommunications Union– Radio Communications Sector (ITU-R).

This document represents the high-level system requirements for the P802.16m draft. All content included in any P802.16m draft shall meet these requirements. This document, however, shall be maintained and may evolve. If a proponent wishes to propose material for the P802.16m draft that is not in compliance with this document, the proponent is advised to first initiate a discussion on the revision of this requirements document.

These system requirements embodied herein are defined to ensure competitiveness of the evolved air interface with respect to other mobile broadband radio access technologies as well as to ensure support and satisfactory performance for emerging services and applications. These system requirements also call for significant gains and improvements relative to the preexisting IEEE 802.16 system that would justify the creation of the advanced air interface.

To accelerate the completion and evaluation of the standard, to improve the clarity and reduce complexity of the standard specification, and to further facilitate the deployment of new systems, the number of optional features shall be limited to a minimum.]

[

1.1 Scope

This document specifies the requirements for P802.16m – an amendment to the 802.16 standard – consistent with the approved PAR [6]. While the scope of the amendment is limited to the air interface, this document provides system-level requirements from which specific air interface specifications would be derived.

1.2 Purpose

Define detailed requirements for an advanced air interface that would also meet the requirements of ITU-R IMT-Advanced.

1.3 Document Revision

As the PAR [6], section 5.3, states, the completion of the project is contingent upon the completion of the ITU-R IMT-Advanced requirements, on a timely basis. Therefore, this document may have to be revised when the IMT-Advanced requirements document is released by the ITU-R.

]

2.0 References

[1] WiMAX Forum™ Mobile System Profile, Release 1.0 Approved Specification (Revision 1.2.2: 2006-11-17) (see http://www.wimaxforum.org/technology/documents).

[2] IEEE Std 802.16-2004: Part 16: IEEE Standard for Local and metropolitan area networks: Air Interface for Fixed Broadband Wireless Access Systems, June 2004

[3] IEEE Std. 802.16e-2005, IEEE Standard for Local and metropolitan area networks, Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems, Amendment 2: Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands, and IEEE Std. 802.16-2004/Cor1-2005, Corrigendum 1, December 2005.

[4] Recommendation ITU-R M.1645: Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000, January 2003

[5] Multi-hop Relay System Evaluation Methodology (Channel Model and Performance Metric), http://ieee802.org/16/relay/docs/80216j-06_013r2.pdf, November 2006.

[6] IEEE 802.16m PAR, http ://standards.ieee.org/board/nes/projects/802-16m.pdf

[7] ITU-R Document 8F/TEMP/495-E: Draft Guidelines for Evaluation of Radio Transmission Technologies for IMT-Advanced, January 2007.

[8] ITU-R Document 8F/TEMP/496-E: Draft [Report on] Requirements Related to Technical System Performance for IMT-Advanced Radio Interface(s), January 2007.

[9] 3rd Generation Partnership Project 2, “cdma2000 Evaluation Methodology”, http://www.3gpp2.org/Public_html/specs/C.R1002-0_v1.0_041221.pdf , 3GPP2 C.R1002-0 Version 1.0, December 2004

[10] WiMAX Forum System Performance White Paper, http://www.wimaxforum.org/technology/downloads/Mobile_WiMAX_Part1_Overview_and_Performance.pdf

3.0 Definitions

Sector	This term refers to physical partitioning of the base station (BS). When there are N transmitting directional antennas in the BS, each of them is named a sector.
Cell	A collection of sectors (typically 3) belonging to the same base station.
[IEEE 802.16e Mobile Station	Compliant with the IEEE 802.16 WirelessMAN-OFDMA specification specified by IEEE 802.16-2004 and amended by IEEE 802.16e-2005.]
IEEE 802.16e Base Station	Compliant with the IEEE 802.16 WirelessMAN-OFDMA specification specified by IEEE 802.16-2004 and amended by IEEE 802.16e-2005]
[IEEE 802.16e Reference System	A system compliant with a subset of the IEEE 802.16 WirelessMAN-OFDMA capabilities specified by IEEE 802.16-2004 and amended by IEEE 802.16e-2005, where the subset is defined by the WiMAX Forum™’s Mobile System Profile, Release 1.2 Approved Specification [1].
IEEE 802.16e Mobile Station	A mobile station compliant with a subset of the IEEE 802.16 WirelessMAN-OFDMA capabilities specified by IEEE 802.16-2004 and amended by IEEE 802.16e-2005, where the subset is

defined by the WiMAX Forum™'s Mobile System Profile, Release 1.2 Approved Specification [1].

IEEE 802.16e Base Station — A base station compliant with a subset of the IEEE 802.16 WirelessMAN-OFDMA capabilities specified by IEEE 802.16-2004 and amended by IEEE 802.16e-2005, where the subset is defined by the WiMAX Forum™'s Mobile System Profile, Release 1.2 Approved Specification [1].]

IEEE 802.16m Mobile Station — Compliant with the IEEE 802.16 WirelessMAN-OFDMA specification specified by IEEE 802.16-2004 and amended by IEEE 802.16e-2005 and IEEE 802.16m

IEEE 802.16m Base Station — Compliant with the IEEE 802.16 WirelessMAN-OFDMA specification specified by IEEE 802.16-2004 and amended by IEEE 802.16e-2005 and IEEE 802.16m

[WirelessMAN-OFDMA/2005 — A compliance profile to be added to Clause 12 during the 802.16 revision project begun in March 2007. This profile includes several subprofiles, distinguished by duplex method (TDD or FDD) and FFT size. By default, each subprofile would specify all mandatory features currently embodied the standard, including maintenance changes.]

[WirelessMAN-OFDMA/2005 — A profile to be added to Clause 12 during the 802.16m project. This profile will include several subprofiles, distinguished by duplex method (TDD or FDD) and FFT size. By default, each subprofile would specify all mandatory features currently embodied the standard, including maintenance changes. Each subprofile in the WirelessMAN-OFDMA/2008 profile shall require legacy support for the corresponding subprofile in WirelessMAN-OFDMA/2008; see Subclause 5.1 for details.]

4.0 Abbreviations and Acronyms

Abbreviation	Description
AAS	Adaptive Antenna System
BS	Base Station
CALEA	Communications Assistance for Law Enforcement Act of 1994
CDF	Cumulative Distribution Function
DL	Downlink
FCH	Frame Control Header
FDD	Frequency Division Duplexing

FER	Frame Error Rate
FTP	File Transfer Protocol
L2/L3	Layer 2/Layer 3
LAN	Local Area Network
LBS	Location Based Services
MAC	Medium Access Control
MBS	Multicast and Broadcast Service
MG	Major Group
MIMO	Multiple-Input Multiple-Output
MS	Mobile Station
OFDMA	Orthogonal Frequency Division Multiple Access
PAN	Personal Area Network
PHY	Physical Layer
PoC	Push over Cellular
PUSC	Partial Use of Sub-Carriers
QoS	Quality of Service
RAT	Radio Access Technique/Technology
RRM	Radio Resource Management
RS	Relay Station
TCP	Transport Control Protocol
TDD	Time Division Duplexing
UL	Uplink
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
WAN	Wide Area Network

5.0General Requirements

Color	Section 5 Source Document Authors	Section 5 Source Document Reference
Blue	San Youb Kim, et. al.	IEEE C802.16m-07/031
Brown	Sassan Ahmadi, et. Al.	IEEE C802.16m-07/042
Violet	Xin Qi, et. Al.,	IEEE C802.16m-07/024
Grey	John Humbert, et. Al.	IEEE C802.16m-07/027r1
Green	Kiseon Ryu, et. Al.	IEEE C802.16m-07/037
Red	Dan Gal, et. Al.	IEEE C802.16m-07/056
Orange	Mark Cudak, et. Al	IEEE C80216m-07/019
Gold	Michael Webb et. Al.	IEEE C80216m-07/023
Pink	Roger Marks	IEEE C80216m-07/079
Plum	Comments input to the meeting	I

This section contains general requirements for IEEE 802.16m systems. These requirements are intended to supplement the requirements specified by the ITU-R for IMT-Advanced systems.

5.1 *Legacy Support*

The IEEE 802.16m amendment is based on the IEEE Standard 802.16 WirelessMAN-OFDMA specification.

IEEE 802.16m shall provide continuing support and interoperability for legacy WirelessMAN-OFDMA equipment, including base stations and mobile stations.

[This continuing support shall be limited to only a "harmonized sub-set" of IEEE 802.16e OFDMA features. This harmonized sub-set is captured by the WiMAX Forum™ definition of OFDMA mobile system profiles [1]. These WiMAX mobile system profiles shall serve as the IEEE 802.16e reference system.]

A new IEEE 802.16m mobile station [should] [shall] be able to operate with a IEEE 802.16e base station at a level of performance that is equivalent to an IEEE 802.16e mobile station.

An IEEE 802.16m base station shall support:

- operation of IEEE 802.16e mobile stations with performance equivalent to an IEEE 802.16e base station, and
- concurrent operation of both IEEE 802.16m and 802.16e mobile stations on the same RF carrier.

[An IEEE 802.16m base station should also support:

- concurrent operation of IEEE 802.16e and 802.16m mobile stations on the same RF carrier where the 802.16m base station operates at a channel bandwidth larger than that of the 802.16e mobile station, and concurrent operation of two 802.16m mobile stations on the same RF carrier in different channel bandwidths.[1]]

[IEEE 802.16m base stations operating in bandwidths greater than 20 MHz shall only be required to support 802.16e mobile stations operating with bandwidths of 20 MHz or less.]

The performance of an IEEE 802.16m system supporting concurrent operation of IEEE 802.16e and 802.16m mobile stations should be proportional to the fraction of 802.16m mobile stations attached to the base station.

[Legacy support requirements shall apply to both TDD and FDD duplexing modes, respectively, with a minimal degradation of performance in backward compatibility operational configurations.][2]

IEEE 802.16m shall enable the efficient upgrade of existing IEEE 802.16e (reference system) base stations to 802.16m compliance and enable graceful migration of IEEE 802.16e systems to fully capable 802.16m systems.[3]

IEEE 802.16m shall operate and support backward compatibility in all bands where existing IEEE 802.16e systems are deployed or could be deployed by the time 802.16m technology is available. [This requirement shall not be construed as different modes of operation for different frequency bands; rather to reduce the number of optional features and the complexity of the standard, a unified baseband system with configurable parameters shall be used for operation in different frequency bands.]

[It shall not be mandatory that every IEEE 802.16m mobile station also support any or all of the IEEE 802.16e modes.]

[It shall not be mandatory that every IEEE 802.16m base station also support any or all of the IEEE 802.16e modes on all channels.]

[In view of continuing support for legacy 802.16 systems, the legacy 802.16 terminals shall be able to be supported within the spectrum band(s) where the IEEE 802.16m might be deployed.]

[IEEE 802.16m system shall meet the IMT-Advanced performance/capability requirements and support legacy terminals simultaneously.]

[The IEEE 802.16m enhancements shall be transparent to the IEEE 802.16e reference-system-based terminals and base stations.]

[IEEE 802.16m may also be deployed on a separate RF carrier as an overlay to legacy IEEE 802.16e reference system.]

Editor's note: choose one of the following:

[The IEEE 802.16m system shall support seamless handover to and from legacy IEEE 802.16e reference system.]

[An IEEE 802.16m base station shall support seamless handover of IEEE 802.16e mobile stations to and from legacy IEEE 802.16e base stations.]

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[1] This probably belongs in a different section.

[2] Legacy requirements only apply to TDD per WiMAX profile??

[3] Maybe move this to a different section??

[Clause 12 of P802.16m shall specify a new profile, tentatively titled “WirelessMANOFDMA/2008.” This profile shall include a number of subprofiles. Each unique combination of duplexing mode (TDD or FDD) and FFT size shall be represented by a unique subprofile. Clause 12 shall not delete the WirelessMAN-OFDMA/2005 profile, nor edit it other than to make minor maintenance changes that are deemed essential. Furthermore, the P802.16m draft will not substantively alter any normative content references by the WirelessMAN-OFDMA/2005 profile, other than to make minor maintenance changes that are deemed essential. If any maintenance changes are made, the P802.16m draft shall rename the WirelessMAN-OFDMA/2005 profile as “WirelessMAN-OFDMA/2005r1”. The nature of any such maintenance changes shall ensure that devices compliant to the originally specified WirelessMAN-OFDMA/2005 profile shall be compliant with WirelessMAN-OFDMA/2005r1.

Each subprofile in the WirelessMAN-OFDMA/2008 profile shall require legacy support for the corresponding subprofile (i.e., the subprofile with matching duplexing and FFT size) in WirelessMAN-OFDMA/2008, specified as follows:

- A WirelessMAN-OFDMA/2008 MS [should] [shall] interoperate with a WirelessMAN-OFDMA/2005 BS at a level of performance that is equivalent to that of a WirelessMAN-OFDMA/2005 MS.
- A WirelessMAN-OFDMA/2008 BS shall interoperate with a WirelessMANOFDMA/2005 MSs at a level of performance that is equivalent to that of a WirelessMAN-OFDMA/2005 BS.
- A WirelessMAN-OFDMA/2008 BS shall support concurrent operation of both WirelessMAN-OFDMA/2005 and WirelessMAN-OFDMA/2008 MSs on the same RF carrier.
- A WirelessMAN-OFDMA/2008 BS shall support seamless handover of WirelessMAN-OFDMA/2005 MSs to and from WirelessMAN-OFDMA/2005BSs.
- {additional conditions to be determined}]

[This standard amends the IEEE 802.16 WirelessMAN-OFDMA specification to provide an advanced air interface for operation in licensed bands. It meets the cellular layer requirements of IMT-Advanced next generation mobile networks. This amendment provides continuing support for legacy WirelessMAN-OFDMA equipment.]

5.2 Complexity

The IEEE 802.16m PHY/MAC should enable a variety of hardware platforms with differing performance and complexity requirements.

IEEE 802.16m shall minimize complexity of the architecture and protocols and avoid excessive system complexity. It should enable interoperability of access networks , support low cost devices and minimize total cost of ownership.

[Standard changes should focus on areas where the 802.16e reference system can be enhanced to meet the requirements.]

[IEEE 802.16m should only provide enhancements in areas where the IEEE 802.16e reference system does not meet the requirements.]

The IEEE 802.16m system shall satisfy the performance requirements in Section 7.0. In addition, the complexity of base stations and mobile stations shall be minimized by adhering to the following:

a) The performance requirements shall be met with mandatory features only.

b) Optional features shall be considered only if they provide significant functional and performance improvements over mandatory features.

c) Support of multiple mandatory features which are functionally similar and/or have similar impact on performance shall be avoided.

d) The number of states of protocols and procedures should be minimized.

All enhancements included as part of the IEEE 802.16m amendment should promote the concept of continued evolution, allowing IEEE 802.16 to maintain competitive performance as technology advances beyond 802.16m.

5.3 Services

IEEE 802.16m should support existing services more efficiently as well as facilitate the introduction of new/emerging types of services.

IEEE 802.16m and its services architecture shall be flexible in order to support services required for next generation mobile networks, such as those identified by Report ITU-R M.2072 and IMT-Advanced (IMT.SERV).

IEEE 802.16m shall support different QoS levels for different services. IMT-Advanced QoS requirements shall be supported including end-to-end latency, throughput, and error performance.

5.4 Operating Frequencies

IEEE 802.16m systems shall operate in RF frequencies less than 6 GHz and be deployable in licensed spectrum allocated to the mobile and fixed broadband services and shall be able to operate in frequencies identified for IMT-Advanced.

IEEE 802.16m shall be capable of coexisting with other IMT-ADVANCED technologies.

5.5 Operating Bandwidths

IEEE 802.16m shall support scalable bandwidths from 5 to 20 MHz. Other bandwidths shall be considered as necessary to meet operator and ITU requirements

5.6 Duplex Schemes

IEEE 802.16m shall be designed to support both TDD and FDD operational modes. The FDD mode shall support both full duplex and half duplex mobile station operation. Specifically, a half-duplex FDD mobile station is defined as a mobile station that is not required to transmit and receive simultaneously.

IEEE 802.16m shall support both unpaired and paired frequency allocations, with fixed duplexing frequency separations when operating in full duplex FDD mode.

System performance in the desired bandwidths specified in Section 5.5 should be optimized for both TDD and FDD independently while retaining as much commonality as possible.

The UL/DL ratio should be configurable. In TDD mode, the DL/UL ratio should be adjustable. In FDD mode, the UL and DL channel bandwidths may be different and should be configurable (e.g. 10MHz downlink, 5MHz uplink). In the extreme, the IEEE 802.16m system should be capable of supporting downlink-only configurations on a given carrier.

Asymmetrical operation should be supported in addition to symmetrical operation.

5.7 Support of Advanced Antenna Techniques

IEEE 802.16m shall support MIMO and beamforming operation.

The IEEE 802.16m standard shall define minimum antenna requirements for the base station and mobile station.

For the base station, a minimum of two transmit and two receive antennas shall be supported. For the MS, a minimum of one transmit and two received antennas shall be supported. This minimum is consistent with a 2x2 downlink configuration and a 1x2 uplink configuration.

5.8 [Regulatory Requirements]

[IEEE 802.16m shall not preclude support of regional regulatory requirements such as CALEA, E911, etc.]

[Supporting high priority service in wireless network is one of important issues from government operator perspective and end-user perspective.]

[End-user: IEEE 802.16m shall provide high priority for emergency service calls (such as 911). Such high priority service shall be protected by proper assignment of radio resources.]

[Government/Operator: In emergency situations, wireless networks can experience severe congestion due to large call volumes. This causes damage to network facilities and further more prohibits emergency callings from Federal, state, and local government personnel. IEEE 802.16m shall support management of and response to emergency callings from government personnel in emergency situations.]

[IEEE 802.16m shall support preemption and prioritized system access.]

[802.16 SHALL support regional regulatory requirements, such as Emergency Services (E9-1-1) [1] and the Communications Assistance for Law Enforcement Act (CALEA) [2] [3].

[1] FCC Docket no 94-102 this includes order numbers 96-264, 99-96, 99-245
[2] Communications Assistance for Law Enforcement Act of 1994 (CALEA), Pub. L. No. 103-414, 108 Stat. 4279.
[3] Communications Assistance for Law Enforcement Act and Broadband Access and Services First Report and Order and Further Notice of Proposed Rulemaking. ET Docket No. 04-295, RM-10865, 20 FCC Rcd 14989 (2005)]

5.9 System Architecture Requirements

TBD

6.0 Functional Requirements

Editor's notes:

Source text is shown in color in this document as shown below:

Black - Original text

Color	Section 6 Document Source	Section 6 Document Reference
Olive	Phil Orlik	IEEE C802.16m-07/014
Orange	Mark Cudak, et. al	IEEE C80216m-07/017r1
Gold	Michael Webb et. al.	IEEE C802.16m-07/021
Violet	Xin Qi, et. al.	IEEE C80216m-07/025
Pink	Ronald Mao et. al.	IEEE C802.16m-07/029
Blue	San Youb Kim, et. al.	IEEE C80216m-07/032
Green	Aeran Youn, et. al	IEEE C80216m-07/038
Brown	Sassan Almadi, et. al.	IEEE C80216m-07/043
Red	Dan Gal, et. al.	IEEE C80216m-07/049

This section contains system level functional requirements targeting higher peak rates, lower latency, lower system overhead as well as PHY/MAC features enabling improved service security, QoS and Radio Resource Management.

6.1 Peak Data Rate

This section defines the peak data rate achievable between a base station and a mobile station under ideal conditions.

The minimum peak rate requirement supported by mobile stations compliant with the 802.16m specification, expressed as a normalized peak rate (i.e. absolute maximum supported data rate divided by the occupied channel bandwidth) is specified in Table 1.

Table 1. Normalized Peak Data Rate

Link Direction	Normalized Peak Rate (bps/Hz)
Downlink (BS->MS)	> 6.5

Uplink (MS->BS)	> 2.8

Notes applicable to Table 1. :

1. The specified requirements of normalized peak rates are not distinguished by duplex mode. Rather, 100% of radio resources are assumed – for the purposes of computing Table 1– allocable to downlink and uplink respectively regardless of duplexing mode.
2. Table 1. accounts for overhead due to provisioning of radio resources for essential functions such as pilots, cyclic-prefix, guard bands and guard intervals.
3. The specified minimum supported normalized peak rates are applicable to all bandwidths specified in Section 5. For example, for mobile stations supporting a 20MHz bandwidth, the minimum supportable peak rate (excluding overhead mentioned above) is > 130Mbps.

6.2 Latency

Latency should be further reduced as compared to the IEEE 802.16e reference system for all aspects of the system including the air link, state transition delay, access delay, and handover.

The following latency requirements shall be met by the system, under unloaded conditions.

6.2.1 Data Latency

Requirements for air link data latency are specified in terms of the time for delivery of a MAC PDU, transmissible as a Layer 1 codeword (i.e. without fragmentation), from the MAC interface of a base station or mobile station entity to the MAC interface of the corresponding mobile station or base station entity, excluding any scheduling delay at the base station. A single Layer 1 re-transmission of the codeword is included in the definition. The latency does not include bandwidth requests. The corresponding maximum latency for delivery of the MAC PDU appears in Table 2.

Table 2. Maximum Data Latency

Link Direction	Max. Latency (ms)
Downlink (BS->MS)	10
Uplink (MS->BS)	10

6.2.2 DELETED SECTION

6.2.3 State Transition Latency

Performance requirements for state transition delay define the transition from IDLE mode to ACTIVE mode.

IDLE to ACTIVE_STATE is defined as the time it takes for a device to go from an idle state (fully authenticated/registered and monitoring the control channel) to when it begins exchanging data with the network on a traffic channel or timeslot measured from the paging indication (i.e. not including the paging period).

Table 3. State Transition Latency

Metric	Max. Latency (ms)
IDLE_STATE to ACTIVE_STATE	100 ms

6.2.4 Handover Interruption Time

Handover performance requirements, and specifically the interruption times applicable to handovers between base stations supporting 802.16e and 802.16m, and intra- and inter-frequency handover.

The maximum MAC-service interruption times specified in Table 4 apply to handover of mobile stations supporting 802.16m between base stations supporting 802.16m and operating in the absence of 802.16e-2005 mobile stations.

Table 4. Maximum Handover Interruption.

Handover Type	Max. Interruption Time (ms)
Intra-Frequency	50
Inter-Frequency	150

6.2.5 DELETED SECTION

6.2.6 DELETED SECTION

6.3 QoS

IEEE 802.16m shall support QoS classes, enabling an optimal matching of service, application and protocol requirements (including higher layer signaling) to RAN resources and radio characteristics. This includes enabling new applications such as interactive gaming [5].

When feasible, support shall be provided for preserving QoS when switching between networks associated with other radio access technologies (RAT's).

6.4 Radio Resource Management

6.4.1 MOVED TO SECTION 6.12

6.4.2 Reporting

IEEE 802.16m shall enable advanced radio resource management by enabling the collection of reliable statistics over different timescales, including system (e.g. dropped call statistics), user (e.g. terminal capabilities, mobility statistics, battery life), flow, packet, etc.

6.4.3 DELETED SECTION

6.4.4 DELETED SECTION

6.4.5 Interference Management

IEEE 802.16m shall support advanced interference mitigation schemes.

IEEE 802.16m shall support enhanced flexible frequency re-use schemes.

6.5 Security

IEEE 802.16m shall include a security function which provides the necessary means to achieve:

- protection of the integrity of the system (e.g. system access, stability and availability)
- protection and confidentiality of user-generated traffic and user-related data (e.g. location privacy, user identity)
- secure access to, secure provisioning and availability of services provided by the system

Example security procedures that can be used to achieve the above-stated goals include user/device authentication, integrity protection of control and management messages, enhanced key management, and encryption of user generated and user-related data.

The impact of security procedures on the performance of other system procedures, such as handover procedures, shall be minimized.

The security function should be self-contained and capable of maintaining security without relying on specific behaviors on the part of algorithms/protocols at any other functions or layers outside the security function. Such assumptions, if and when necessary, shall be explicitly specified.

6.6 Handover

IEEE802.16m shall support optimized handover within and between all cell types in an IEEE802.16m system. IEEE802.16m shall provide optimized handover with legacy IEEE 802.16e systems.

IEEE 802.16m shall provide support for handover with other RATs. However, an IEEE 802.16m MS is not required to be multi-mode.

IEEE802.16m shall provide service continuity during handover for both inter-RAT and intra-RAT handover.

IEEE 802.16m should support IEEE 802.21 Media Independent Handover (MIH) Services.

Mobility procedures should be fully compatible with the IEEE 802.16 Network Control and Management Services (NCMS).

6.7 Enhanced Multicast Broadcast Service (MBS)

IEEE 802.16m shall provide support for an enhanced Multicast Broadcast Service (E-MBS), providing enhanced multicast and broadcast spectral efficiency (Section 7).

IEEE 802.16m shall support E-MBS delivery via a dedicated carrier.

IEEE 802.16m shall support optimized switching between broadcast and unicast services, including the case when broadcast and unicast services are deployed on different frequencies.

6.7.1 MBS Channel Reselection Delay and Interruption Times

E-MBS functionality defined as part of IEEE 802.16m shall support the following requirements for maximum MBS channel change interruption times when applied to broadcast streaming media.

Table 5. MBS channel reselection maximum interruption times.

MBS Channel Reselection Mode	Max. Interruption Time (s)
Intra-frequency	1.0
Inter-frequency	1.5

Note that requirements of Table 5 apply to the interruption time between terminating delivery of MAC PDU's from a first MBS service to the MAC layer of the mobile station, and the time of commencement of delivery of MAC PDU's from a second MBS service to the mobile station MAC layer.

6.8 Location Based Services (LBS)

IEEE 802.16m shall provide support for high resolution location determination.

6.9 [Reduction of User Overhead]

[The system shall provide mechanisms for reducing overhead already present in a bearer stream, by natively supporting improved and efficient header compression schemes, capable of suppressing overhead caused by IP/TCP layers, as well as other vital applications, such as VPN, PPPoE etc.]

6.10 [System Overhead]

[The percentage of system resources consumed by overhead, including overhead for control signaling procedures as well as overhead related to bearer data transfer, should be minimized.
]

[The IEEE 802.16m standard shall support the required throughput with a minimum downlink efficiency of 80%, where airlink efficiency shall be defined as:

1 - (Number of downlink MAC and PHY overhead slots (Preamble, MAP, sub-MAP, FCH, etc.) per frame / Total number of downlink slots per frame)

The IEEE 802.16m standard shall support the required throughput with a minimum uplink efficiency of 80%, where airlink efficiency shall be defined as:

1 - (Number of uplink MAC and PHY overhead slots (ranging allocations, HARQ Ack-Nack, CQICH, etc.) per frame / Total number of uplink slots per frame)
]

[Further optimization of the MAC should be considered for "16m". Overhead for critical real-time, latency-sensitive applications, should be reduced as far as feasible without compromising other performance criteria. More specifically, 802.16m should support various FEC-block, MAC-PDU and other protocol layer block sizes, optimized for typical applications by minimizing padding bits, i.e., matching payload to block sizes for the key application that need to be supported (VoIP, Gaming, Video, etc)]

[Although backward compatible 802.16m should be able to receive the legacy DCD/UCD messages, as well as the DL and UL MAPs, other non compatible operating modes shall be supported where the overhead of the layer 2 maps is significantly reduced.]

6.11 [Enhanced Power Saving]

[The 802.16m amendment shall provide support for enhanced power saving functionality to help reduce power consumption in client devices during multimedia services such as push-to-X and also when the device is idle. The following functional enhancements with respect to the reference 802.16e system are possible:

- Optimized sleep to scan and scan to sleep mode switching
- Automatic sleep mode reactivation provided by the BS
- Optimized sleep mode deactivation/reactivation by MS
- Optimized paging message indication and decoding]

6.12 Multi-RAT Operation

IEEE 802.16m shall support multi-RAT operation. For example, IEEE 802.16m may support interworking with the following RATs:

- IEEE 802.11 networks
- 3GPP GSM/EDGE, UMTS WCDMA, and LTE networks
- 3GPP2 CDMA2000 networks

7.0 Performance requirements

The performance requirements are specified in terms of absolute performance and relative performance with respect to that of the IEEE 802.16e reference system.

For relative performance requirement, this performance goal is specified in terms of spectral efficiency performance relative to IEEE 802.16e *reference* system using 2 transmit and 2 receive antennas at the base station and 1 transmit and 2 receive antennas at the mobile station. The performance metrics are average sector throughput, average user throughput and five percentile user throughput (cell edge throughput) defined in Table 7.

Typical overhead (control channels, pilots, guard interval…) shall be estimated for the operating point used for calculations.

Performance metrics are specified in terms of commonly understood definitions of Sector Throughput, User Throughput, Cell Edge User Throughput and VoIP capacity.

7.1 User throughput

7.1.1 Relative performance

The targets for average user-throughput and cell-edge user throughput of downlink/uplink for data only system for baseline antenna configuration are shown in Table 6. Both targets should be achieved relative to 802.16e *reference* performance as per antenna configuration defined above.

Table 6. Data only system

Metric	Relative Throughput	
	DL Data (x 802.16e)	UL Data (x 802.16e)
Average User Throughput	> 2x	>2x
Cell Edge User Throughput	> 2x	>2x

Note that the Cell Edge User Throughput is defined as the 5% point of the cumulative distribution function (CDF) of the user throughput for a given DL:UL ratio (in TDD duplex mode), a given number of users, site-to-site distance, and a given fairness and delay criterion in a fully loaded network with full-buffer traffic.

7.1.2 Absolute performance

The targets for average user-throughput and cell-edge user throughput of downlink/uplink for data only system for baseline antenna configuration are shown in Table 7.

Table 7. Absolute throughput of Data only system

Metric	DL Data	UL Data
Average User Throughput	TBD	TBD
Cell Edge User Throughput	TBD	TBD

7.2 Sector Capacity

Sector Throughput is defined as the total unidirectional sustained throughput (downlink/uplink), excluding MAC & PHY layer overheads, across all users scheduled on the same RF channel. Sector throughput requirements must be supported for realistic distributions of users of a fully loaded cell surrounded by other fully loaded cells using the same RF channel (i.e. an interference limited environment with full frequency reuse).

7.2.1 Relative Sector Capacity

Table 8. Relative Sector Throughput (bps/Hz/sector)

Speed (km/h)	DL	UL
TBD	**>2x**	**>1.5x**

Table 9. Relative VoIP Capacity

Speed (km/h)	Capacity (Active Users/MHz/sector)
TBD	>1.5x

7.2.2 Absolute Sector Capacity

Table 10. Sector Throughput (bps/Hz/sector)

Speed (km/h)	DL	UL
TBD	TBD	TBD

Table 11. VoIP Capacity

Speed (km/h)	Capacity (Active Users/MHz/sector)
TBD	> 60 (FDD)

VoIP capacity assumes a 12.2 kbps codec with a 40% activity factor such that the percentage of users in outage is less than 3% where outage is defined such 97% of the VoIP packets are delivered successfully to the users within the delay bound of 80 msec.

7.3 Mobility

Mobility shall be supported across the 802.16m network. IEEE 802.16m shall be optimized for low speeds such as mobility classes from stationary to pedestrian and provide high performance for higher mobility classes. The performance shall be degraded gracefully at the highest mobility. In addition, the IEEE 802.16m shall be designed to maintain the connection up to highest supported speed and to support the required spectral efficiency described in clause 7.2.

Table 12 summarizes the mobility performance.

Table 12. IEEE 802.16m mobility support

Mobility	Performance
Low (0 –15 km/h)	Optimized
High (15– 120 km/h)	Marginal degradation
Highest (120 km/h to 350 km/h)	System should be able to maintain connection

7.4 Cell Coverage

IEEE 802.16m shall provide significantly improved coverage with respect to the IEEE 802.16e reference system.

The link budget of the limiting link (e.g. DL MAP, UL Bearer) of 802.16m shall be improved by at least 3 dB compared to the IEEE 802.16e *reference* system.

IEEE 802.16m shall support legacy cell sizes allowing for co-location of IEEE 802.16e deployments.

Support for larger cell sizes should not compromise the performance of smaller cells. It is also required to support increased number of simultaneous users and enhanced user penetration rates. Specifically, 802.16m shall support the following deployment scenarios in terms of maximum cell range:

Table 13. 802.16m Deployment Scenarios

Cell Range	**Performance target**
Up to 5 km	Optimized Performance targets defined in clause 7.1-7.3 should be met
5-30 km	Graceful degradation in system/edge spectral efficiency
30-100 km	System should be functional (thermal noise limited scenario)

7.5 Enhanced Multicast-Broadcast Service

As outlined in Section 6, IEEE 802.16m shall support enhanced multicast-broadcast service for IMT-Advanced multimedia multicast broadcast services in a spectrally efficient manner.

The IEEE 802.16m enhanced multicast-broadcast service may support larger cells (e.g. 50 km).

Minimum performance requirements for E-MBS, expressed in terms of spectral efficiency over the coverage area of the service, appear in Table 14.

Table 14. MBS minimum spectral efficiency vs. inter-site distance

Inter-Site Distance (km)	**Min. Spectral Efficiency (bps/Hz)**
0.5	4

1.5	2

The following notes apply to Table 14:

1. The performance requirements apply to a wide-area multi-cell multicast broadcast single frequency network (MBSFN).
2. The specified spectral efficiencies neglect overhead due to ancillary functions (such as synchronization and common control channel) and apply to both mixed unicast-broadcast and dedicated MBS carriers, where the performance is scalable with carrier frequency bandwidth.

7.6 DELETED SECTION

7.7 DELETED SECTION

7.8 Location-Based Services (LBS) Performance

IEEE 802.16m should provide support for LBS. The IEEE 802.16m should satisfy the following requirements:

Table 15. Location-Based Service Requirements

Feature	Requirement	Comments
Location Determination Latency	< TBD s	
Handset-based	Position Accuracy 50 (67%) - 150 (95%)	Need to meet E911 Phase II Requirements
Network-based	Position Accuracy 100 (67%) -300 (95%)	

8.0 Deployment-related requirements

Color	Section 8 Source Document Authors	Section 8 Source Document Reference
Blue	San Youb Kim, et. al.	IEEE C802.16m-07/034
Brown/Dk Red	Sassan Ahmadi, et. al.	IEEE C802.16m-07/045
Violet	Xin Qi, et. al.,	IEEE C802.16m-07/026
Rose	Sunil Vadgama et. al.	IEEE C802.16m-07/047r1
Green	Jin Sam Kwak et.al	IEEE C802.16m-07/040
Red	Dan Gal, et. al.	IEEE C802.16m-07/011
Orange	Mark Cudak, et. al	IEEE C802.16m-07/019
Dark Yellow	Phil Orlik	IEEE C802.16m-07/016
Gold	Michael Webb et. al.	IEEE C802.16m-07/023

8.1 Legacy Support – All Legacy support items moved to section 5

8.2 Spectrum Requirements

[IEEE 802.16m should be optimised to support contiguous spectrum allocations]

[IEEE 802.16m should be suitable for deployment both in spectrum already identified for IMT radio access technologies (RATs), and for any additional spectrum identified for IMT RATs by ITU (e.g. at WRC 2007)]

[The IEEE 802.16m shall be possible to operate standalone, i.e. there is no need for any other carrier to be available.]

[IEEE 802.16m should offer better frequency assignment support by allowing [better] finer granularity. This would facilitate an optimized utilization of variable spectrum block sizes. Optimization/adaptation of channel bandwidth should also utilize the OFDMA capability to switch off channel-edge sub-carriers.]

[The IEEE 802.16m standard shall provide MAC and PHY support to enable Flexible Spectrum Use (FSU) between different IEEE802.16m systems e.g., frequency sharing between homogeneous 802.16m networks of different operators and be able to share or reutilize the bandwidth with the legacy systems.
[Where possible, IEEE 802.16m should support frequency sharing with other communication systems, at least other IMT-Advanced networks.]
Flexible Spectrum Use should enable the use of [paired and unpaired spectrum] and [scattered spectrum].

8.3 System Architecture

8.3.1 DELETED SUBSECTION

8.3.2 Support for Multi-hop Relay

IEEE 802.16m should provide enhancements to enable multi-hop relays.

IEEE 802.16m should enable deployment of multi-hop relays based IEEE 802.16j.

8.4 System Migration

[The IEEE 802.16m amendment shall provide for a smooth migration from legacy IEEE 802.16e systems to IEEE 802.16m deployments. To achieve this goal, the following requirements are applicable:

- IEEE 802.16m and IEEE 802.16e mobiles shall be able to coexist on the same RF carrier.
- All IEEE 802.16m enhancements shall be transparent to a legacy IEEE 802.16e terminal.
- IEEE 802.16m cell sites shall be able to operate in a 16m mode while adjacent to legacy IEEE 802.16e cell sites.
- IEEE 802.16m cell sites shall not cause significant degradation to the performance of the adjacent IEEE 802.16e cell.
- Handoff between legacy IEEE 802.16e cell sites and IEEE 802.16m cell sites shall be supported and efficient. The efficiency should be equivalent to legacy IEEE 802.16e handoffs.
- IEEE 802.16m amendment shall allow the handoff from an IEEE 802.16e operating mode on a legacy BS directly into an IEEE 802.16m operating mode on IEEE 802.16m BS.

The above requirements provide for a smooth cell-site by cell-site migration strategy.]

[The IEEE 802.16m system may be deployed without an underlying legacy network. In this case, while the standard and implementations remain fully backward compatible, the deployment may be optimized for the new IEEE 802.16m terminals.]

8.5 [Synchronization]

[Synchronization between different BSs shall be required, at least for TDD mode.]

9.0 Usage Models

Color	Section 9 Document Source	Section 9 Document Reference
Red	Jean-Pierre Balech et. al	IEEE C802.16m-07/52
Orange	Mark Cudak et. al.	IEEE C802.16m-07/020
Blue	Sang Youb Kim	IEEE C802.16m-07/035
Pink	Jianmin Lu et.al.	IEEE C80216m-07/028
Brown	Sassan Ahmedi et. al	IEEE C802.16m-07/46

.

[The IEEE 802.16m air interface, as an amendment to the existing IEEE 802.16-2004 and IEEE 802.16e-2005 standards, shall support a wide range of deployment scenarios and usage models including a) those considered during formulation of the existing standards and b) as envisioned by IMT-Advanced requirements. The examples provided in this section are informative only.

The Standard should support different usage models. More specifically, it should cover (but not be restricted to)

1) Higher data rates and improved performance (compared to 802.16e) in legacy cell sizes (of several kilometers radius).

2) Very high data rates in smaller cells
3) High mobility optimized scenarios
4) Deployment with Multi-hop Relay Networks
5) Co-Deployment with Other Networks
6) Provision for PAN/LAN/WAN Collocation / Coexistence

This section is informative only. It includes service and application scenarios and deployment scenarios. The deployment scenarios described in the following sections include topologies networks and frequency reuse schemes where 802.16m terminals and base stations are exclusively used, where a mix of 802.16m and 802.16e (migration from legacy to new systems), a scenario where fixed and mobile relay stations (used for coverage and throughput enhancements) are used and a scenario optimized for high mobility. It also describes deployments with other systems.]

9.1 [Service and Application Scenarios]

[The types of services that can be provided by IEEE802.16m-based packet-switched network can include:

- Voice services (e.g., VoIP)
- Data services (e.g., Email, IMS, web browsing, file transfer, internet gaming)
- Multimedia services (e.g., Audio and/or video streaming, broadcast, interactive conferencing)

Section 5.7 provides details on the class of services for next generation of mobile networks.

The type of end users can include:

- Personal use (e.g., mobile internet)
- Business/Enterprise use (e.g., backhaul, VPN)
- Special use (e.g., dedicated network for public safety needs)

End users anticipate new services, new features, and new devices for IMT-Advanced. For example, HDTV plasma screens will be popular for notebook type of devices. Real-time gaming or Real-time video streaming service over high definition screens will be a typical service in the future. High priority E-commerce, telemetric, Broadcast/Multicast for TV, news, and advertisement over the handheld will be popular services as well.]

9.2 [Deployment Scenarios]

[The IEEE 802.16m radio access technology shall be suitable for deployment in a number of propagation environments including

- Outdoor environments including outdoor-to-indoor environments (e.g., rural, urban, suburban)
- Indoor environments (e.g., hot-spot, overlay for improved coverage and/or capacity)

The end users in an IEEE80.16m-based network also shall be supportable with different levels of mobility including

Fixed/Stationary (e.g., CPE with fixed antenna)
Pedestrian or quasi-static (e.g., portable devices)
Mobile (e.g., handsets)]

9.2.1 [Frequency Reuse]

[In the usage model example of cellular networks, a network coverage area can be served by a number of Base Stations (BS), each of which may further contain a certain number of sectors. For areas that need enhanced coverage or require additional throughout, additional IEEE 802.16m-based BS's can be overlaid onto existing 802.16e reference system topologies.

Cellular deployment scenarios specify the pattern of RF channel (or carrier) usage in terms of a "frequency reuse factor" which is a factor of the total spectrum size allocated to it. RF channels are assigned to different cells (i.e. BS sites) or sectors and this allocation can be repeated across adjacent sites or adjacent cluster of sites throughout the network. The resulting frequency reuse can be indicated as the triplet (*c, s, n*) where *c* is the number of BS sites per cluster, *s* is the number of sectors per BS site and *n* is the number of unique RF channels needed for reuse. Typical examples of reuse (1,3,1) and (1,3,3) are shown in Figure 9.1 and 9.2.

As in the existing 802.16e reference network, the 802.16m system may allow each sector to use only a non-overlapping part of the spectrum thus creating an equivalent reuse pattern. For example in PUSC permutation of 802.16e, the whole band is divided into six major groups and the FCH (Frame Control Header) message of each sector contains a bitmap that indicates the major groups usable to that sector. If the major groups are divided equally to three sets, a reuse pattern equivalent to (1,3,3) will be created. Sometimes, the PUSC frequency reuse is referred to as "in-band" reuse.

In the reference system it is also possible to have a different reuse pattern in different zones. For example for MBS (Multicast and Broadcast Service) deployment a (1,3,1) pattern can be used while the other data service can still use (1,3,3) reuse pattern.

The 802.16m system may offer a similar degree of flexibility.

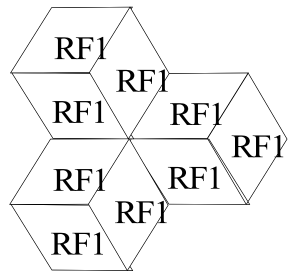
As a convention, it is recommended to describe the patterns of the channel and the different zones by a notation (*c,s,n/k*), with *k* indicates the effective reuse factor of each zone. Thus (1,3,1/1) indicates a full re-use pattern of all zones, while (1,3,1/3) indicates 1 unique RF channels segmented to 3 to produce an effective re-use 3 in a given zone.

It is expected that tight spectrum constraints may limit the number of unique frequency channels allocated to a given deployment, thus the IEEE 802.16m amendment may support the deployment modes as described in the following subsections, all are of a very small spectrum allocation:]

9.2.1.1 [Single RF channel allocation, (1,3,1) frequency re-use pattern]

[(1,3,1) : In this allocation each cluster comprising one BS site. Each BS site has three sectors and all sectors are assigned the same RF channel

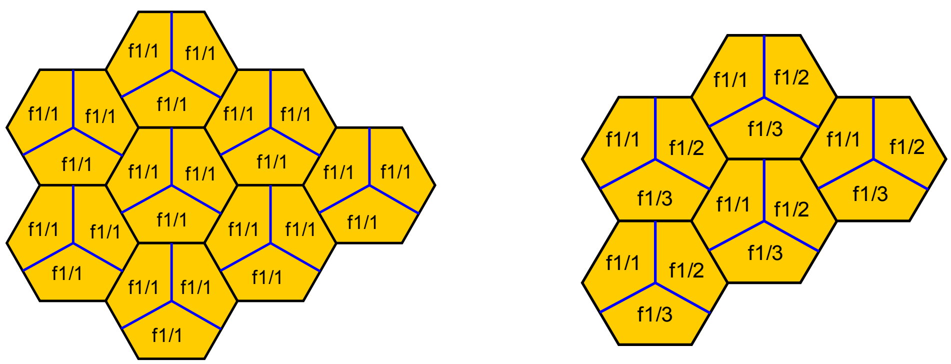
Examples of (1,3,1) Frequency Reuse is given in Figure 9.1.



(1,3,1) Frequency Reuse

Figure 9.1 — Example of (1,3,1) frequency reuse.

A comparison of an in-band reuse (1,3,1/3) to a full band re-use (1,3,1/1) pattern is given in Figure 9.2, where in each cell the notation f_i/s_i indicates the RF channel (f_i) and the segment number s_i of the particular sector. Fig. 9.2a shows a (1,3,3) re-use with the same segment allocated to each sector, while Fig. 9.3b shows the same re-use pattern with different segments allocated to each sector.



(a) Full re-use 1 identical segments (1,3,1/1) (b) Full re-use 1 different segments (1,3,1/3)

Figure 9.2 : (1,3,1) Frequency Reuse Patterns

]

9.2.1.2 [Three RF channels allocation, (1,3,3) and (3,3,3) frequency re-use pattern]

[With three RF channels allocated, one can distinguish between two different patterns:

- (1,3,3) : in which each cluster comprising one BS site. Each BS site having three sectors where each of the three sectors is assigned a unique RF channel, as depicted in Figure 9.3

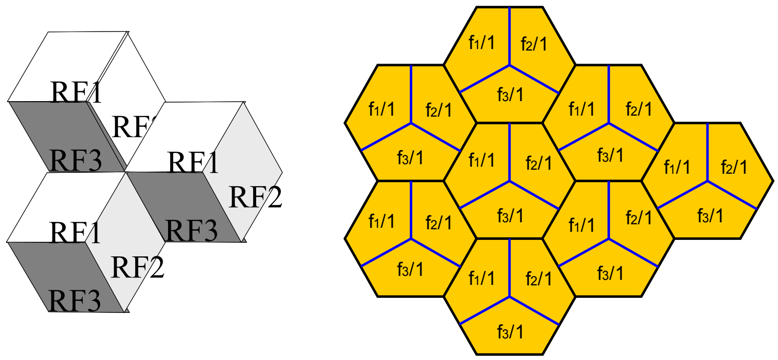


Figure 9.3 — Examples of (1,3,3) frequency reuse, with different sector orientations.

- (3,3,3) 3 BS per cluster, 3 sectors per BS and 3 unique RF channels. Each BS is assigned a single RF channel, as depicted in figure 9.4

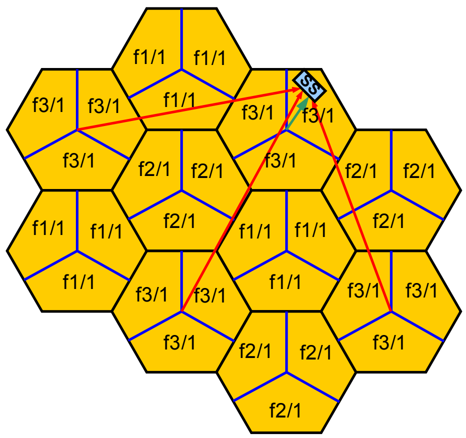


Figure 9.4: Frequency reuse pattern (3,3,3) with no segmentation in each BS]

9.2.1.3 [Reuse patterns with 4 and 6 sectors]

[Increasing the number of sector may improve the system performance and reduced interference between a sector and a close by cell. It however adds burden to the handover process. Still, multiple sector base stations may be of use. Thus one can define the following re-use patterns.

(1,6,3) :1 BS per cluster, 6 sectors per BS Site, 3 unique RF channels
(1,4,2) : 1 BS per cluster, 4 sectors per BS Site, 2 unique RF channels
(1,4,1) :1 BS per cluster, 4 sectors per BS Site, 1 unique RF channel
(1,6,1) : 1 BS per cluster 6 sectors per BS site, 1 unique RF channel]

9.2.1.3 [Additional consideration for frequency reuse pattern selection]

[Another factor that should be taken into account is the spatial planning. Even though a reuse 1 deployment with full use of sub-carriers that is described in this section does not require frequency planning, it could be impacted by the antenna's orientation of different sectors. In case of frequency deployment shown in Figure 9.1, the number of interfering sectors for every tone is not influenced by the BS's orientation, but the interference power per tone could be influenced by it. This effect is much more significant for the interference levels for the zones which have a higher re-use factor (see Figure 9.5 for illustration of spatially unplanned preamble deployment).

As a convention, it is recommended adding an additional letter, 'p' or 'u', at the beginning of the notation. indicating weather the deployment is spatially planned or not For example the deployments in Figure 9.1 and Figure 9.5 can be described as p(1,3,1) and u(1,3,1/3) respectively. Note that in practice frequency planning and spatial planning must be performed jointly and cannot be separated into two different tasks.

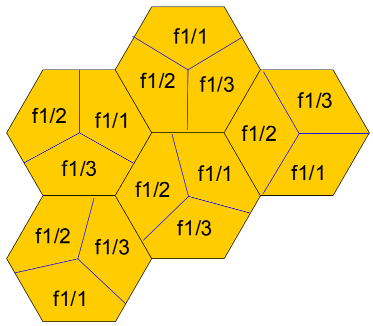


Figure 9.5: Frequency reuse pattern on preamble sub-carriers for Scenario I with different segment numbers in case of spatially unplanned antennas.

In the existing IEEE 802.16e reference system, use of partial loading (for example using only 1/3 of the sub-channels) can help reduce interference in zones which use different permutation base. Similarly, the IEEE 802,16m air interface should be considered as a function of the system load.]

9.2.2 [Co-Deployment with Other Networks]

[The IEEE 802.16m amendment is anticipated to be deployed in the same RF carrier as the legacy network (refer to the Section 5.1 and 8.1). Moreover, it is also envisioned that the IEEE 802.16m air interface can be deployed in the same or overlapping geographical areas with other wireless networks based on different RAT (Radio Access Technologies). These non-802.16 networks may operate in the neighboring licensed frequency bands such as CDMA2000, 3GPP (e.g., GSM, UMTS, LTE) or in unlicensed bands such as 802.11x networks. They may or may not have the same network topology. Coexistence of networks specified on the basis of the IEEE 802.16m amendment with these networks must be guaranteed from the perspective of being both an interferer and being a victim. Inter-working in the form of handoff as described in Section 7 is also expected. A possible deployment of IEEE 802.16m with legacy system is depicted in figure 9.5

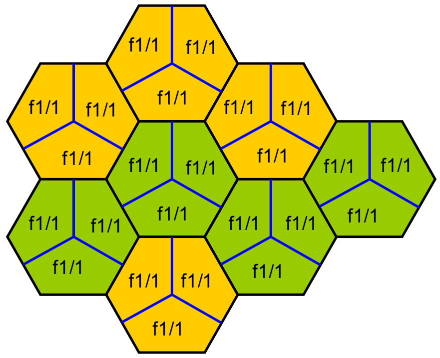


Figure 9.5: Possible deployment of 802.16m with legacy systems, with a similar re-use pattern]

9.2.3 [Deployment with Multi-hop Relay Networks]

[This scenario (shown in 9.6 is an example of IEEE 802.16m deployments (network topologies) that include fixed and/or mobile relays for coverage extensions and filling coverage holes and throughput improvement. The air-interface between the mobile stations and the relay stations will be in the IEEE 802.16m amendment (some deployment scenarios may include IEEE 802.16e based air-interface). The performance evaluation of the proposals containing fixed or mobile relay stations shall follow the evaluation methodology defined by IEEE 802.16j Relay Task Group for mobile multi-hop relay networks [6].

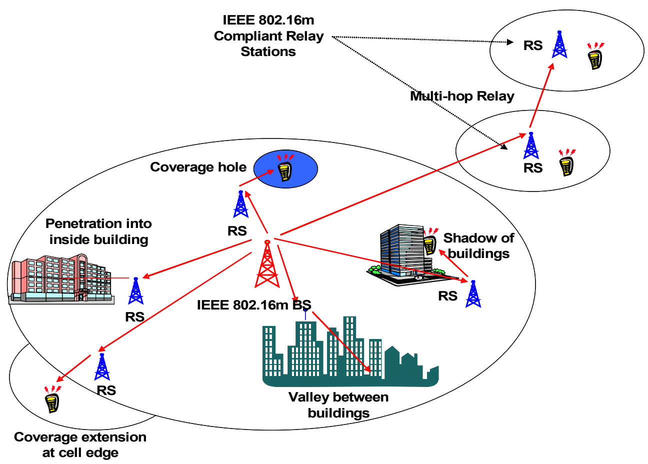


Figure 9.6: IEEE 802.16m with multi-hop relay networks (the RS can be fixed or mobile depending on the usage and deployment specifics).

]

9.2.4 [High Mobility Optimized Scenario]

[The system or one mode of the system needs to provide services to high-speed users. In this scenario mobile terminal speeds range from 200 to 300kmph with likely large penetration losses in a large and irregular coverage area. The service environment may dynamically and rapidly change and differentiated service with high granularity may be required. The air interface shall be optimized and balanced between reducing link level maintenance overhead and providing optimized burst profile and handover performance.]

9.2.5 [Provision for PAN/LAN/WAN Collocation / Coexistence]

[As a provision for proper operation of various wireless access technologies on multi-radio terminals, the IEEE 802.16m should provide (measurement / report / radio resource allocation) methods to mitigate interference from other wireless radios on the same (collocated) device given minimum adjacent channel isolation. As a result, IEEE 802.16m radio will not suffer from interference from other wireless devices, or cause destructive interference to other wireless devices. Currently, Wi-Fi and Bluetooth radios are likely to coexist/collocate with an IEEE 802.16m radio.]