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Re:	Requirements for P802.16m-Advanced Air Interface
Abstract	This version has been revised according to the comment resolution conducted by TGm in Session #49
Purpose	Updated high-level system requirements for the P802.16m draft
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Contents

1.0 Overview

The P802.16m draft shall be developed in accordance with the P802.16 project authorization request (PAR), as approved on 6 December 2007 [1], and with the Five Criteria Statement in IEEE 802.16-06/055r3 [2].

According to the PAR, the standard shall be developed as an amendment to IEEE Std 802.16 [3][4]. 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) [5][6][7].

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.

2.0 References

[1] IEEE 802.16m PAR, December 2006, http://standards.ieee.org/board/nes/projects/802-16m.pdf

[2] IEEE 802.16 WG, "Five Criteria Statement for P802.16m PAR Proposal," IEEE 802.16-06/55r3, November 2006, http://ieee802.org/16/docs/06/80216-06_055r3.pdf

[3] 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

[4] 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

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

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

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

[8] WiMAX Forum™ Mobile System Profile, Release 1.0 Approved Specification (Revision 1.4.0: 2007-05-02), http://www.wimaxforum.org/technology/documents

[9] IEEE 802.16 Relay Task Group, "Multi-hop Relay System Evaluation Methodology (Channel Model and Performance Metric)", IEEE 802.16j-06/013r2, November 2006, http://ieee802.org/16/relay/docs/80216j-06_013r2.pdf

[10] 3rd Generation Partnership Project 2, "cdma2000 Evaluation Methodology", 3GPP2 C.R1002-0 Version 1.0, December 2004, http://www.3gpp2.org/Public_html/specs/C.R1002-0_v1.0_041221.pdf

[11] 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 BS
WirelessMAN-OFDMA Reference System	A system compliant with a subset of the WirelessMAN-OFDMA capabilities specified by IEEE 802.16-2004 and amended by IEEE 802.16e-2005 and IEEE 802.16Cor2/D3, where the subset is defined by WiMAX Forum Mobile System Profile, Release 1.0 (Revision 1.4.0: 2007-05-02), excluding specific frequency ranges specified in the section 4.1.1.2 (Band Class Index)
Legacy MS	A mobile station (MS) compliant with the WirelessMAN-OFDMA Reference System
Legacy BS	A BS compliant with the WirelessMAN-OFDMA Reference System
IEEE 802.16m MS	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 BS	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

4.0 Abbreviations and acronyms

BS	base station
CALEA	Communications Assistance for Law Enforcement Act
DL	downlink
E-MBS	enhanced multicast broadcast service
FDD	frequency division duplex
IP	Internet Protocol
ITU-R	International Telecommunications Union – Radio Communications Sector
LAN	local area network
LBS	location based services
MAC	medium access control layer
MBS	multicast broadcast service
MBSFN	multicast broadcast single frequency network
MIH	media independent handover
MIMO	multiple input multiple output
MS	mobile station
NCMS	network control and management services
OFDMA	orthogonal frequency division multiple access
PAN	personal area network
PAR	project authorization request
PDU	protocol data unit
PHY	physical layer
QoS	quality of service
RAN	radio access network
RAT	radio access technology
RRM	radio resource management
RS	relay station
TDD	time division duplex
UL	uplink
VoIP	voice over IP
WAN	wide area network

5.0 General requirements

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.

IEEE802.16m shall meet the IMT-Advanced performance requirements.

Some of the requirements in this document are separated for the mobile station (MS) and the base station (BS). Such requirements shall be construed as minimum performance requirements for the MSs and BSs. 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 MSs and BSs.

5.1 Legacy support

IEEE 802.16m shall provide continuing support and interoperability for legacy WirelessMAN-OFDMA equipment, including MSs and BSs. Specifically, the features, functions and protocol procedures enabled in IEEE 802.16m shall support the features, functions and protocol procedures employed by WirelessMAN-OFDMA legacy equipment. IEEE 802.16m shall provide the ability to turn-off legacy support.

This continuing support shall be limited to only a "harmonized sub-set" of WirelessMAN-OFDMA features, functions and protocol procedures. This harmonized sub-set is captured by the WiMAX Forum Mobile System Profile, Release 1.0 (Revision 1.4.0: 2007-05-02) [1]. The features, functions and protocol procedures specified by WiMAX Forum Mobile System Profile shall serve as the WirelesMAN-OFDMA Reference System (see definitions).

The following are backward compatibility requirements:

- An IEEE 802.16m MS shall be able to operate with a legacy BS, at a level of performance equivalent to that of a legacy MS.
- Systems based on IEEE 802.16m and the Wireless-OFDMA Reference System shall be able to operate on the same RF carrier, with the same channel bandwidth; and should be able to operate on the same RF carrier with different channel bandwidths.
- An IEEE 802.16m BS shall support a mix of IEEE 802.16m and legacy MSs when both are operating on the same RF carrier. The performance of such a mix should improve with the fraction of IEEE 802.16m MSs attached to the BS.
- An IEEE 802.16m BS shall support seamless handover of a legacy MS to and from legacy BS
- An IEEE 802.16m BS shall be able to support a legacy MS while also supporting IEEE 802.16m MSs, at a level of performance equivalent of what a legacy BS provides to a legacy MS when operating on the same RF carrier.

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.

IEEE 802.16m should only provide enhancements in areas where the WirelessMAN-OFDMA 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 MSs and BSs 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 draft 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 quality of service (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-R requirements.

5.6 Duplex schemes

IEEE 802.16m shall be designed to support both Time Division Duplex (TDD) and Frequency Division Duplex (FDD) operational modes. The FDD mode shall support both full-duplex and half-duplex MS operation. Specifically, a half-duplex FDD MS is defined as a MS 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 BS and MS.

For the BS, 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 Support for government mandates and public safety

IEEE 802.16m shall be able to support public safety first responders, military and emergency services such as call-prioritization, pre-emption, push-to-talk.

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).

6.0 Functional requirements

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 (RRM).

6.1 Peak data rate

This section defines the peak data rate achievable between a BS and a MS under ideal conditions.

The minimum peak rate requirement supported by MSs 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:

a) 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.

b) Table 1 accounts for overhead due to provisioning of radio resources for essential functions such as pilots, cyclic-prefix, guard bands and guard intervals.

c) The specified minimum supported normalized peak rates are applicable to all bandwidths specified in Section 5. For example, for MSs 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 WirelessMAN-OFDMA 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 Protocol Data Unit (PDU), transmissible as a Layer 1 codeword (i.e. without fragmentation), from the MAC interface of a BS or MS entity to the MAC interface of the corresponding MS or BS entity, excluding any scheduling delay at the BS. 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 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

6.2.3 Handover interruption time

This section addresses handover performance requirements, and specifically the interruption times applicable to handovers between legacy BSs and IEEE 802.16m BSs, and intra- and inter-frequency handover.

The maximum MAC-service interruption times specified in Table 4 apply to handover of IEEE 802.16m MSs between IEEE 802.16m BSs operating in the absence of legacy MSs.

Table 4–Maximum handover interruption

Handover type	Max. interruption time (ms)
Intra-frequency	50
Inter-frequency	150

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 radio access network (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 (RATs).

6.4 Radio resource management

6.4.1 Reporting

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

6.4.2 Interference management

IEEE 802.16m shall support interference mitigation schemes.

IEEE 802.16m shall support 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

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 MS, and the time of commencement of delivery of MAC PDU’s from a second MBS service to the MS 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

IEEE 802.16m shall provide improved mechanisms for reducing overhead in the bearer stream associated with headers of higher layer protocols.

6.10 System overhead

Overhead, including overhead for control signaling as well as overhead related to bearer data transfer, for all applications shall be reduced as far as feasible without compromising overall performance and ensuring proper support of systems features.

6.11 Enhanced power saving

The 802.16m draft shall provide support for enhanced power saving functionality to help reduce power consumption in devices for all services and applications.

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 (FDD and TDD), 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 WirelessMAN-OFDMA Reference System.

For relative performance requirement, this performance goal is specified in terms of spectral efficiency performance relative to WirelessMAN-OFDMA Reference System using 2 transmit and 2 receive antennas at the BS and 1 transmit and 2 receive antennas at the MS. 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.

The performance requirements shall be met without inclusion of the relay stations.

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 WirelessMAN-OFDMA Reference System 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 ms.

7.3 Mobility

Mobility shall be supported across the IEEE 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 sub clause 7.2.

Table 12 summarizes the mobility performance.

Table 12–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 WirelessMAN-OFDMA Reference System.

The link budget of the limiting link (e.g. DL MAP, UL bearer) of IEEE 802.16m shall be improved by at least 3 dB compared to the WirelessMAN-OFDMA 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, IEEE 802.16m shall support the deployment scenarios captured in Table 13 in terms of maximum cell range.

Table 13–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 Location-based services performance

IEEE 802.16m should provide support for LBS. The IEEE 802.16m should satisfy the requirements in Table 15.

Table 15–Location-based service requirements

Feature	Requirement	Comments
Location determination latency	< TBD s	
Handset-based position accuracy (in meters)	50m (67% of the time) – 150m (95% of the time)	Need to meet E911 Phase II Requirements
Network-based position accuracy (in meters)	100m (67% of the time) – 300m (95% of the time)	

8.0 Operational requirements

8.1 Spectrum-related operational requirements

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

8.2 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 on IEEE 802.16j.

8.3 Synchronization

Frame timing and frame counter shall be synchronized across the entire system deployed in a given geographic area, including synchronization among all BSs and MSs operating on the same or on different carrier frequencies and among BSs of same-technology neighboring systems, whether operated by the same operator or not. This requirement is key to coexistence of TDD systems and would be useful, but not essential, for FDD systems as well.

8.4 Co-deployment with other networks

IEEE 802.16m is anticipated to be deployed in the same RF bands as the legacy network. Moreover, it is also envisioned that the IEEE 802.16m 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 as well as other IEEE 802.16 networks must be guaranteed from the perspective of being both an interferer and being a victim.

Annex A: Usage models (informative)

IEEE 802.16m should 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.

IEEE 802.16m should support different usage models. More specifically, it should cover (but not be restricted to):

1) Higher data rates and improved performance (compared to WirelessMAN-OFDMA Reference System) 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 BSs 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.

A.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 and conference call)
- Data services (e.g., Email, IMS, web browsing, file transfer, internet gaming, white boarding)
- Multimedia services (e.g., Audio and/or video streaming, broadcast, interactive conferencing)

To meet IMT-Advanced requirements, IEEE 802.16m may also support new services, new features, and new devices. For example, real-time gaming or real-time video streaming service over high definition screens may be a typical service in the future. High priority E-commerce, telemetric, Broadcast/Multicast for TV, news, and advertisement over the handheld may be popular services as well.

A.2 Deployment scenarios

The IEEE 802.16m RAT should 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 should 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)
- High mobility

A.2.1 Frequency reuse

In the usage model example of cellular networks, a network coverage area can be served by a number of BSs each of which may further contain a certain number of sectors. For areas that need enhanced coverage or require additional throughput, flexible frequency reuse schemes can be employed. The frequency reuse scheme should allow for both hard reuse and soft reuse, where soft reuse refers the case where the power on some of the tones is reduced rather than not used. IEEE 802.16m should allow for adaptive frequency reuse schemes, which enable frequency reuse only when coverage improvement is necessary.

IEEE 802.16m should support the flexibility of applying different reuse patterns in different zones. For example, the MBS (Multicast and Broadcast Service) can employ reuse 1 pattern, while other unicast services can employ another reuse pattern.

In the consideration of the frequency reuse planning, the resulting system signal to interference ratio should be maintained to satisfy the minimum system performance requirement and this interference should include all co-channel and adjacent channel interferences resulting from the same system and from other co-existing systems.

In an IEEE 802.16m system different frequency reuse patterns may be used in every BS.

A.2.2 Deployment with multi-hop relay networks

IEEE 802.16m aims to develop an air interface providing high transmission rate as specified in the IMT-Advanced requirements. The target transmission rate is much higher than that defined in the IEEE 802.16e standard. Cost effective provisioning of high data rate coverage over a wide area as well as to avoid coverage holes in the deployment areas are important deployment requirements. Intelligent relays are an effective technology to achieve those goals with lower investment costs and lower operational costs. In addition, upgrading the networks in order to support higher data rates is equivalent to an increase of signal-to-interference plus noise ratio (SINR) at the receivers' front-end. Also, through deployment the network providers have to avoid coverage area holes.

A traditional solution to increase the receiver's SINR is to deploy additional BSs or repeaters to serve the coverage area holes with required data rates. Unfortunately, the cost of BS is high and the wire-line backhaul may not be available everywhere. On the other hand, repeater has the problem of amplifying the interference and has no intelligence of signal control and processing. In order to achieve a more cost-effective solution, relay stations (RS) capable of decode and forward the signals from source to destination through radio interface. Here, RSs do not need a wire-line backhaul; the deployment cost of RSs is expected to be much lower than the cost of BSs. The system performance could be further improved by the intelligent resource scheduling and cooperative transmission in systems employing intelligent relays.

Deploying RS can improve IEEE 802.16m network in different dimensions. The following figures illustrate the different benefits can be achieved by deploying RS in IEEE802.16m network.

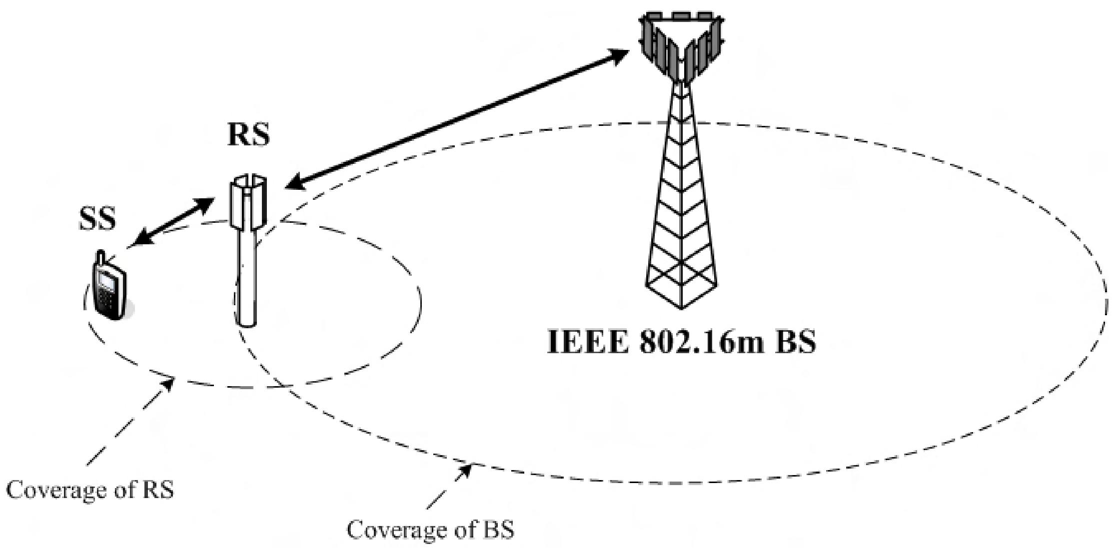

Figure 1–Coverage extension by deploying RS in a IEEE 802.16m network

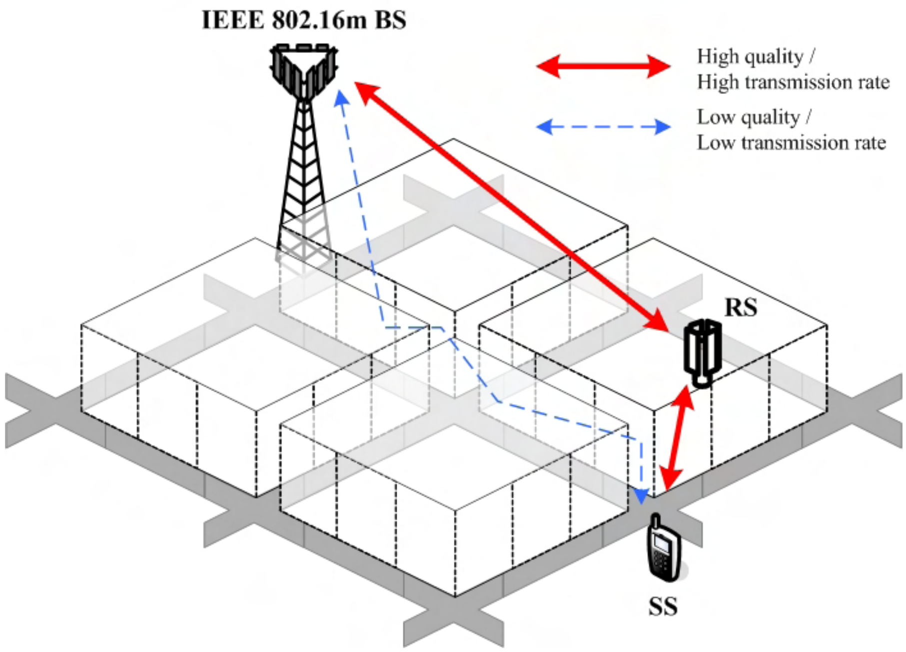

Figure 2–Deploying RS can enhance transmission rate for the SS located in shaded area or cell boundary

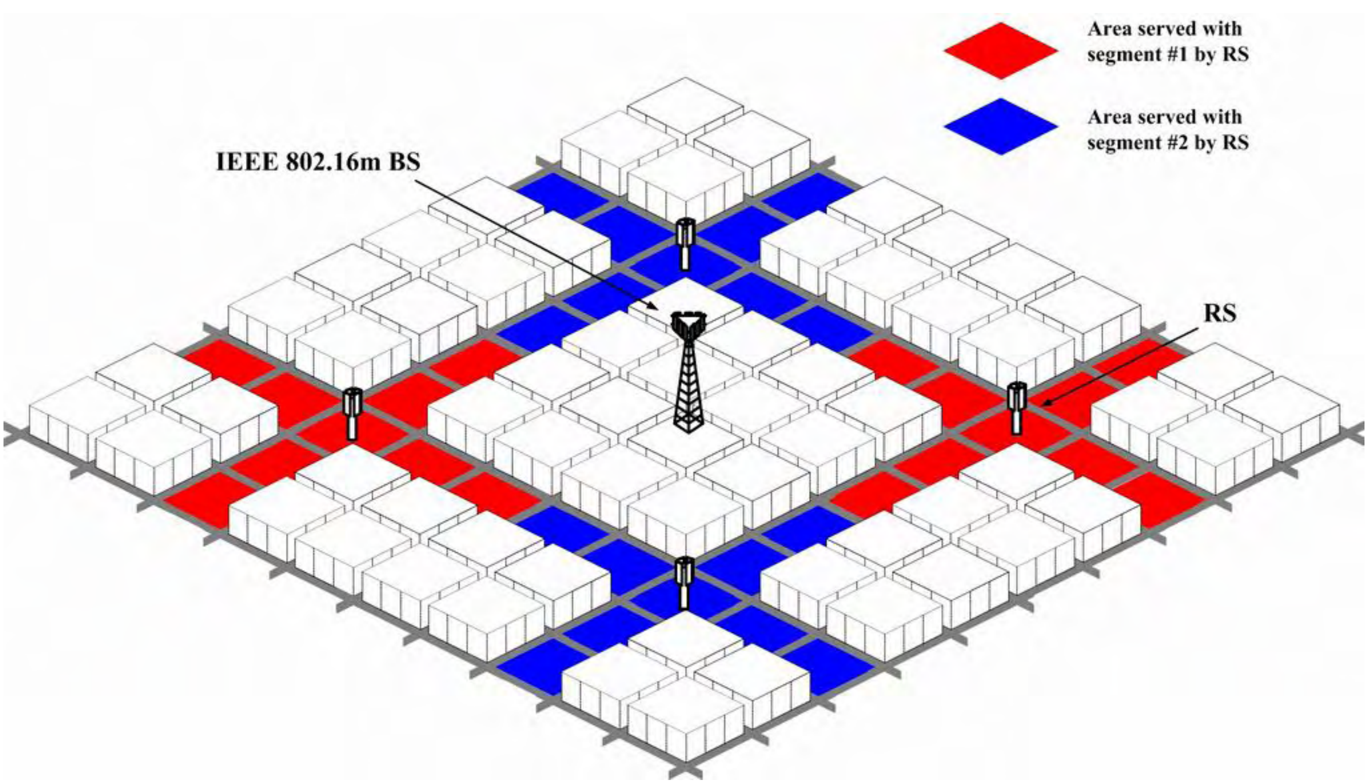

Figure 3–More aggressive radio resource reuse by deploying RS in IEEE 802.16m network

A.2.3 High mobility optimized scenario

IEEE802.16m should provide services to high-speed users. In this scenario, the speed of the MSs is usually higher than 120 km/h and can be up to 350 km/h. The MSs may experience large penetration loss. The service environment may change dynamically and rapidly. The air interface may be optimized for high-speed users.

A.2.4 Provision for PAN/LAN/WAN collocation / coexistence

As a provision for proper operation of various wireless access technologies on multi-radio terminals, IEEE 802.16m should provide methods to mitigate interference from other wireless radios on the same (collocated) device given minimum adjacent channel isolation. As a result, an 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.